Bo Lindell

The history of radiation, radioactivity, and radiological protection

PART 4. 1967 – 1999+

THE TOIL OF SISYPHUS

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The History of Radiation, Radioactivity, and Radiological Protection

PART IV. 1967 – 1999+

Translated by Helen Johnson
through Snabböversättare Sverige AB

Translator’s note: Any views expressed herein on any subject have, to the best of my knowledge, been expressed in the manner in which they are expressed in the original text and are not necessarily my own.

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* Sten Grapengiesser passed away in 2020.

FOREWORD

I HAVE FINALLY succeeded in putting together the fourth and final volume in my series about the history of radiation, radioactivity and radiation protection. I have called it *The Toil of Sisyphus.* According to a Greek myth, in the Underworld, King Sisyphus was compelled to try to roll an immense boulder up a steep hill. Each time he came close to completing his task, the boulder rolled back down and I thought this could be an appropriate analogy to illustrate the worldwide power industry's bumpy ride towards gaining acceptance for nuclear power plants. Little did I realise that my work with the book would also become reminiscent of Sisyphus' endeavours.

I have thought a great deal about how I should set about my task on this occasion. International radiation protection activities, as well as Swedish ones of course, increased substantially in the latter 1990s. It was desirable to describe activities in many more countries than before, but the number of important people and their contributions added up to much more than the capacity I had to deal with them all. The first three volumes contain 'main themes' and recount the development in epic form. *Pandora's Box* tells the story of the relevant growth of natural science up until it culminated in the discovery of nuclear fission. *The Sword of Damocles* is a coherent story of the birth and use of the first atomic bombs, a story which is conveyed by an inherent power. *The Labours of Hercules* tells the story of Rolf Sievert's achievements for international radiation protection, with particular emphasis on the important organisations called the ICRP and UNSCEAR.

The story became increasingly subjective volume after volume. For *Pandora's Box* I had endeavoured to be objective to the extent that some readers complained that I had not actually revealed my own opinion of the various events. In *The Sword of Damocles* I had one final chapter which my troubled editor quite rightly thought was an affront to the style in that situations were suddenly about me. I had been involved in the events described in *The Labours of Hercules* and therefore found it difficult be completely objective in dealing with them.

In planning this fourth volume, *The Toil of Sisyphus*, my practical intention, for both capacity reasons and the difficulty in obtaining source material, was to limit the story largely to the matters that I had actually been involved with. The narrative would still enjoy a broad international coverage because I had had such extensive international assignments myself. I had experienced for myself much of the international, and Nordic, significance over the decades which I would be writing about. However, I would unfortunately not be able to write about what also happened in different countries and the achievements of many national and regional participants. A great deal has obviously also taken place within the Swedish Radiation Protection Institute into which I have had no insight and concerning which, although they would have been well worth writing about, I feel that my insight would be inadequate.

Doing so would mean that the portrayal, despite my objective ambition, would make the story very subjective. The fact that so much would centre around me because of the strategy did concern me. Colleagues whom I had consulted and to whom I had expressed qualms about writing so much about myself endeavoured to reassure me. Arne Hedgran wrote: 'I could have just OK'd your draft but I wanted to comment on your question as to whether it was egocentric. I think it is near enough the opposite and sometimes find myself searching for a little more subjectivity'. Jan Olof Snihs wrote: 'It is clear that everything revolves very much around you as a person and your involvement in many of the events that are described. However, that is what also makes it unique, i.e., having this insider information regarding what did actually happen in your subjective opinion. This then has to be weighed up against what others may write about different sections of what you describe, i.e., unique source material for future research'.

I was particularly delighted by a letter from Lars Gyllensten on 31 October 2003. He wrote:

> Many thanks for 'The Labours of Hercules' – which I find really interesting. I think it is necessary for the scientists who have been at the forefront of modern research and their social connections to come up with retrospective narratives of how things took place within their field. Your own mammoth efforts fill a significant gap in the history of science. I congratulate you on having produced this book!

Adhering to my initial intention to limit the content to things that I had been involved in myself was proving to be difficult. The course of events developed in such a way that it forced me to rethink. The government ended up deciding to merge the Swedish Radiation Protection Institute and the Swedish Nuclear Power Inspectorate to form a new authority called the *Swedish Radiation Safety Authority (SSM)*. This meant that the Radiation Protection Institute, which was formed in 1965, would cease to exist after 30 June 2008. But it also meant that the total lifetime of the Institute happened to be the same period that I intended to write about in *The Toil of Sisyphus*. The reader would get the impression that I was writing the history of the Radiation Protection Institute, which was not my intention. Being head of the Radiation Protection Institute, a member of the ICRP, UNSCEAR's Swedish representative and Chairman of both the ICRP and UNSCEAR for a few years meant I had a complete overview of the period of 1965-1982. For the period of 1982-1996 I still had a good insight into the Radiation Protection Institute's activities and was active within the ICRP and UNSCEAR for most of that period. During the first half of 1996-2008, I still had a work room at the Radiation Protection Institute but a steadily-decreasing insight into the activities. I would therefore not be able to do the Institute justice in writing about its history through the noughties.

In the previous volumes, I occasionally included anecdotal information which my editor at the time sometimes thought was irrelevant but which readers appear to have appreciated. I do even more of that in this volume for two reasons – partly because it provides light relief from a narrative which the reader might otherwise perceive as heavy, and partly because it adds atmosphere and helps people to understand what has happened. Scientific inventions, technical progress and administrative measures do not hover around freely. They are linked to what is happening in society and to the way in which people react as thinking or reckless individuals.

In reading what I have written in the book, it strikes me that a reader may gain the impression that those dealing with international radiation protection are always partying. That is not the case of course, but the tourist anecdotes are explained by the fact that those who were hosting visits were just as anxious to show off local attractions as we in Stockholm might be to take visitors to Skansen or the Wasa Museum. On the photographs that have been included in the book, those depicted often have a glass in their hand. This must not be taken as a sign of widespread alcoholism, but rather that receptions and parties are the events that usually attract photographers. The significance of socialising should not be underestimated; in reality, this is where the most important decisions are made rather than at the conference table.

In my previous volumes, the chapters have dealt with different issues or problems, sometimes without a direct link to the chronology. For *The Toil of Sisyphus* I have chosen to use each chapter to deal with one year, except that I have sometimes been obliged, within the chapter relevant to the matter, to provide a summary of the problem even though it does mean looking back over previous years. To make it easier for the reader to get something out of reading individual chapters or accounts of interesting events, I have sometimes repeated information that has already been stated in previous sections. It may irritate a reader who is reading the whole of the book – if indeed there is anyone who can manage to – but because I believe that there would be few such readers, the irritation may be justified in order to make up for ease of reading.

I have endeavoured to quote letters and articles from the past which I still clearly remember. Experience tells me that not even very clear memories are that reliable.

Although I am not an historian, the narrative is a *story of a history* and gives an account of the way things *were* and what people *thought* in the relevant years. It does not show the way things *are* and what people *know* at the time of writing. The book is thus not a source of knowledge regarding what was applicable in the year it was printed; it concerns mainly the 1900s, and much more has already happened since the start of the noughties. As regards relevant quantities and sizes, units, limit values and radiation protection policy, the reader is referred to current recommendations and facts from the ICRP, ICRU, ICNIRP and UNSCEAR and provisions from the Swedish Radiation Protection Authority (now the Radiation Safety Authority).

The pictures in this volume are more comprehensive than in the previous volumes, which is partly due to the more personal presentation and the fact that I have taken many of the pictures myself.

My sincere thanks go to: Roger Clarke, Robert Finck, Anders Glansholm, Abel González, Arne Hedgran, Lasse Johansson, Sven Löfveberg, Leif Moberg, Lars-Erik Paulsson, Lars Persson, Jan Olof Snihs, David Sowby and Jack Valentin. My very good friends Arne Hedgran and Sven Löfveberg unfortunately passed away during the final phase of the writing*. Particular thanks must go to my daughter Karin Lindell and to my beloved wife and life companion Marrit who patiently endured my writing but unfortunately passed away in 2008.

I am also grateful for generous grants from the Swedish Radiation Safety Authority and from the Riksbankens Jubileumsfond (the Swedish Foundation for Humanities and Social Sciences) which rendered the publication of this possible, and for the support and genuine interest shown by my *[Swedish]* publishers, Atlantis, during many years. It has been a great pleasure to receive, as during the work with *The Labours of Hercules*, expert editorial assistance by Atlantis editor Tomas Blom. *(Readers may also wish to refer to Prof. Lindell's foreword to the English translation of the book series; see Pandora's Box).*

Bo Lindell

* Note to the English version: David Sowby died in 2014.

1. THE YEAR 1967

1.1. Where it all started*

Rolf Sievert (1896-1966), the pioneer of international radiation protection, died on 3 December 1966. 1967 therefore introduced a new epoch in which the radiation protection pioneers were succeeded by a new generation, but a generation that had inherited the pioneering spirit. The rapid development within physics and technology meant that much was still new and that there was still room for ground-breaking achievements.

The next ten years would lead to a radical change to radiation protection activities. It had previously been limited largely to the use of x-ray devices and radium within healthcare. It was now time for the breakthrough in the use of radioactive substances, but primarily the organisation of civil nuclear power and the fight for survival, the events that made me call this book 'The Toil of Sisyphus'.

At the same time, the next ten years led to drastic political and social changes through a number of events whose context and significance were scarcely realised by those of us who were working with radiation protection during this period. It is just as *Staffan Heimerson* stated in *Aftonbladet* on 18 March 2004, that in retrospect it is easy to 'hear the starting gun and see the milestones'.

The Vietnam War characterised the next few years and led to increasing criticism of the American policy. A number of authors, including *Sara Lidman* and *Jan Myrdal*, formulated the criticism and in May 1967 there was a meeting in Stockholm of the 'Russell Tribunal' (actually the International War Crimes Tribunal created by *Bertrand Russell*) which condemned the USA's action. In 1967, the umbrella organisation for 'The United FNL Groups' was also formed in Stockholm for the groups who supported the Southern Vietnam National FNL Liberation Front. However, the indignation did not just include the USA and the Vietnam War but also the injustices that were seen in the way the rich countries utilised the poorer ones. The rebel, *Che Guevara*, who was killed in Bolivia in October in 1967, became a symbol for the protestors.

In the meantime, against this seething background, the impending nuclear power industry in Sweden was seen to be a sound and desirable development. The political parties had agreed on this. The increase in well-being created a desire mainly for more electrical energy, but there was not much more room for the development for hydropower for that purpose. Nuclear power would safeguard the remaining undeveloped rivers and make us less dependent on oil imports. The accidents that had occurred in reactors, such as at Windscale in 1957, did not seem all that dreadful, particularly since the Windscale plant was a military plutonium production reactor rather than a nuclear power plant. The likelihood of an enormous catastrophe in a nuclear power plant was thought to be negligible. Some investigations, such as the British report from *H. M. Parker* and *J. W. Healy* (1955) and the American *WASH-740* (1957), had certainly estimated that a major reactor catastrophe could kill thousands of people and cause hundreds of millions of dollars of economic damage, but the experts were unable to find that such catastrophes came within the frameworks of the realistic options. The first Swedish nuclear power plant, Oskarshamn, was being built in 1967. Very little was said about the waste problems.

However, the investment in light water reactors which was exhorted by the impatience of the power industry was not exactly popular among reactor physicists. The obligation to forego 'the Swedish line', i.e., reactors using natural uranium and heavy water, was nothing to regret since both the military and politicians had abandoned the plans for Swedish nuclear weapons. At the same time, some of the physicists, among them Professor of Reactor Physics at KTH *Karl-Erik Larsson* (1923-2015), saw the light water reactors as an awkward solution and thought that early investment in breeder reactors would have been preferable. The view was also shared by a number of lower ministry officials, although probably none in any positions of responsibility. Larsson wrote (Larsson, 2000):

> Right from the start of the reactor development during the war and over the next few years, the general view among scientists was that thermal reactors of the type used at the time would be only a primitive transition over to a system that systematically transformed non-combustible uranium-238 into combustible plutonium-239, which would be the reactor fuel of the future. This was the idea behind the breeder reactors. Personally, I was increasingly surprised by the development in the 60s, particularly the progress of light water reactors. It represented a victory for short-term solutions and, to some extent, clumsiness. My opinion was that a well-functioning breeder system would be far more elegant, resource-saving and necessary in the long term. The question also being asked by me and others was what would be done with spent fuel in the type of American reactor that gained victory throughout the world as of 1965.

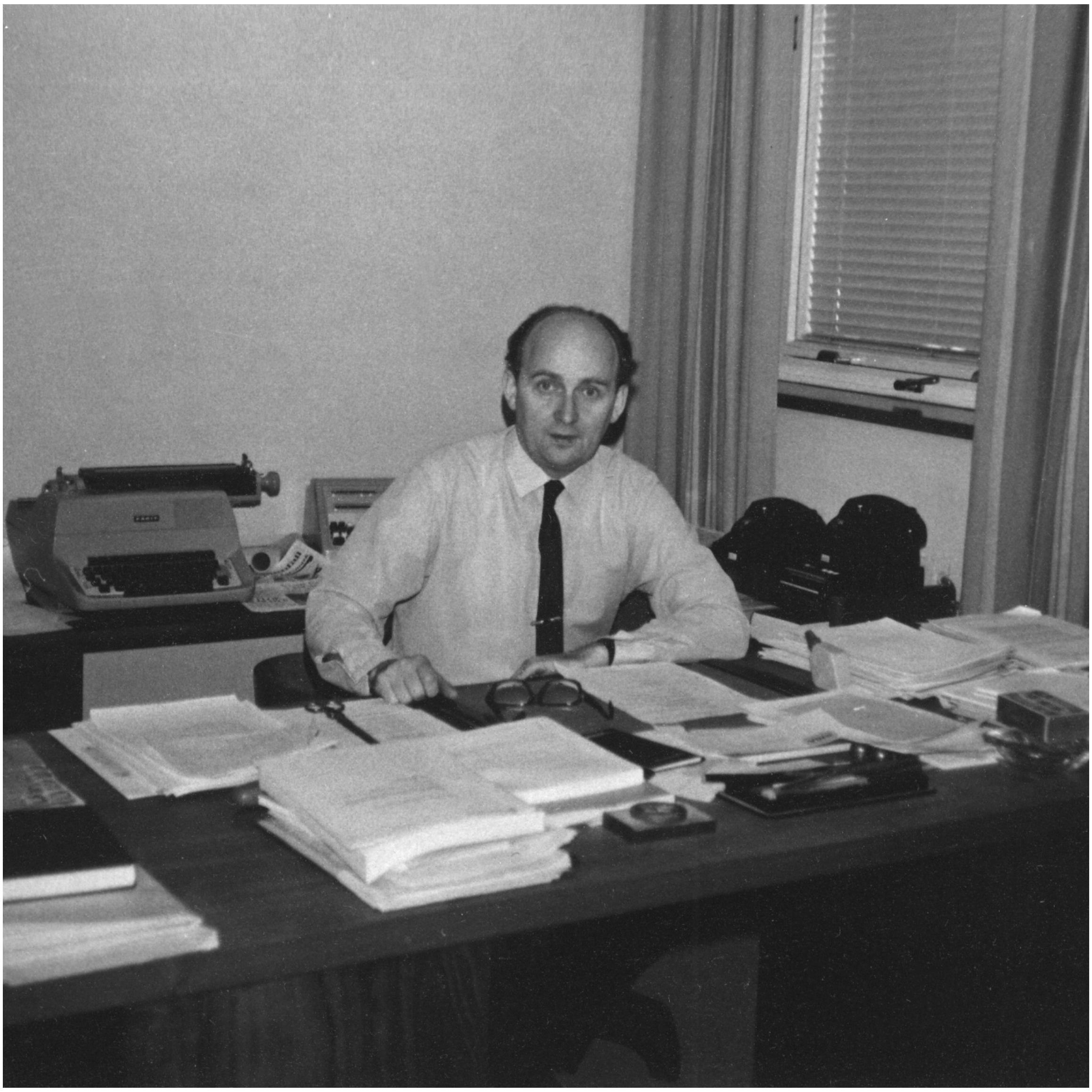
However, the breeder reactor was not popular in the White House. Larsson writes:

> In the overall view of the use of nuclear energy, the American government's main endeavour has always been to use all means to prevent the spreading of nuclear weapons. When Eisenhower came up with his Atoms for Peace programme in 1953, what lay behind this was not so much a matter of altruism but more purely and simply American power politics in very attractive packaging: they wanted to control the expansion of reactors so that no uranium-235 or plutonium would 'disappear' and be converted into nuclear charges. The USA never ended up investing in a breeder reactor project for the production of electricity on a large scale – quite the opposite. In the mid-1970s, all such efforts were closed down. The Carter regime put an end to it. This was because they were afraid that the quantities of plutonium that had to start circulating in connection with breeder reactors could lead to the concealed or open production of nuclear weapons.

Another type of breeder reactor was also discussed, i.e., one that uses natural thorium (thorium-232) as a fuel source where the thorium, through irradiation with neutrons followed by two gradual beta decays, is converted into fissile uranium-233. Since there is more thorium than uranium in the natural surroundings, it is possible to use thorium as a source of energy for a longer period than uranium. Discussions regarding this option have occasionally been resumed but the problems with the necessary reprocessing have dampened the original enthusiasm. However, it would mean avoiding the objectionable plutonium and instead handling uranium-233, less hazardous in radiation terms yet also fissile.

In 1967, the 'cold war' was at its height. The Berlin Wall had been in place for six years. Following the fall of Khrushchev in 1964, the Soviet Union was controlled by the *Brezhnev-Kosygin-Podgorny* troika with Brezhnev as the leader. In the USA, Democrat *Lyndon Johnson* was President since John F. Kennedy had been murdered in 1963. In the UK, Labour's *Harold Wilson* was Prime Minister. *Charles de Gaulle* was President of France. The President of West Germany was the creator of the Christian Democratic Party (the CDU), *Heinrich Lübke*. In China, the dramatic Cultural Revolution (1966-1976) was ongoing under the 74 year-old *Mao Tse-tung* and his wife *Jiang Qing*. In Japan, the 66 year-old emperor *Hirohito* was now simply a symbolic head of state with no power and the country was controlled by a democratically-elected Conservative government. The vivacious *Juan Perón*, who had been President of Argentina in 1946-1955, was exiled in Madrid in 1967 but was biding his time.

When Sievert died I had been 'Professor and Manager' of the Swedish Radiation Protection Institute (the SSI) for just over one year. I had taken over an institution with which I was fundamentally familiar but I still had a feeling of uncertainty and concern, bearing in mind that the Radiation Protection Institute was responsible for supervising the radiation protection measures at the planned Swedish nuclear power plants. When I started as head I knew almost nothing about nuclear reactors. The only person at the Institute who was really familiar with the subject was *Arne Hedgran* (1921-2009), who was in charge of the Department for Nuclear Physics. Bearing in mind how important the matter was, I spent most of my time familiarising myself with the radiation protection issues concerning nuclear power and, out of the Institute's officials, Arne was the one who became my closest cooperation partner. The other officials at the Radiation Protection Institute with whom I had close contact at the time include *Ragnar Boge* (1933-1990), *Svea Forss* (1919-1997), *Matts Helde* (1910-1999), *Carl-Gösta Hesser* (1927-2004), *Bengt Håkansson* (born in 1925), *Stig David Johansson* (1918-1995), *Lars-Eric Larsson* (1920-1997), *Sven Löfveberg* (1928-2009), *Bengt Pettersson* (1939-) and *Jan Olof Snihs* (1932-), and *Lars Johansson* (1935-) at the Department for Clinical Radiophysics. And my Secretary *Torborg Hammarberg* (1913-2012) and her successor *Margareta Rydell* as well, of course.



Bo Lindell at his desk as 'Professor and Manager' of the newly formed
Swedish Radiation Protection Institute (the SSI) in 1966.
As yet, no computer on the desk.

During the first decade I cooperated on a particularly intense basis with Sven Löfveberg, who became the Radiation Protection Institute's head of information. Many 'heated' issues would come up, such as the environmental problems of nuclear power, gamma radiation and radon in homes, and the interpretation of the recommendations of ICRP. Right from the start we examined press cuttings and reproduced and commented on the most interesting ones in the Institute's stencilled information letter, *Strålskyddsnytt* (Radiation Protection News) which also aroused interest beyond Sweden's borders.

Through my involvement in the work within primarily ICRP (the International Radiation Protection Commission) and UNSCEAR (the UN's Scientific Radiation Committee) but also within IAEA, OECD and WHO and IRPA (the International Radiation Protection Union), I had the privilege of gaining an extensive international network of contacts. I was a member of the ICRP Main Commission and Chairman of its Committee 3 on protection against external sources of radiation. I was also Sweden's UNSCEAR representative.[*]

In Sweden, *Tage Erlander* (1901-1985) was Prime Minister. The Radiation Protection Institute came under the Ministry of Health and Social Affairs of which *Sven Aspling* (1912-2000) was head, but I had little contact with our Ministry. At the Chancellery, it was still thought that the governmental authorities would work independently following the directions issued by Swedish Parliament and without unnecessary political involvement from the government.

When he retired in 1965, Sievert's big imperium had been divided into three sections: a radiophysics institute with *Rune Walstam* (1923-2002) as Professor, a radiobiology institute with *Arne Forssberg* (1904-1975) as Professor, and the Radiation Protection Institute with me (born in 1922) as its head under the job title of 'Professor and Manager'. Sievert had suggested including the word 'Professor' because he was afraid that if it were not, the manager could end up being an administrator who had no specialist knowledge.

I had known and cooperated with Rune Walstam for nearly twenty years, so I could expect to continue having good contact with him. With his becoming head of the new Institute of Radiophysics, he was also made responsible for leading the medical physics activity at *Karolinska sjukhuset* (the Karolinska University Hospital), an activity which, strangely enough, for the time being came under the Radiation Protection Institute for administration purposes. The hospital had chosen not to take over the employment responsibilities for the medical physicists; the hospital management were afraid that this would lead to expenses for which there was no contribution to the budget. Rune was ably assisted with the ongoing hospital work by Lars-Eric Larsson as assistant manager. I received indispensable help from Lars-Eric in my ICRP assignments when he was Secretary of its Committee 3.

In terms of premises, the Institutes were divided as follows. The Radiation Protection Institute had its main premises in the large extension that had been used by Sievert in 1964. The radiophysics and radiobiology institutes remained in the Institute of Radiophysics' old building, which is also where the Radiation Protection Institute's dosimetry laboratory had its premises. Medical physics had premises at *Radiumhemmet*.

The Nuclear Power Inspectorate did not yet exist. The existing nuclear power issues were handled by the delegation for Atomic Energy Issues (DFA) which was almost a part of the Ministry of Trade and Industry of which *Gunnar Lange* (1909-1976) was head. However, in 1967 the DFA was to move to the finance department which was ruled by the authoritative *Gunnar Sträng* (1906-1992). The DFA was not an operating authority; the ongoing affairs were dealt with by its Reactor Location Committee (RLC) where *Torsten Magnusson* (1907-1987) was Chair and Arne Hedgran was one of its members.

At the Swedish Defence Research Establishment (FOA), my closest contact was with head of research *Kay Edvarson* (1925-2006) and with Torsten Magnusson who was head of department at the FOA in 1967. The research into the radioactive fallout from the nuclear weapons testing at the start of the 1960s had brought together experts from a number of different fields. This cooperation had been supported by both Magnusson and Sievert. It meant that I had close contact with Professor of Clinical Chemistry at the Royal Veterinary College of Sweden *Bertil Åberg* (1925-1992), and Assistant professor in Agricultural Radiobiology at the Agricultural College of Sweden in Alnarp *Lars Fredriksson* (born in 1913).

In 1967, my main contacts at *AB Atomenergi* were *Lars Carlbom* and *Stig Bergström*. *Bo Aler* (1926-2009) was on his way from *Atombolaget* to the Ministry of Finance. I obviously had good contact with the country's radiophysics institutes, primarily with Professor *Kurt Lidén* (1915-1987) in Lund.

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[*] The early work within these organisations is described in 'The Labours of Hercules'.

At international level, the people with whom I had the most contact were those in ICRP, UNSCEAR and IAEA, in said order. *E. E. ('Bill') Pochin* (1909-1990) was Chair of ICRP in 1967 with the Canadian *Gordon Stewart* as Deputy Chair. The Chairmen of ICRP's four Committees were *Howard Newcombe* (C1), *Karl Z. Morgan* (1907-1999, C2), Bo Lindell (C3) and *Henri Jammet* (1920-1996, C4). The Secretary of the Commission was my good friend *David Sowby* (1926-2014). The illustrious *Dan Beninson* (1931-2003) still only participated in Committee 4 in 1967 but was the Argentinian UNSCEAR representative.

The senior partner of radiation protection *Lauriston Taylor* (1902-2004) was Chair of ICRP's sister committee, the ICRU on units and measurements, with *Harold Wyckoff* (1910-1999) as Secretary, both having a career within the US National Bureau of Standards. The head of UNSCEAR's Secretariat was Italian *Francesco Sella*. Of the national UNSCEAR representatives, I had the best contact with Beninson, Jammet and Pochin but also with the Canadian *Gordon Butler*. The leadership of IAEA's radiation protection activities changed over the years, but the permanent contact with this was through the Egyptian doctor *Hussein Daw*. I also had good connections with the IAEA Director General, the Swede *Sigvard Eklund* (1911-2000).

The Secretary of OECD's nuclear energy body, the ENEA's* Radiation Protection Committee, later known as the CRPPH (Committee on Radiation Protection and Public Health), was Dr. *Emile Wallauschek*, who was assisted by an efficient lady. Ms. *Zabel Chéghikian*. Arne Hedgran was the Committee's Swedish delegate but I would soon succeed him, and this led primarily to close cooperation with my Nordic colleagues. The Nordic cooperation that Rolf Sievert had initiated also worked well. In my case it led to good contact with Medical Officer *Eigil Juel Henningsen* of the Board of Health in Denmark, and Norwegian *Per Grande*, who had been in charge of the Board of Health's radiation hygiene laboratory. In Norway, the equivalent contact was maintained with *Reidar Eker*, who was Chair of the Norwegian National Council in 'radiation hygiene matters', and with *Kristian Koren* (1911-1990) who was in charge of the State Institute for Radiation Hygiene (SIS). Contact with Finland was still limited, partly because the head of the Finnish Radiation Protection Institute, *Kauno Salimäki* (1905-1971), did not speak Swedish and also belonged to an older generation. The head of the Icelandic Radiation Protection Institute, *Geislavarnir ríkisins*, was *Gudmundur Jonsson*.

Of the many radiation protectionists and radiation scientists abroad with whom I generally kept in contact, I should mention *John Harley* (1916-1993), *John Hursh* (1907-2003), *Charles Meinhold* and *Harald Rossi* (1917-2000) in the USA, *John Dunster* (1922-2006), *Greg Marley*, *Eric Smith* (1911-1998) and *Scott Russell* in the UK, *Pierre Pellerin* in France, *Albrecht Kellerer* and *Wolfgang Jacobi* in Germany, *Carlo Polvani* in Italy, *Shinji Takahashi* in Japan, and *Alex Moiseev* in the Soviet Union.

1.2. **Radiophysicists and medical radiology**

During the 1966/1967 New Year holiday, the news in the major Swedish broadsheet *Dagens Nyheter (DN)* was that, on retiring from his job as Assistant Professor and Head of the Institute of Radiophysics at *Sahlgrenska Sjukhuset* in Gothenburg in 1966, *Sven Benner* (1900-1986) had been given the title of Professor, something which was well deserved. However, he went on to remain active for almost another twenty years. When he died in 1986, some of his colleagues† wrote the following words in *DN*:

> Sven Benner was not one for talking big. He was a humble person, the patient and meticulous master. His knowledge was substantial and covered broad areas from classical languages to modern physics. He was a learned man in the best sense of the word. His network of contacts with the world's radiation physicists was impressive and was very significant to the development within Nordic radiophysics. Sven Benner was

* The European Nuclear Energy Agency. 'European' was subsequently dropped when non-European countries took part in the activity. The ENEA then became the NEA.

† *Magne Alpsten*, *Bertil Arvidsson*, *Sören Mattson*, *Inger Ragnhult* and *Holger Sköldborn*

someone who took the initiative and instigated the formation of Swedish and Nordic as well as international medical physics associations.

On 3 January, the Swedish Radiation Protection Institute* sent out a circular which reported the responses to a questionnaire that had previously been sent to the country's medical physicists containing questions about the Radiation Protection Institute's dosimetry and dose control activities and surveying of radiotherapy sources. The questionnaire had been answered by 21 medical physicists. The main question was whether it ought to be the Radiation Protection Institute or the medical physicists who did surveys and took control measurements from the x-ray therapy devices and teletherapy devices. Everyone apart from one of those who answered placed his cross in the 'yes' box for the alternative which read:

> Much of the dose control is being taken over by medical physicists. The standard laboratory is becoming a service authority that can be consulted directly as well as serving the supervisory departments in terms of dose control (in the absence of medical physicists).

1.3. **The Nairobi project**

In January 1967, a 'Cancer in Africa' conference was held in Nairobi. Those travelling to the conference from Sweden included *Jerzy* and *Nina Einhorn*, *Georg* and *Eva Klein*, and Rune Walstam. A colleague of Georg Klein, *Peter Clifford*, was very anxious that Sweden assist with the radiation treatment of the very rapidly-growing tumour called Burkitt's lymphoma. The Swedes proposed that this treatment take place at the Aga Khan Platinum Jubilee Hospital in Nairobi. Rune Walstam has written about this (Walstam, 2002):

> A simple wooden building, a few square metres of lead sheet and a 200-kV x-ray device was what it was thought our funds could cover. Over a period of two years we would treat a number of cases of Burkitt's lymphoma and let the Kenyans look at all of the material. Georg Klein's colleague, Doctor Peter Clifford, was very committed and positive regarding the plan, as was the KCC (the Kenya Cancer Council), a very active local organisation.
>
> The Kenyan Ministry of Healthcare (MoH) politely but resolutely declined the proposal. They wanted something more long-term with a placement at the University Hospital, the Kenyatta National Hospital. Jerzy said that this was a much bigger and more time-consuming project. It would require a cobalt device, a concrete building and extensive training plans over a period of 10 to 20 years. It would require significant local inputs. On the journey home I was fairly pessimistic about such a project coming to fruition.
>
> However, a few months later, the KCC gave notice that local funds that could support a larger project had been collected. The contributors included President Jomo Kenyatta himself and the local Rotary Club. I was asked to draw a minimum concrete bunker that would be built between two nursing wings.

This was the introduction to a cooperation which, over the next few years, would demand substantial contributions from Jerzy Einhorn and Rune Walstam. I will say more about this in the Chapters on 1968 and 1969.

* 'Statens strålskyddsinstitut' (SSI), a regulatory authority. The Swedish name literally translates as 'the Swedish Radiological Protection Institute' but other English names have also been used at times (the National Institute for RP; the Swedish RP Authority). In 2008, merged with the Swedish Nuclear Power Inspectorate ('Statens kärnkraftinspektion', SKi), to form the Swedish Radiation Safety Authority ('Strålsäkerhetsmyndigheten', SSM).

1.4. Medical radiation treatment in Sweden

On 15 February, *Jan Cederlund* moved from Borås to Uppsala. Jan had been active as a medical physicist at the Central General Hospital in Borås for five years and had worked with Professor *Harold Johns* in Canada for two years before that. He now came to *Akademiska sjukhuset* and its 'high voltage department' where Professor *Bengt Norman* was Chief Physician. They had since long had a small cobalt device for radiation treatment (an Elema decacurie device with 30 curies, i.e., 1.1 terabecquerels*, of cobalt-60) for a long time but there had been no room for larger treatment devices in the old building. However, since the new construction of bunkers which had iron ore concrete walls sunk into the ground, they had now started to install a larger teletherapy device, a Siemens Gammatron 3 with 3000 curies (110 terabecquerels) of cobalt-60, and were preparing for the installation of a Brown Boveri betatron. *Uppsala Nya Tidning* wrote:

> *Akademiska sjukhuset's* new cobalt gun – the gammatron – is to be charged. The room in which the gammatron is assembled has strong walls made of iron ore concrete as radiation protection. It will be possible to monitor the patient during treatment through a green lead glass peephole using a reflective mirror. At this very moment, men in white are cautiously manoeuvring a truck towards the gammatron. On the truck is a lead container almost one metre tall within a steel plate mantle. In the lead housing in a tungsten cartridge is the small tube – 2 cm in diameter – containing radioactive cobalt. The sender of the lead colossus, Atomic Energy of Canada, is not going to send such substances over the Atlantic in an ordinary case.
>
> ...
>
> Men from the Swedish Radiation Protection Institute are monitoring the situation with rem-reading devices around their throat.

But *Akademiska sjukhuset* was not the only place at which radiation treatment was being prepared in Uppsala. *Uppsala Nya Tidning* related what happened at the Gustaf Werner Institute where people had access to a synchrocyclotron which generated proton beams and where Assistant professor *Börje Larsson* (1931-1988) led a research group:

> Assistant professor Larsson leads a task group which is involved with something which could be called basic natural science research within the radiotherapy field. The results achieved in such research can then be used clinically, in brain tumour therapy, neurosurgery, in the treatment of cancer of the genital area and in general radiotherapy, for example.
>
> At the Werner Institute, we can only accept a very few tumour patients for treatment – no more than a couple a month, says Assistant professor Larsson. We have no resources to accept any more, and we also believe that the basic research we are now doing in the field of radiation will be of substantial value in the longer term. Irradiation resources need to be expanded in order to be able to make practical use of the applied research results that have been achieved. However, even if this does not take place, results of research as we do it can still be applied. This has happened in neurosurgery.

The reason for the newspaper article was that Börje Larsson had received a 40,000 Swedish kronor† research grant from the Swedish Cancer Society. However, Larsson emphasised that the research done by his group could not be directly transferred to practical radiation treatment in healthcare:

> The Uppsala synchrocyclotron would now cost approx. 15 million Swedish kronor to build – approx. the same as a modern fighter plane, says Assistant professor Larsson.

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* A terabecquerel (TBq) is an activity of 10^{12} nuclear disintegration per second, i.e., approx. 27 curies.

† To provide a context, in 1965 one British pound corresponded to 14.43 Swedish kronor, in 1975 to 9.22 kronor, in 1985 to 11.09 kronor, and in 1995 to 11.25 Swedish kronor. The corresponding exchange rates for 1 US dollar were 5.16 Swedish kronor in 1965, 4.16 kronor in 1975, 8.59 kronor in 1985, and 7.13 Swedish kronor in 1995.

> Together with a group of researchers at the Johnson Institute for Industrial Research and Professor Leksell at the Neurosurgery Clinic in Stockholm, we have now constructed a smaller and considerably cheaper source of radiation, a device which goes by the working name of the 'Gamma Knife'.*

Leksell also cooperated with Larsson regarding 'bloodless surgery' using the proton beam. In 'The Labours of Hercules' I wrote: 'The attempts were successful but the use thereof was inhibited by the contact difficulties that arise when medical research and development take place outside the actual hospital environment'.

In Jönköping, they had also received new resources which were described in *Jönköpingsposten* on 18 March:

> A radiotherapy clinic is a valuable addition which is being developed at Jönköping General Hospital. One such clinic has existed there since 1 May last year, although in fairly makeshift premises. There will now be some refurbishment and extensions. New devices to be purchased will include a cobalt gun and a betatron for a total value of more than one million. With these, it will be easier to go to the depth of tumours in radiation treatment. The County of Jönköping is therefore being given this type of department, which corresponds to those in other parts of the country. This also means that fewer people needing tumour treatment will be referred to other clinics.
>
> The chief physician at the new clinic is Dr. *Bengt Mårtensson*, who is coming from the regional hospital in Örebro. The medical physicist will be Dr. *Carl-Gösta Rylander*, who was previously associated with the National Radiation Protection Institute in Stockholm.

'The cobalt gun' was the Siemens Gammatron 3 with 5000 curies (185 terabecquerels) of cobalt-60. The betatron, whose operation would be delayed by another few years, was an 18-MeV Siemens betatron.

New teletherapy devices at *Södersjukhuset* in Stockholm were described by *Expressen* on 9 March. A picture showed how the head of the hospital's radiotherapy department, Dr. *Folke Mossberg*, and medical physicist *Berndt Söderborg*, monitored the charging of one of the two 'cobalt guns'. The newspaper wrote:

> Yesterday morning, a large group of doctors and journalists gathered around a radiation capsule inscribed with 'Warning – radioactive material' at *Södersjukhuset*. If someone had removed all of the capsule's steel, lead and tungsten protective cover, we would all have died within three minutes. Before this, we had managed to catch sight of 8 millilitres of cobalt (it looks like Russian caviar). The radiation strength of these 8 millilitres is very effective, the equivalent of 11.5 kilos of radium.
>
> *Södersjukhuset* charged its two new cobalt guns, the City of Stockholm's first high voltage plant for the treatment of tumours. With their very powerful radiation, the cobalt guns can cure tumours that ordinary x rays do not reach.

The two devices concerned were both Siemens Gammatron 3, with 6000 and 3000 curies (220 and 110 terabecquerels) of cobalt-60 respectively. It was likened to Russian caviar because the cobalt existed in the form of small balls. Stating the size of the preparation in millilitres was an original approach. The unprotected source of radiation could definitely have emitted a fatal radiation dose in three minutes, but the death would have not occurred until after a few weeks, not after a few minutes.

The stated examples show that 1967 was a breakthrough year for radiation treatment with teletherapy devices. Accelerators in the form of betatrons and linear accelerators also began to see further use. The Swedish Radiation Protection Institute's report for the 1967 activities shows six accelerators. Three

* You can also read about the synchrocyclotron and the Gamma Knife in Chapter 9 of 'The Labours of Hercules'.

clinics had procured Brown Boveri's 35 MeV betatron (*Sahlgrenska Sjukhuset* in Gothenburg, Lund General Hospital and Umeå General Hospital). Two had Siemens betatrons: the Regional Hospital in Örebro (42 MeV) and *Radiumhemmet* in Stockholm (16 MeV). *Sahlgrenska Sjukhuset* also had a 5 MeV linear accelerator from Associated Electrical Industries. Two Siemens betatrons were on the way – one for Jönköping (18 MeV) and another device (42 MeV) for *Radiumhemmet*. *Radiumhemmet* would soon also receive a 6 MeV linear accelerator from Varian.

The Swedish Radiation Protection Institute's activities report for 1967 gave no details of teletherapy devices, but the report for 1968 gave a table of data for 25 teletherapy devices that had kilocurie sources and 6 decacurie devices (from Elema). Two of the kilocurie devices were Pickers devices and used caesium-137 (Borås and Lund); the others used cobalt-60 and were at the General Hospital in Borås, the Central General Hospitals in Eskilstuna, Gävle, Jönköping and Karlstad, *Sahlgrenska Sjukhuset* in Gothenburg, the Regional Hospital in Linköping, the General Hospital in Lund, the General Hospital in Malmö, *Radiumhemmet*, the Red Cross Hospital and *Södersjukhuset* in Stockholm, the General Hospital in Umeå, *Akademiska sjukhuset* in Uppsala and the Regional Hospital in Örebro. The 'radiation knife' produced at the Motala workshop for Professor Leksell at *Sophiahemmet* in Stockholm used 4000 curies (150 terabecquerels) of cobalt-60.

On 2-8 April 1967, the first European Congress of Radiology was held in Barcelona with more than 3000 participants. The account of the trip, which was jointly written by Assistant Radiology Professor *Gustaf Notter* and medical physicist *Per-Erik Åsard*, was an eye-opener for us in terms of the speed of the technical development. In 1967, computer technology was clearly still not mature enough for practical application in dose planning for the radiation treatment of tumours. Notter and Åsard wrote about 'the computer':

> A discussion regarding the significance of computers within dose planning had been organised. Opinions were divided as to whether the calculation of dose distributions using a computer was preferable, particularly from the economic point of view.

1.5. Radiophyisicists defending theses

On 17 May, Licentiate of Philosophy *Gunnar Bengtsson* (1941-) defended his thesis in Lund. The newspaper *Arbetet* ('The work') in Malmö had noted the event. Big headlines on the Thursday were as follows:

INFORMATION FROM LUND STUDY:

Children and pregnant women are affected less by radiac!

> The actual article began with:
>
> The effects on humans of radiation from radioactive fallout are significantly less in children and pregnant women than in other adults. The radiation dose – and thereby the risk of radiation injuries – increases with the person's age. The results were revealed in Ph. Lic. Gunnar Bengtsson's doctoral thesis, which was defended in Lund on Wednesday. The author has determined the presence of the radioactive isotopes in humans as being strontium, caesium, radium and potassium.
>
> One of the five sections of the doctoral thesis deals with the transformation of radioactive caesium in pregnant women and infants. The results are based on a survey conducted by the author with medical physicist Yngve Naversten and research engineer Göran Svensson under the leadership of Professor Kurt Lidén at the Institute of Radiophysics at Lund University.

I had been appointed faculty opponent while Gunnar had chosen his colleague *Bertil Persson* as the second opponent. The defence proceeded with no surprises; Gunnar had produced solid work.

A few days later, the first doctoral defence took place at the Faculty of Philosophy in Umeå. The person defending was Ph. Lic. *Curt Pettersson*, who was to become medical physicist at Borås. The thesis concerned a method for measuring doses during irradiation from the betatron in Umeå. The first opponent was Assistant professor *Sten Carlsson* and the second opponent Jan Cederlund. In an interview with *Dagens Nyheter*, Curt says:

> The measurements are physically complicated. There are carefully prepared methods for these measurements for the radiation sources that are used in Borås, for example. There were no equivalent experiences for the particle accelerator. There was no dosimetry there.
>
> Here, I have drawn up a special measurement system to be able to determine the values. The basic instrument which I prepared was a calorimeter which can determine temperature increases in water down to one hundred thousandth of a degree. A normal dose which is administered during therapy (for cancer) raises the temperature by one thousandth of a degree. IAEA (International Atomic Energy Agency) in Vienna (a UN body) has compared different measurement methods and my method produced a good test result.

1.6. **Medical physics in Örebro**

The Regional Hospital in Örebro was delighted that *Karl Johan Vikterlöf* had been awarded a research grant ‘to refine the determination of patient doses for betatron and cobalt irradiation, with particular reference to function studies in organs where exposure to radiation is not wanted’. *Nerikes Allehanda – Nerikes Tidningen* interviewed Vikterlöf, who said:

> Don’t start thinking that I’m running a new form of cancer research. I’m no medic (Assistant professor Vikterlöf is Dr. of Philosophy). But as a medical physicist, it is my task to ensure that the irradiation doses we have are used in the best possible way. Thanks to an improved device – as you know we have a betatron and cobalt guns – we have new possibilities of making the treatment adequate and correct.

1.7. **The Congress of Radiology in Umeå**

In June 1967, the Nordic Society for Medical Radiology held its 28th Congress in Umeå. The opening meeting was held at 09.00 on 15 June in the Umeå Secondary School’s assembly hall. In his welcome address, the President, Professor *Lars-Gunnar Larsson*, paid tribute to the two honorary members, Elis Berven and Rolf Sievert, both of whom had died in the previous year. In the minutes of the Congress, the Secretary wrote: ‘The Congress was graced with wonderful, warm weather, and for the many people who live in the more southerly parts of the Nordic countries it was a big experience to see how long and light the northern Nordic day is and how intense the summer can be there as well’.

Before the Congress, *Asmundur Brekkan*, Secretary of the Icelandic Radiological Society, had said that their society now had nine members and that it was therefore starting to think about convening a meeting of the Nordic Society in Reykjavik (the meeting was held in 1971).

In the diagnostics section of the scientific programme, Professor *Olle Olsson’s* pioneering work into the x-ray diagnostics of cancer of the pancreas was what attracted the most attention. However, therapy, physics and nuclear medicine sections dominated with a total of 56 presentations. The technical development was reflected in general headings such as:

> Medical use of accelerators
> Scanning of radionuclides
> Standardisation of detailed measurements of betatrons

1.8. X-ray diagnostics in Lund

Many saw Olle Olsson as Sweden's most prominent x-ray diagnostician and he had a good international reputation. On 11 November, *Arbetet* carried an article about his institution in Lund. The following was written in the introduction:

> The x-ray department is something with which all people will sooner or later come into contact with at a hospital appointment. Nowadays, 100,000 examinations take place per year in Lund, an unusually high percentage of which are qualified cases. The majority are carried out on inpatients. The move to the block will start shortly. It will take place gradually to be fully completed by 1969. It is a huge adaptation process which will give Lund the biggest independent unit of this type in Europe. Swedish x-ray diagnostics are also world-renowned and have set a worldwide trend, and the Lund radiologists have played a leading role in this respect.

In addition to Olle Olsson, the Lund radiologists referred to the article were Assistant professor *Erik Boijsen* (1922-2017), who became Professor in 1970, Assistant professor *Olof Norman* (born in 1920), Dr. *Sten Cronqvist* and Dr. *Thure Holm*. Olle Olsson described his philosophy in *Arbetet*:

> Swedish x-ray diagnostics are held in such high international regard primarily because we have a prominent basic healthcare organisation, says Professor Olsson. I often emphasise to foreign experts the importance of activities of this type being a) independent and b) centralised. This philosophy is now *en route* to making a worldwide impact.

The way in which the x-ray diagnostics activities were run in 1967 was described in *Arbetet*:

> The x-ray images will be transferred using TV as far as possible. For example, a picture will be taken of an injured patient in an emergency admission and the image will be sent by means of TV from the radiologist to the emergency department, which can use TV to communicate with colleagues at the central x-ray department. The image will be analysed, whereupon it can be demonstrated on the TV screen to the treating doctor wherever the latter is; that is flexible image communication for you.
>
> Practically the entire x-ray activities stand or fall with the organisation. Many purely organisational ideas have been borrowed from trade and industry. X-ray departments have grown into 'industries' in just a few decades as regards the way the image is actually processed – a type of service industry you might say, the significance of which to healthcare has come under increasing focus at the major hospitals.

1.9. X-ray equipment for developing countries?

A few weeks previously, *Arbetet* had described another aspect of Olle Olsson's activity. Together with mainly Lars-Eric Larsson he had constructed an easy and cheap piece of x-ray equipment for hospitals in developing countries which lacked resources. The following introduction was written:

> The chief medical officer in charge at the General Hospital in Lund, Professor Olle Olsson – WHO's x-ray expert – has, together with radiation protection physicist in Stockholm, Dr. Lars-Eric Larsson [the name was incorrectly spelled in the article] and Chief physician J J Stevenson from London, come up with a completely new and much simpler x-ray device for the needs of developing countries. The idea of simplifying it is to be able to cut down on the level of personnel resources needed, but also to enable the device to be installed in the simplest of surroundings, which therefore also means it has been shown to be an excellent 'field device'. The tests have taken place in Kenya and the Congo. Four of the world's leading x-ray companies have been involved in building up the facilities and mass production (1000 devices for the first batch) will now begin.

> Russia has also registered its interest in being able to demonstrate its x-ray activities and to be in the competition along with Holland, the UK, Germany and America.

However, the good and well-intended initiative was not enthusiastically received by everyone. In the ‘developing countries’ the initiative was perceived by many as condescending protection and as an insinuation that people would indeed not be able to have such good equipment as that in the rich countries.

1.10. **Radiophysics in Lund**

Radiophysics under Kurt Lidén also made progress in Lund. On 11 February, *Skånska Dagbladet* ran the headline ‘Substantial funding for research in Lund’. Lidén was the one who, along with Professor of Radiotherapy and Tumour Diagnostics *Martin Lindgren*, had been given 365,000 Swedish kronor to procure a gamma camera. On 7 September, *Arbetet* was also able to say that the Institute of Radiophysics in Lund had begun its move into new, specially-built premises. Since low-activity measurements would also be taken there, it was necessary to use specially-selected building material as was the case with Sievert’s institute in Stockholm. *Arbetet* wrote:

> The National Board of Public Building and *Skånska Cement* have had to continuously submit the building material to Professor Lidén in order to ascertain whether the material was radioactive. For example, it was found that the white lime mortar had much less radioactivity than the usual red bricks, and only when it came to bricks were surveys done in Sweden as well as abroad. The concrete in the walls at basement level has also been closely inspected and they have had to use two different sorts of concrete.

1.11. **The annual meeting of the Society of Radiophysicists**

The Swedish Society of Radiophysicists held its annual meeting on 1 December 1967. The following board was elected for the forthcoming activity year:

Karl Johan Vikterlöf, Chair
Lennart Sundbom, Secretary
Bengt Pettersson, Treasurer
Yngve Naversten
Carl-Olof Widell

Kurt Lidén gave an account of a planned cooperation between people who were interested in biophysics. Jan Cederlund began a discussion regarding the competence that was expected from medical physicists. A Committee to look at the matter was set up with Holger Sköldborn as the convenor. Sven Löfveberg had compiled an inventory of professionally-active radiophysicists. The number of existing jobs was 97, of which 38 were held by physicists with licentiate degrees or doctorates. At the Radiation Protection Institute there were 25 jobs, at the Institutes of Radiophysics (Lund, Gothenburg, Stockholm, Umeå) 15, within the nuclear power industry 15, 12 at the Swedish Defence, and there was a total of 25 jobs for medical physicists at 19 hospitals.

1.12. **The radiation in our homes**

The awareness that there was an uncomfortably high level of radiation in some homes meant that the Radiation Protection Institute began to consider some form of intervention. The most obvious thing was to attempt to stop the production of the most radioactive building material, Ytong, a slate-based gas concrete. In a working document from February 1967, I attempted to summarise the problems based on *Bengt Hultqvist’s* measurement results in houses made of different building materials in the 1950s.

Hultqvist's measurements showed that the radiation dose from gamma radiation in houses made of gas concrete was more than twice as much as in brick houses. The highest radiation doses that Hultqvist measured were estimated to give almost 300 millirad per year (corresponding to approx. 3 millisieverts) in bone marrow and the genitals. Such high radiation doses ought to be avoided, but there were still no international recommendations to use as a basis. The Radiation Protection Institute also had no power to issue provisions other than for the protection of workers. The available options were to convince directly responsible authorities to intervene, which was something that would not be easy without international support, or to convince the producer of Ytong to voluntarily close down its production. I wrote:

> As shown by that which is mentioned above, people have been well aware of the radioactivity in building material for 10 years, and know which radiation doses it causes. These are not high enough to warrant taking any drastic measures at all against the most radioactive materials, even though it can be said that every unnecessary increase in the general level of radiation is less than desirable. A gradual transition to less active materials may be recommended and appears to be taking place. The most active building materials may be appropriate for use in structures and parts of buildings where the radioactivity has the least disruptive effect. It is a welcome development that professionals have shown an understanding of these problems

In addition to radiation doses from gamma radiation from building material, the inhabitants also received radiation doses in their lungs from inhaled radon, primarily its radioactive daughter products. Hultqvist's results showed that the radon level in gas concrete houses was high but not considerably higher than the maximum values that had been shown in houses made of brick. The explanation for this is that it is not just the level of radium in the building material which determines the level of radon in the indoor air, but also the degree of ventilation and emanation of radon from the ground. I wrote:

> The radon concentrations are not that much higher than what is recommended to justify intervention from the risk point of view. Not only that, the highest radon levels are down to poor ventilation rather than particularly active material; they occur in brick houses just as they do in light concrete houses. However, from the radiation protection point of view, the problem with radon seems to merit early attention unless the current distribution of materials and types of house changes radically.

If the ventilation was poor, it turned out that radon levels which were 10-100 times higher than with good ventilation* could be received. In a few apartments with poor ventilation, Hultqvist had measured radon levels which exceeded the limit values that had been recommended for miners!

One conclusion whose significance I missed at the time was that the radon which comes up from the ground can be important. This is shown by the fact that the radon levels that Hultqvist measured in basements had no conspicuous connection with the type of building material, and because increased radon levels could also be demonstrated in timber houses.

The Radiation Protection Institute followed the development with interest and trepidation. Something ought to be done, but what would we be able to do other than criticise the risks and attempt to get international bodies like ICRP and OECD to formulate recommendations? However, our international colleagues saw the situation in Sweden as unique and of no interest to other countries. We did have the particularly radioactive building material Ytong after all!

It should be pointed out that in 1967 we were a long way off having the knowledge of the risk of radiation from radon which we now have. There was still no definite connection between the inhalation of radon daughter products and a risk of lung cancer. Many still believed that there were threshold values for radiation doses and that small radiation doses therefore probably carried no risks. However, there

* There is sometimes a misunderstanding concerning *ventilation* and *airing*. Ventilation is the normal air change method while airing increases the air change only temporarily. Ventilation is what determines how high the average level of radon is. Airing reduces the level of radon only for a short time.

was absolutely no doubt that the high incidence of lung cancer among miners in Czech Joachimsthal and Schneeberg were caused by the high radon levels in the air of mines. However, it was still thought not to be possible to estimate the risk from high radon levels in homes, and risk-estimating groups such as UNSCEAR and ICRP had not yet discussed the matter.

The situation was complicated by the fact that there were worse materials than the slate-based gas concrete which attracted developers, namely conceivable building materials based on raw material from Ranstad. The Ranstad works had been built to ensure access to uranium for the Swedish nuclear power programme. It was in operation from 1965-1969 during which a total of 213 tonnes of uranium were produced from the alum shale from Västergötland; thereafter, only experiments took place. The activity was never profitable and was no longer viable when the prices of uranium fell and it was possible to import it. One option to improve the profitability would have been to produce building material based on the slag residues, which unfortunately were pretty radioactive. An *Atombolaget* report by Stig Bergström and *Thor Wahlberg* showed that using the raw material from Ranstad as building material would considerably increase the Swedish population's exposure to radiation and the project was put off.

1.13. The problem with radon in mines

The following can be read in the Radiation Protection Institute's activities report for 1967:

> In 1967 there were preliminary attempts at air activity measurements in mines. What was then the Institute of Radiophysics had already done some control measurements in air in the Boliden mine at the start of the 1950s. The results gave no cause to suspect that the level of radon in Swedish mines could be high enough to cause a health problem. The mines abroad which have had serious problems with the radon levels have been uranium mines which do not exist in Sweden. However, the problem with radon in the mines abroad has been extensively studied in recent years, which has also brought forth information that high radon levels can occur in other types of mine. The Radiation Protection Institute has therefore resumed taking radioactivity measurements of mine air. In 1967, measurements were carried out in the Näsliden and Långsele mines at Boliden. In this connection it was ascertained that the radon level did not involve any problem provided people worked with good ventilation. However, in Sweden there are around 80 ore mines with approximately 10,000 people working in them. There are no reasons to believe that the mines surveyed so far should be the most radioactive, and examining other mines as well must therefore be considered to be justified from a radiation hygiene point of view.

In a couple of articles in April, the *Washington Post* had referred to a new report which estimated that 1150 American uranium miners would end up dying of lung cancer from radon just from the radiation they had already received, but that it could take decades for the disease to develop. The articles thought that the new protection standards which were being drawn up were inadequate (and they were also not as cautious as ICRP's recommendations).

With reference to the uncertainty regarding the level of radon in Swedish mines, Jan Olof Snihs, who was in charge of the Radiation Protection Institute's special laboratories for radiation measurements at the time, applied for 3000 Swedish kronor from the Folksam Research Council in October 1967 for 'measurements in a few selected mines'. It may seem strange that we did not put more into the mine surveys, but we had still no sign that there were any major problems, and the endeavour that was made in 1967 was seen largely as a way of checking that the situation really was without problems.

1.14. The radioactive contamination of foods

On 9-13 October, the UN's Food and Agriculture Organisation (the FAO) and IAEA arranged a meeting in Lisbon to discuss which levels of radioactive substances could be accepted in foods during times of peace. IAEA had invited me to take part.

The meeting was the type that IAEA usually called a panel meeting (discussion group) and therefore had a limited number of participants, 12 panel participants plus a number of observers. You may be interested in seeing who the participants were and where they came from:

C. L. Comar	Chair of the Department of Physical Biology at Cornell University in Ithaca in New York
Lars Fredriksson	Manager of the Radiobiology Department at the University of Agricultural Sciences in Uppsala
Bo Lindell	Manager of the Radiation Protection Institute in Stockholm
W. G. Marley	Head of the Radiological Protection Division of the UK Atomic Energy Authority in Harwell
G. Michon	Secretary of the Interministerial Commission for Artificial Radioelements in Gif-sur-Yvette in France
Jan Müller	Manager of the Institute for Radiation Hygiene in Prague
J. M. Payne	Institute for Research on Animal Diseases at the Agricultural Research Council in Compton Newbury in the UK
E. E. Pochin	Director of the *MEDICAL RESEARCH COUNCIL* Department of Clinical Research at University College Hospital in London
Carlo Polvani	In charge of the Radiation Protection Department of the Italian Atomic Energy Commission in Rome
H. P. Schmier	Deputy Director of the Radiation Protection Department, the Board of Public Health in (West) Berlin
R. Scott Russell	In charge of the Radiation Biology Laboratory of the Agricultural Research Council at Letcombe Regis in the UK
Paul Tompkins	Executive Director of the Federal Radiation Council in Washington D.C.

The current position was that everyone was still at a stage where the meaning of and the principles for setting limits were unclear. The limits used for various non-radioactive food contaminations were actually *action levels*, i.e., were used to determine whether a contaminated food could be sold. On the other hand, the *dose limits* that were recommended by ICRP for the public were intended to form the basis for the requirements that had to be set for the normal running of activities which could lead to people being exposed to extra radiation doses. Because these requirements applied to normal situations and were therefore strict, it was not reasonable to also apply them as action levels should something unexpected occur, because this could lead to unwarranted measures and perhaps even lead to greater risks.

The thought that an activity during normal operation could be permitted to cause an extra radiation dose was not easy for everyone to understand. Many asked how the authorities could permit anything other than zero when it came to extra radiation doses. Some people sharpened the criticism by saying that a licence for an activity which is run despite the fact that people are irradiated amounted to a 'licence to kill'.

The critics sometimes did not have enough technical and physical knowledge to realise that it was not possible to achieve zero doses in many cases. Comparisons can be made with many other activities in which the zero risk is impossible to achieve, such as traffic or phenomena such as noise. In the latter case you would like the environment to be as quiet as possible, but you do not take measures against a source of noise until it is sufficiently inconvenient.

There was no reason to take measures against a normal activity which was limited by requirements originating from ICRP's radiation protection recommendations. If on the other hand an accident occurred which scattered radioactive substances in the environment, and perhaps also in foods, it would be necessary to consider whether special protection measures were justified. The limitations that applied to the normal situation were irrelevant in such circumstances. Instead, it would be necessary to consider which protection measures were viable, which were the most effective, and primarily whether any intervention would improve the situation. In this connection there were no dose values or concentration values which could generally be used as an action level. The given situation had to be observed, and action levels could be recommended only for a specific situation. It was easy to see that a ban on the use of contaminated water would have to be based on different grounds in a) a catastrophe where no other drinking water was available and b) in a situation where rejecting the water would have no negative consequences. People ought also to have realised (although many did not) that a specific concentration of a radioactive nuclide led to different radiation doses and different risks if they occurred in a basic food such as milk or in a food that is eaten in only small quantities, such as a spice.

These problems were particularly relevant when it came to the reindeer meat which was contaminated with caesium-137 from the radioactive fallout following the major Soviet nuclear explosions at Novaya Zemlya in 1961 and 1962. Reindeer meat was a basic food for the reindeer-herding Saami but a relatively rare delicacy for much of the Swedish population. Banning the sale of contaminated reindeer meat therefore had no noteworthy consequences for the Swedes in general, but major consequences for the Saami people's lifestyle, not only when it came to their own food but for the whole of their sustenance. At the same time, it was the Saami who had the greatest radiation doses through their substantial consumption of reindeer meat. The reindeer meat was also the most contaminated food following radioactive fallout over Sweden. Not owing to the proximity to Novaya Zemlya – the caesium had travelled on the winds in the troposphere around the globe before reaching Sweden – but owing to the fact that it stuck to large areas of lichens on which the reindeer grazed.

The presence of the radioactive substances in reindeer meat was discussed in a letter to the editor in no. 35 if *Läkartidningen*, the author, Ph. Lic. *A. M. Uesson*. The conclusion regarding his observations read:

> Reindeer meat ought therefore to be supplied with a warning regarding its radioactivity and regular consumption of the same be forbidden.

I did not think that such action was warranted, bearing in mind the low risk. Uesson did not know that the Radiation Protection Institute's measurement data on the contamination of the reindeer meat had been published in the daily press when the activity was at its highest (winter 1964-1965) and that accounts of the situation had been published in the Saami people's national newspaper *Samefolket*. Bearing in mind the serious consequences that concern for the reindeer meat could have for reindeer husbandry, I contacted *Läkartidningen* regarding a correction. In the conclusion of my contact I wrote:

> In this respect, the reindeer-herding Saami population are doubly the most vulnerable group. They consume maybe one hundred times the amount of reindeer meat per person and year that an average Swede does. Their radioactivity uptake is consequently considerably greater and, were there to be a risk, it would affect them long before it affected anyone else. There are also no factual grounds to assume that the radioactivity in the reindeer meat would make it unsuitable for consumption in large quantities per day. However, the unwarranted rumour that this would be the case means difficult economic and social harmful effects for the particular group of people whom ill-advised but well-intentioned people intend to 'protect'.

I did of course send a copy of my contribution to Assistant professor *Israel Ruong*, editor of *Samefolket*.

1.15. **The isotopic lighthouse**

The breakthrough of the civil nuclear power industry meant that the waste issue presented an even greater problem. Not only was it politically undesirable, it was also a technical challenge to see the radioactive waste from the nuclear power plants as something positive, an additional asset. The long-lived gamma-emitting nuclide caesium-137 is one of the fission products and it could be separated for use as a powerful source of radiation. The need for this source of radiation was not obvious; as was often the case, something that could be used was available but you had to look around for the areas of application. The one that looked the most promising was the UV sterilisation of foods, a technique which I will discuss in further detail in chapter 17*.

The other long-lived fission product in the waste which is of technical interest is strontium-90, although this is purely beta-emitting (through its short-lived daughter product yttrium-90). There was also an eager search for areas of application in this connection but this was not very successful. The idea of strontium-90 as a source of energy for wristwatches did not take off and the phenomenon was very short-lived. A more realistic use of strontium-90 as a source of energy concerned lighthouses in areas which were difficult to access and where maintenance was a problem. Such strontium-run lighthouses were tested in Stockholm's archipelago for a few years.

The source of power for this lighthouse was a British make and was called Ripple (for Radio Isotope Powered Pulsed Light Equipment). Ripple was manufactured by the UKAEA (UK Atomic Energy Authority) which wanted to set up three testing plants - one in England, one in Denmark and one in Sweden. The trial run would be for five years and then the source of radiation would return to England. The project was reviewed by the Radiation Protection Institute with Bengt G. Pettersson as executive officer. In September 1967, 'BGP' wrote a memorandum containing a description of the plans.

The benefits of an 'isotopic lighthouse' (as it was called) compared with lighthouses with more conventional sources of power (batteries or gas) were primarily that they were easier to maintain. Instead of three to four service visits per year, one visit per year was enough. Not only that, there was also no need for heavy transportation of batteries or gas tubes.

The Swedish isotopic lighthouse was set up in a special lighthouse building erected just outside Stavsnäs on the southern of two flat rocks called *Tegelhällorna*. That rock is no more than twenty square metres, which is why the lighthouse building took up almost all of the rock area.

The electric generator contained two sources of radiation, each with 4000 curies (150 terabecquerels) of strontium-90 as encapsulated, pressed and sintered strontium titanate in the form of a cylinder that was four centimetres long and three centimetres in diameter. The ceramic material had been selected for its high melting point (2080 ^{o}C) and poor solubility in water.

There were no good reasons not to agree to the trial run of the isotopic lighthouse. Small boats which could collide with the lighthouse would not be able to damage it. Large vessels would be prevented by the bedrocks in the surrounding shallow water. If despite all odds a collision were to destroy the lighthouse and fling the source of radiation into the sea, it would be easy to salvage it. According to the agreement, the UKAEA would both take care of the maintenance work and be responsible for the safety arrangements for any rescue operation, even though the formal responsibility lay with the Maritime Authority.

Although everything indicated that safety was guaranteed, we at the Radiation Protection Institute had a bad feeling about the project. 8000 curies (approx. 300 terabecquerels) was still an impressive activity of a potentially dangerous nuclide. Luckily, everything went well (except for the expected success which did not come about) and it was possible to return the strontium to England following the trial period.

At the same time, in the 1960s, the Soviet Union had also developed thermoelectric generators with strontium-90 as their source of energy. Here, the area of application was considerable; up until the 1990s, a total of a thousand such generators ('RTG' for Radioisotopic Thermoelectric Generator) were erected along the Russian coasts as a source of power for lighthouses like the one which was tested in the Stockholm archipelago, but also in radio beacons and weather stations. Every RTG contained strontium-90 with activities of between 20,000 and 350,000 curies (i.e., between 740 and 13,000 terabecquerels), considerably more than in the Swedish lighthouse.

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* A sterilisation plant had already been planned by 1967 for foods (fish) in Skärhamn in Tjörn with 300 000 curies (11 petabecquerel) of cobalt-60 as its source of radiation. It was commissioned in 1968 but the intended irradiation of fish to extend its shelf life during transportation never came to fruition owing to the Swedish ban on the irradiation of foods. One petabecquerel (PBq) is an activity of 10^{15} nuclear disintegrations per second, i.e., approx. 27 000 curies.

It has become apparent that the Russian authorities did not have full control over these RTGs. A good number of orphan sources of radiation went astray. Most RTGs are or were unmonitored and had no fencing or warning signs. In several cases, thieves tempted by valuable metals disassembled the installation, unaware of the strontium and the risk of radiation. The risk lies not only in the fact that someone can receive surface irradiation from the beta radiation from strontium-90 through its daughter product yttrium-90, but also in being exposed to penetrating 'bremsstrahlung'. In the worst case scenario, fatal radiation doses can be received following a few hours' exposure if the radiation shields have been removed. The many cases of valuable metal theft show that the actual radiation source has also been easy to access. This has aroused the concern that terrorists could access the strontium and misuse it, maybe in a 'dirty' bomb where common explosives could spread strontium-90 over large areas and thereby create panic.

Sweden and Norway showed an interest in the situation in the Baltic and the Cap of the North. The RTG lighthouses which are being collected and disassembled are being taken care of in Russia. The strontium is being taken care of in the Mayak industrial complex in the western Urals, south of Yekaterinburg, the city of a million inhabitants, the complex which was originally built for plutonium production. Since the end of the 1990s, Norwegian efforts have meant that around 200 Russian RTG lighthouses in the area around the Kola Peninsula have been dealt with and replaced by solar cell lighthouses.

At the time of writing this, there are still several hundred RTG lighthouses in Russian waters which the Russians hope to be able to phase out over a five-year period if they receive international assistance. In this respect, interest has been shown by Canada, Norway, Sweden and the USA. The Swedish Radiation Protection Institute hopes to be able to contribute expertise.

1.16. **Israel's nuclear weapons**

June 1967 saw the start of the clashes between Israel and a number of Arab States which came to be known as the Six-Day War. The prelude to these was the increasing tension between Israel and Syria and the associated border conflicts that followed. Syria referred to its military alliance with Egypt from 1966 and Egyptian troops then marched up to Israel's border. Both Jordan and Iraq soon entered into a defence pact with Egypt and Israel found itself surrounded by openly hostile Arab States. On 5 June, Israel's Air Force attacked the former and its ground troops were able to attack while under cover from the aircraft. The West Bank was conquered by Israel on 7 June. After just three days, Israel had occupied the whole of the Sinai Peninsula and reached the Suez Canal, and Syria's resistance was also soon broken. On 10 June there was a ceasefire following a resolution by the UN's Security Council. The war was a complete success for Israel.

At the time of the Six-Day War, Israel is said to have put together at least two atomic bombs of same size as the Japan bombs. Therefore, in addition to superiority in terms of conventional combat forces, they had an important advantage over Egypt. Egypt had tried unsuccessfully to obtain nuclear weapons from the Soviet Union, whereas Israel was already regarded as a nuclear arms state by 1967. How had this come about?

A detailed report was submitted by Colonel Farr (Farr, 1999) at the American Air Force's Counterproliferation Centre at the Maxwell Air Force Base in Alabama. I cannot tell how neutral it is in the conflict between Israel and the Arabs, but my perception is that it is reliable – it has extensive and by all accounts reliable references – and this is my main source. In order to understand Israel's situation during the Six-Day War, it is necessary to look back at the development of events since the 1940s.

Many Jewish scientists emigrated to Palestine in the 30s and 40s. One of these was chemist *Ernst Bergmann*, who would end up being head of Israel's Atomic Energy Commission and the person who took the initiative regarding the country's nuclear weapons programme. Bergmann was a close friend of and adviser to Israel's first Prime Minister, *David Ben-Gurion* (1886-1973). At the Daniel Sieff Institute, which went on to be renamed the Weizmann Institute in 1949, Bergmann was in charge of the Institute of Chemistry. In 1952, a secret Atomic Energy Commission was formed which came under the Ministry of Defence.

In 1949, cooperation between Bergmann and the nuclear physicist *Francis Perrin* began at the French Atomic Energy Commission, which led to close cooperation within France and Israel's nuclear technology in the 1950s. After the Second World War, both of the countries were scientifically and technically equal when it came to nuclear energy research where France had lost competence during the war. The two countries supported one another in countless practical and technical matters.

Israel was worried that the Soviet Union would provide Egypt with far too much support, and when Egypt's President *Gamal Abdel Nasser* (1918-1970) closed the Strait of Tiran in 1953, which leads from the Red Sea to the Gulf of Aqaba to Israel, Ben-Gurion began developing plans for unconventional weapons, including nuclear weapons.

On 26 July 1956, Nasser stated that Egypt intended to nationalise the Anglo-French Suez Canal company and the 'Suez Crisis' began. At the initiative of the Americans, the UN prepared measures to settle the crisis. However, at the same time, British and French officers very secretly prepared a military attack on Egypt, plans in which Israel would later take part. The three States saw Nasser as a troublesome threat for different reasons.

During these preparations, Ben-Gurion and his adviser *Shimon Peres* (1923-), then Deputy Defence Minister, reached an agreement in September 1956 with representatives of the French CEA that France would give Israel a research reactor.

On 29 October 1956, Israel began its attack by striking Egypt over the Sinai Peninsula. The attack was a great success. When Egypt then immediately rejected a British-French ultimatum, an air raid was started and on 5 November, a British-French unit landed in the northern part of the Suez Canal. However, the attack stirred up substantial resistance in the UN from the two superpowers, the USA and the Soviet Union. These forced the UK and France to ignominiously withdraw their troops, which left Israel alone in the area. Bulganin and Khrushchev threatened a nuclear weapons attack if Israel did not also withdraw.

On 7 November, a meeting was held with Shimon Peres, *Golda Meir* (1898-1978, Israel's Foreign Minister), *Christian Pineau* (1904-1995, the French Foreign Minister) and *Maurice Bourges-Manoury* (the French Defence Minister). The Israelites were deeply concerned about the threat from the Soviet Union and the French were embarrassed that they had not been able to support their allies. At the meeting, the promise of a research reactor was changed to a larger reactor with 18 MW of thermal power with the possibility of subsequently increasing the power. The French would provide plutonium separation technology with the reactor.

In March 1957, Israel was finally forced to withdraw from the whole of the Sinai Peninsula and the Gaza Strip. There had still been a military victory and security had been fortified, but Nasser could also be seen as a victor and his position in the Arab world was strengthened. The Suez Canal was re-opened to traffic in 1975, but it had become less important by then since the merchant fleets had begun to use super tankers which could not yet use the canal.

The following can be quoted from Farr:

> Why was France so eager to help Israel? DeMollet* and then de Gaulle had a place for Israel within their strategic vision. A nuclear Israel could be a counterforce against Egypt in France's fight in Algeria. Egypt was openly aiding the rebel forces there. France also wanted to obtain the bomb itself. The United States had embargoed certain nuclear enabling computer technology from France. Israel could get the technology from America and pass it through to France. The U.S. furnished Israel with heavy water, under the Atoms for Peace programme, for the small research reactor at Soreq. France could use this heavy water. Since France was some years away from nuclear testing and success, Israeli science was an insurance policy in case of technical problems in France's own program. The Israeli intelligence community's knowledge of past French (especially Vichy) anti-Semitic transgressions and the continued presence of former Nazi collaborators in French intelligence provided the Israelis with some blackmail opportunities. [From Farr, Warner D: *The Third Temple's Holy Of Holies: Israel's*

* Farr means *Guy Mollet* (1905-1975) who was President of the French Cabinet in 1957.

Nuclear Weapons. Counterproliferation Paper No. 2, the USAF Counterproliferation Centre, Air War College, Air University, Maxwell Air Force Base, Alabama (1999).]

The French built the promised reactor, which the French called EL-102, underground at Dimona in the Negev Desert in southern Israel, near Beer Sheva, the largest place in the Negev area (160,000 inhabitants in 1997). Dimona is a place which was founded in 1950 to assist with the settlement of Jewish immigrants. It was not expected to become a large town since its location was remote and the climate uncomfortable, but it now has approx. 20,000 inhabitants. It is also known as the home of the Black Hebrews, a sect which originally came from Chicago.

Many of the contractors who were involved in the construction of the French plutonium factory in Marcoule also assisted in Dimona. Hundreds of French engineers and technicians were noted in Beer Shiva. The same French company built the reprocessing plants in both Marcoule and Dimona.

The real purpose of the plant was kept secret. It was initially said to be a textile factory and then a manganese factory. The Americans photographed it from the air at the end of 1958 and concluded that it was probably a reactor plant. It was also not possible to keep the number of French technicians secret.

In 1960, before the reactor had been commissioned, the French government under de Gaulle began to worry about the consequences. They wanted to discontinue the project but let the reactor building continue since Israel has promised not to produce nuclear weapons. The work at the reprocessing plant was discontinued. Israel had also been forced to promise to publish what took place, but never got around to doing this before the American Ministry of Foreign Affairs published a statement on 2 December 1960 that Israel had a secret nuclear energy plant. The statement was reproduced on 16 December in the *New York Times*. This led to Ben Gurion's announcement on 21 December that Israel was building a 24 MW research reactor for peaceful purposes.

The USA publicly accepted Israel's declaration but suspected that something else was going on. Confirmation was demanded, as was the possibility for American inspectors to be able to make regular visits to review the activity. However, the Israelites had built a false plant above ground with a simulated control room and never showed what was below ground.

At the same time, the French withdrew from the project and the cooperation with them ceased, as did the technical support. Israel now had to continue under its own steam. It was possible to start the reactor in 1962. The work with the reprocessing plant was resumed, and with the French back on board with their assistance, it was possible to commission it, which probably took place in 1965. Security was fortified to the extent that the Israelis shot down one of its own Mirage planes which had happened to enter the area during the Six-Day War in 1967. The plant was now officially called the Negev Nuclear Research Centre. *

1.17. **The activities of ICRP**

A task group under ICRP Committee 3 met in Washington DC from 27 February until 4 March. The group had been formed in 1966 and had the task of drawing up recommendations for the protection of the patients during x-ray examinations. The Chair of the group was the American radiologist *Reynold Brown*, who had the following experts to assist him:

Jon Flatby, Norway
J. M. Heslep, the USA
Thure Holm, Sweden
A. Laugier, France
Zwanette Nooteboom-Beekman, the Netherlands
Sidney Osborn, the UK
Ken Rowley, the UK

* The continued development of events concerning Israel's nuclear weapons is dealt with in Chapter 7 (1973).

E. W. ('Ted') Webster, the USA

I took part in the Washington meeting as the Chairman of Committee 3. At this first meeting of the task group, Thure Holm and 'Nettie' Beekman from Lund were the most active as they were later on. We three took a long walk from central Washington to the NCRP's office in Bethesda and on another day visited Arlington Cemetery and John F. Kennedy's grave.

The group's work led to a text which was finally approved by Committee 3 and the Main Commission in 1969. It was then published as ICRP Publication 16 in 1970. In 1974, the Swedish Radiation Protection Institute published a translation entitled 'Patient radiation protection during x-ray examinations'. In this work, they were also able to include a statement made by ICRP in the same year to the International Congress of Radiology in Madrid regarding current patient protection problems.

The ICRP Main Commission had held the following meetings since the Congress of Radiology in Munich 1959:

Munich	1959 (together with the Committees)
Stockholm	1962 (together with the Committees)
Ottawa	1962
London	1964
Stockholm	1965 (together with the Committees)
Rom (Fiuggi)	1965

In addition to the meetings that took place with the Main Commission, Committee 3 had met separately in Washington DC in 1966. In 1967, the Commission met the Committees at the Royal College of Physicians in London from 3-12 April. At the start of the period, the Committees met individually to later report to the Commission. The members of the Commission for the period of 1965-1969 were:

E. E. Pochin, the UK, Chair
Gordon Stewart, Canada, Deputy Chair
Louis Bugnard, France
Otto Hug, Germany
Henri Jammet, France
A.A. Letavet, the Soviet Union
Bo Lindell, Sweden
John Loutit, the UK
Karl Z. Morgan, the USA
Howard Newcombe, Canada
C. C. Powell, the USA
Lauriston Taylor, the USA
Brian Windeyer, the UK

The Scientific Secretary of the Commission was David Sowby. The Anglo-Saxon dominance was conspicuous and would remain so for some time into the future.

As Chair of Committee 3 (on protection against external radiation) I was well assisted by Lars-Eric Larsson who was Secretary of the Committee. The most important work assignment for the Committee was to examine the draft of recommendations from Reynold Brown's task group for radiation protection for patients during x-ray examinations. The members of Committee 3 at this time were:

Bo Lindell, Sweden, Chair
Eric Smith, the UK, Deputy Chair
Lars-Eric Larsson, Sweden, Secretary
Fred Cowan, the USA
Jean Dutreix, France
Shinji Takahashi, Japan
Dale Trout, the USA
Harold Wyckoff, the USA

My memory of the ICRP meeting at the College of Physicians is dominated by the adventure I experienced with Lars-Eric. We had stayed long into the evening after the Committee 3 meeting, and when we came to leave the building we found that the entrance door was locked. However, we were able to get out into a yard, but unfortunately it had no open exit. We therefore climbed over a wall in order, so we thought, to get out onto the street, but we ended up in another yard where there was no visible exit. On the other hand, there *was* a large dog there who objected to our trespass and we just managed to scramble over yet another wall before the dog was able to catch us. By then we had finally made it out on the street.

In my travel report to the Ministry of Health and Social Affairs, I wrote the following with reference to ICRP's finances:

> ICRP is currently financed by contributions from WHO, IAEA and the Ford Foundation. Furthermore, a very large contribution is being received because so far, only approx. 25-30 % of those participating in the meetings of the Commission, its Expert Committees and their task groups have needed to appeal to ICRP for travel and subsistence contributions, whereas 70-75 % have had their travel paid for by their international organisations. It is essential for this circumstance to be able to continue in order for the Commission's work to continue.

From the meeting of ICRP Committee 3 in London, 1967.
Seated around the breakfast table at the hotel, from left the Committee Deputy Chair Eric Smith, Lars-Eric Larsson, and Fred Cowan, USA.

At Committee 3's meeting, another important task group was set up, whose task was to re-work the general recommendations regarding protection against external radiation which had been published as ICRP Publication 3 in 1960. Norwegian Per Grande, who was then head of Danish radiation protection, was appointed as Chair of the task group. The group was composed of the following:

Per Grande, Denmark. Chair.
Klaus Becker, Germany, Deputy Chair.
Brian Jones, the UK, Secretary
John Kelley, the USA
Kristian Koren, Norway

Charles Meinhold, the USA
Pierre Pellerin, France
Ralph Thomas, the USA

The group met for the first time at the Radiation Protection Institute on 19-21 June. Grande was a little shocked. He had seen the Chairmanship as an honour but had not expected the burden of work that the assignment brought with it. He thought the group had to work at an unreasonably high pace.

In December, an invitation came from Pierre Pellerin to hold the next task group meeting at his organisation, *Service central de protection contre les rayonnements ionisante* (SCPRI) in le Vésinet in the western suburbs of Paris. The SCPRI had premises spread out in a park area. Pellerin tended to see task groups as his guests and treated them to wine and good food under the supervision of a boss dressed as a *chef*! This may not always have been the best possible way to assist performance capacity.

1.18. **The activities of IRPA**

Right at the time of the ICRP meeting, the Executive Committee for the International Radiation Protection Union, the International Radiation Protection Association (IRPA), met at the British Institute of Radiology in London. IRPA was a new organisation which had been formed in September 1966 in Rome at the initiative of Karl Morgan. In 1967, 15 radiation protection societies were affiliated, representing the following 22 countries: Argentina, Belgium, Canada, Denmark, the Philippines, Finland, France, Iceland, Israel, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Switzerland, the UK, Sweden, Germany, the USA, Hungary and Austria. The five Nordic countries were represented by the Nordic Society for Radiation Protection while the German-speaking countries were represented by the *Fachverband für Strahlenschutz*. Chair of the Nordic Society in 1967 was Kristian Koren. The Swedish members of the Society's board were Professor Kurt Lidén in Lund, the head of research at the FOA, *Arne Nelson*, and Chief Engineer Lars Carlbom in Studsvik.

IRPA was steered by a General Assembly which met every four years, and in between that by an Executive Committee, the one which was now meeting in London and which consisted of the following members:

K. Z. Morgan	USA	Chair
Y. Nishiwaki	Japan	Deputy Chair
W. G. Marley	the UK	Congress President 1970
P. Bonet-Maury	France	Secretary
P. Courvoisier	Switzerland	Treasurer
W. S. Snyder	USA	Director of Publications
C. Polvani	Italy	1966-1974
B. Lindell	Sweden	- " -
J. R. Horan	USA	- " -
L. Bozoky	Hungary	1966-1970
D. Beninson	Argentina	- " -
A. M. Marko	Canada	- " -

Dr Polvani gave an account of the experiences of IRPA's first Congress in Rome in 1966. It had been attended by 845 people. Proceedings of the scientific negotiations were being printed. The following can be quoted from my report to the Ministry of Health and Social Affairs regarding the meeting (a condition for the travel contribution I had received):

> The majority of the discussions the second day concentrated on the matter of establishing various Committees. The Chairman, Dr. Morgan, had proposed not only new Committees but also named members of each Committee. This met with criticism; it was stressed that the suitable way would be to firstly discuss the need for the Committees and then write to the affiliated national societies and ask whether they wanted to propose candidates for one or more of the Committees which had been

> accepted. Only then ought the Executive Committee to determine suitable members from among the proposed candidates. It was agreed to act in accordance with these guidelines and then decided that only some of the proposed Committees ought to be set up.

This was one of many examples of Karl Morgan's inclination to act quickly and arbitrarily, something which often irritated people who thought that they ought to have been asked. The following can also be quoted from my travel report:

> The general impression of this meeting of the IRPA Executive Committee is that the new organisation has a tendency towards over-organisation with unnecessarily detailed regulations and Committees springing up here and there, etc. However, owing to its size, IRPA will no doubt be a significant factor in the international radiation protection activities, and the initial intimation of unease regarding a development which may disrupt the uniformity that has prevailed thus far within the field of radiation protection recommendations will remain to some extent in the future.

The unease was based on the fact that the initiator and Chair of IRPA, Karl Morgan, had started to criticise ICRP where he was still Chair of the Committee but not particularly popular, owing to his independence and reputed stubbornness. It would have been unfortunate had IRPA become a competitor of ICRP. Luckily, this was never the case.

On 20 November, Karl Morgan wrote to Dr. *M. Delpla* in Paris to thank him for his preparations for IRPA's first European Congress which was planned for autumn 1968 in Menton. Morgan also expressed his satisfaction that Kristian Koren been asked to be Chair of the Scientific Programme Committee.

1.19. **UNSCEAR's 17th session**

In 1967, the UN's Scientific Radiation Committee was to hold its 17th session in Geneva. In May, I received a letter from the head of the Secretariat, Francesco Sella, in which he asked me to review a working document written by the head of research at the FOA, Kay Edvarson, who was working at the UNSCEAR Secretariat temporarily. The document described the principles for the dose commitment, a concept that the Committee was using more and more but which was surrounded by an (unwarranted) mystery which scared many people. Sella wrote:

> May I ask your opinion on the enclosed unprocessed, I repeat unprocessed, draft? It is the fruit of your good friend Kay's labours, whose analytical thoroughness is indomitably expressed here, and those of Peter Barry, a Canadian, which is largely responsible for lowering Kay's equations and huge amounts of data to processable dimensions. Although it does not surprise me, I find the conformity between your 1959 (and even previous predictions) and the values we have, slightly more negligently, derived from actual measurements fairly remarkable.

I responded to this at the start of June, writing:

> Although I may not be quite as talented as I sometimes wish I were, I still think I can be counted as an average reader, at least with the assistance of my knowledge on the subject. Nevertheless, I found it difficult to read the text (including the mathematics) fluently, so I assumed it was intended for a more talented readership. This annoyed me a little since I ought to be in a position to comprehend a part of it. I therefore began again in the attempt to concentrate and see! I began to understand it. I actually found it quite good, even in the places where I had had difficulty understanding it. I really like the presentation, but I do wonder how in the world we are going to be able to count on the majority of the task group, or even the physics sub-group, understanding it if they have not studied it in detail, which I do not believe they will do.
>
> ...

> Finally, although I very much like the current draft, I do not like the almost play on respect in references to a certain Lindell, who clearly appeared to be saying something which was now obsolete but was not actually of sufficient historical interest to come up that often in the text.
>
> I really hope that the incredible nonsense which makes civilised people shout and kill in the Middle East is brought to an acceptable end very soon. To add to all the obvious evil, UNSCEAR's work will also be affected – that is if it is not seen as too cynical to be thinking of such smaller problems given the current situation.

I now thought the difficulty of performing relevant dose calculations would make it difficult for the physics sub-group to deal with the matter on its own. A joint meeting of the sub-groups might be necessary, but I doubted that the biologists were prepared for this.* Sella did not think they were either, and wrote as much in his response to me:

> There is of course nothing to prevent a joint meeting of the two sub-groups during the session, and this can be determined by the first task group which will concentrate on organisational matters. The main purpose of the schedule was to facilitate the plans for the delegations, which will have chromosome experts and neuro-radiobiologists with them. I had doubts about planning a joint meeting since I thought it would be a bit silly to have a load of cytologists and neuro-physiologists, most of whom would be nothing to do with the matter, being among the dose commitments bunch for what would probably be the one and only time. As far as I know, the only 'biologists' present at the session who can contribute anything to the discussion will be Brues, Nelson and Pochin. They will probably be pleased to leave the nervous system behind for half a day, even if we do not formally convene a joint meeting.

UNSCEAR's 17th session was held in Geneva from 26 August – 6 September. I was Sweden's Committee representative, with Arne Nelson as my deputy. Assistant professor Lars Fredriksson from the Agricultural College of Sweden and Assistant professor Börje Larsson from the Gustaf Werner Institute in Uppsala were there as advisers.

Chair of the meeting this time was A. R. Gopal-Ayengar from India, with Gordon Butler from Canada as Deputy Chair. 'Gopal', which was what everyone called him, was an eccentric man who loved to tell stories that were risqué to a greater or lesser degree. When he was our guest in Sweden he made a great impression on our daughter by consuming incredible quantities of cold, Swedish tap water with which she had to constantly refill his glass. It is easy for us to forget that clean drinking water in many countries is an exclusive item that is in short supply.

Gordon Butler, representing Canada, sat on the other side of the table right opposite me. He had discovered that I had difficulty stifling an impulse to yawn if someone else was yawning. So, to my annoyance and his satisfaction, on the occasions when I asked to speak, he held up his hand and imitated a yawn with his thumb and index finger.

As at the previous meetings, we were able to enjoy the scientific discussion between Scott Russell and Lars Fredriksson when it came to the uptake by crops of radioactive substances from the ground. Scott Russell's academic English was conveyed with power and derision while Lars made his contribution more tactfully but firmly. The forceful representatives were 'Bill' Pochin of the UK and *Richard Chamberlain* of the USA, but Professor *Kuzin* from the Soviet Union, with his clear-cut, Georgian features, was also an impressive figure. His compatriot, *Angelina Guskova*, had developed from being a pedantic, loquacious woman into a clever and knowledgeable doctor with substantial

* A short plenary meeting was held at the start and the end of UNSCEAR's sessions, during which the delegates spoke their mother tongue if this was one of the UN's official languages. For the rest of the session, the Committee met a number of times in a 'task group' where the dealings were less formal, but for most of the time the Committee was divided into a biological and a physics sub-group which met in parallel. There was sometimes also a genetics sub-sub-group.

experience. Sievert had once jokingly nicknamed her 'God's gift' but would now doubtless have treated her with more respect.

A slightly embarrassing situation for me arose when the French representative, Professor *Louis Bugnard* (born in 1901) told me that, to honour Sievert's memory, he intended to make a contribution to the Royal Academy of Sciences' fund for gold medals for radiation protection achievements. He intended to contribute ten thousand francs. I did not know what to say. Ten thousand French francs corresponded to approximately ten thousand Swedish crowns. I really ought to be displaying surprise and great appreciation of such a gift. But maybe Bugnard meant ten thousand *old* francs, which corresponded to just one hundred Swedish kronor, which was a much more likely amount. It was odd if that were the case since the old franc had already ceased to exist in 1958. My maternal grandfather had certainly still referred to twenty-five *öre* coins as 'three-penny' coins in the 1930s, but it was astounding to think that a prominent French Professor could still be referring to the old money nine years later. However, in spite of everything, that was the most likely explanation. I therefore stopped at being polite without exaggerating gratitude. And yes, it did turn out to be old francs.

1.20. **The Swedish National Committee for Radiation Protection Research**

In 1963, the Royal Academy of Sciences had set up a new National Committee at Sievert's initiative. The Academy's national committees within various fields act as contact bodies for Swedish participants in international scientific cooperation. Sievert had been active within the National Committee for Physics in the 1940s and had initiated the coordination of Swedish military physics research, which was later taken over by the FOA. The new National Committee was named the National Committee for Radiation Protection Research and Sievert was its first Chair of course. After his death, the Chairmanship had fallen to me.

The National Committee met on 13 February 1967 at the Radiation Protection Institute. The most important subject for discussion was a referral from IAEA. It had gone to the Ministry of Trade and Industry which had forwarded it to the Radiation Protection Institute and *Atombolaget*. The Radiation Protection Institute had requested a statement from the National Committee and said that the Institute should refrain from making its own statement if it concurred with the Committee's points of view. In that case, the Radiation Protection Institute would forward the National Committee's points of view to the Ministry of Trade and Industry and simply note its assent. *Atombolaget* had also said it was willing to do this.

IAEA had requested abstracts concerning all projects about radiation protection research and had also asked the Swedish authorities to prioritise such projects that had been included in a list compiled by an expert group convened by IAEA in Budapest in 1966. The National Committee's members were very critical of both these wishes, as could be expected. In its statement to the Radiation Protection Institute, the following was written about the desired prioritisations:

> As regards the prioritisation of research projects, the National Committee is most sceptical. Research within the radiation protection field consists of basic research and applied research. Prioritising tasks for basic research – in addition to the prioritisation in the decision regarding inputs within the radiation protection field as such – is hardly appropriate in the National Committee's opinion. It ought to be possible to conceive of an action to prevent duplicate work but there is often relatively effective self-regulation here. It is more obvious and theoretically viable to prioritise applied research tasks, although this does require preparation by an international body with considerably wider coverage than IAEA and a significantly more thorough penetration of the problems than that which IAEA's panel of experts has been able to provide. There is currently no suitable body for this task and we are a long way from being sure that an acceptable mechanism for this type of prioritisation can actually be realised.

The National Committee was even more negative about the idea of abstracts and wrote:

> As regards abstracts, the National Committee does not think the value of a collection and distribution of such organised by IAEA within this field of research is something that outweighs the level of trouble associated with the act of collecting it and the risk of misunderstandings which may arise by issuing a detailed description of a research project too early.

The members of the National Committee who took part in the formulation of the response were Lars Carlbom, Lars Fredriksson, Arne Hedgran, Kurt Lidén, Bo Lindell, K. G. Lüning, Torsten Magnusson, Arne Nelson and Rune Walstam.

1.21. The ECSC, EEC, EURATOM, the EC and the EU

In order to understand the sometimes confusing acronyms (EEC, EC, EU, etc.) and the equivalent participants in the European cooperation in the latter half of the 1900s, a brief summary may be of assistance. According to the Paris Treaty, which became valid in 1952, the European Coal and Steel Community (ECSC) was formed by France, West Germany, Belgium, the Netherlands, Luxemburg and Italy. The experience of the cooperation was good so the European cooperation was extended through the Treaty of Rome in 1957 when a decision was made to set up another two cooperation bodies, namely the European Economic Community (EEC), also called the 'common market', and the European Atomic Energy Community (EURATOM). In 1967, this cooperation was called the European Community (EC). The deeper cooperation which led to the European Union (EU) came about through the Maastricht Treaty in 1993.

1.22. The CRPPH

I have previously mentioned the ENEA (European Nuclear Energy Agency) which was the OECD's (the OEEC at the time) nuclear energy authority and which changed its name to just the NEA when the word 'European' was dropped because of the emergence of non-European Member States.*

The NEA's Radiation Protection Committee, the CRPPH (Committee on Radiation Protection and Public Health) was originally formed under the ENEA (and the OEEC) in 1957 and celebrated its 50th anniversary in May 2007. In the initial period, the CRPPH's value was primarily in its pedagogic contributions. This should be seen against the background of the USA's Atoms for Peace policy. It involved generous offers of research reactors and assistance working with radioactive nuclides. This required acute safety and radiation protection measures for which there was still no professional competence at national level. People who would be responsible for the safety matters in their own countries were gathering in the CRPPH but their experience and knowledge still varied a great deal. It was important to convey to them knowledge of international recommendations and the application thereof. This is where the Committee made an important pedagogic contribution.

Despite his diminutive size, or maybe thanks to it, Secretary of the Committee, Dr. Wallauschek, was a very ambitious and vigorous man. It worried Arne Hedgran and me (who took over from Arne some time after Sievert's death when Arne left the Radiation Protection Institute to become head of the Reactor Safety Authority, later the Nuclear Power Inspectorate). We thought that Wallauschek was getting the CRPPH to take on problems which were already being tackled by other bodies, primarily IAEA, and thereby causing unnecessary duplicate work.

The meetings with the CRPPH brought a welcome extra occasion to meet Nordic colleagues. At Trocadero there was a small, very Parisian restaurant where the Nordic delegates usually met for dinner.

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* The OECD, i.e., the Organisation for Economic Co-operation and Development, was formed in 1961 by twenty western 'I countries' to promote long-term economic growth and employment. The organisation is domiciled in Paris. It was formed from the OEEC where the two Es stand for European Economic. The OEEC came about in 1948 to administer the Marshall plan. The organisation's Nuclear Agency (NEA) was called the ENEA right from the start until 1972.

This is where I used to meet Thorleif Hvinden and Kristian Koren from Norway and Mogens Faber and Per Grande from Denmark.

1.23. **Radioactive ID cards**

On 21 November, *AB Atomenergi* wrote to the National Radiation Protection Institute and asked the Radiation Protection Institute 'to sanction the use of radioactive material to mark identity documents'. The letter was signed by Stig Bergström, manager of the company's section for radiation protection and safety, and his colleague Thor Wahlberg who had previously been the radiation protection inspector at Rolf Sievert's. The latter was marked 'Confidential' which was of no particular practical significance, but was the natural thing to do since no-one wanted to tip forgers off as to the measures that were being taken to prevent falsifications. The letter expressed the following justification:

> Cheque fraud and the falsification of identity documents cause Swedish banks millions of losses every year. Owing to this, an investigation has taken place within one such company with regard to a conceivable way of using specially-prepared identity documents to make impossible or at least make said types of falsification considerably more difficult. Since for various reasons several methods which initially appeared to be appropriate have to be rejected, the result of the investigation in question is a proposal to appropriately mark the identity documents with radioactive material.
>
> The bank in question has approached *AB Atomenergi* with a request for a report into whether suggested control system could be implemented in a manner that was unobjectionable from the radiation safety point of view and, if so, whether the company could undertake the parts of the production of the identity documents which would be a natural part of its area of activity, and also deal with and dispose of inappropriate or used identity documents.

Atombolaget issued no proposal regarding the intended radionuclide but presupposed that it would be a beta-emitting substance with an activity between 10^{-8} and 10^{-7} curies, i.e., between 370 and 3 700 becquerels.

There was nothing in the application to indicate that it concerned anything other than a limited number of identity documents issued by a stated bank. At a meeting of 14 December, the Radiation Protection Institute's board declared that 'in this special case, in principle it had no objections to such use of radioactive material under the conditions stated in the letter'. The board assumed that 'the further details of the project will be designed with the observance of the terms that would be issued with the Radiation Protection Institute's usual strategy'.

The further development of the case is described in Chapter 3 (Section 13.25).

1.24. **Swedish 'atomic energy'**

Swedish atomic energy or, more correctly, the Swedish nuclear reactor programme, was in its infancy in 1967. No nuclear power plants other than Ågesta nuclear power plant were yet in operation. The Ågesta plant, which was built by *Atombolaget* and the Swedish State Water Power Board, had been started in 1963 and was commissioned in 1964. It supplied a thermal power of 65 MW, 10 MW of which was used to produce electricity and the rest was used for district heating in Farsta, a suburb just south of Stockholm. The other three reactors which were in operation in 1967 were the R1 reactor in Stockholm on Drottning Kristinas väg, which was run with a thermal power of 0.6 MW, and research reactors R2 and R2-0 in Studsvik, which were run with thermal powers of 30 MW and 1 MW respectively. The emission of the radioactive substances was reported in the Radiation Protection Institute's printed activities report. The report also mentioned that power reactors were being built at Oskarshamn and Marviken. The 'Swedish line' with natural uranium and heavy water had not yet been abandoned.

1.25. The Barsebäck Nuclear Power Plant is planned

In the 1960s, *Sydkraft* reviewed a number of conceivable location sites along the Blekinge-Skåne-Halland coastline but decided on Barsebäck. In 1963, contact had already been made with Torsten Magnusson, the Reactor Location Chair of the Committee, about the different alternatives. The decision on Barsebäck was made in December 1965 and the ground was acquired on the 18th of the same month. *Sydkraft's* MD, *Sture Wetterlundh*, gave an account of the building plans at a meeting of the delegation for Atomic Energy Issues on 18 April 1967.

2. THE YEAR 1968

2.1. **Dispersion of plutonium**

ON 21 JANUARY 1968, a B-52 aircraft carrying nuclear weapons crashed outside the American airbase at Thule on Greenland. The plane carried four hydrogen bombs which were spread over and through the ice which was around 1 metre thick. The ‘blasting caps’ (small fission bombs) of the bombs contained plutonium-239 which caused concern. The evening paper *Aftonbladet* asked questions of a number of experts and their answers were in the newspaper on 24 January.

An expert on Greenland *Bertil Wedin* of the FOA was asked: ‘What was the USA’s bomber doing in Danish air space?’

> Everything indicates that the B-52 was preparing to land at the Thule base. The position is stated as 12 km south-west of Thule. This means that the plane was directly over the North Star Bay ... when it crashed.

And *Jan Prawitz*, scientific adviser to the disarmament commission, was asked: ‘May units from the USA’s ‘strategic bomber command’ land in Denmark?’

> No, Denmark has banned all planes armed with nuclear weapons from flying over.

‘So is the USA defying this ban?’

> It is possible that the plane found itself in an emergency situation and was forced to seek refuge at the Thule base.

‘Can the bombs explode?’

> Probably not. The bombs are ‘secured’ when they are stored in the patrolling plane. The blasting cap for the hydrogen bomb is stored elsewhere in the plane.

‘What scope do the USA and Soviet ‘Strategic bomber commands’ have?’

> The USA has around 600 B-52s and 80 B-58s, all armed with nuclear weapons in constant preparedness. The oceans are also being patrolled by 40 Polaris submarines, each carrying 16 rockets. Soviet nuclear weapons are constructed in a different way. They are also more reticent about their defence. However, they clearly appear to have adequate nuclear weapons for retribution if the USA attacks. There are now more than 10,000 nuclear weapons in the world

Assistant professor Bertil Wedin was asked: ‘What is the possibility of fishing out the bombs?’

> At the moment it is impossible. At this time of year, Thule is dark 24 hours a day. The ice in North Star Bay is at least 1 ½ metres thick. They could not really be salvaged until the summer.

Aftonbladet aside, *Arne Karsberg* had an article with the headline ‘Plutonium radiation more dangerous than the experts thought’ in *Dagens Nyheter* on 4 February. He maintained that the Swedish experts had not initially thought that the risks of radiation from plutonium would be greater than the chemical risk. 'There has been a rapid change of heart and the significance of the situation can be compared with the one that currently characterises the mercury subject'.

This misunderstanding made me write Karsberg a letter:

> We have had some concerns owing to editor Karsberg's article on the level of danger regarding radiation from plutonium in *DN* on Sunday 4 February; people who work with plutonium have expressed concern that radiation protection regulations thus far would be dissatisfactory because the danger of plutonium has been reassessed.
>
> The article was probably slightly misleading. There has been no 'change of heart' along the lines of 'the one that currently characterises the mercury subject'. The fact is that the danger of plutonium from the radioactivity point of view is assessed as being the same today as it was ten years ago. ...
>
> The chemical toxicity of plutonium has always been considered to be considerably less than the <u>radio</u>toxicity thereof and all worker protection against plutonium is based on its radiotoxicity. When working with uranium, the relation is not always the same, depending on the form in which the uranium occurs. ...
>
> I am anxious to establish that there has been no change to the radiation experts' assessment of the radiotoxicity. Ever since 1959, the highest permissible average daily intake of the most usual plutonium isotopes has been approx. 0.1 μCi [3700 becquerels] if you swallow it and 10 pCi (!) [0.37 Bq] if you inhale it. Converted into grammes, this is approx. 1 and 0.0001 microgrammes respectively for Pu-239, which is the plutonium isotope that is of the greatest interest.[*]

At the time and also much later, statements were made that plutonium was 'the most toxic substance in the world', but that is an exaggeration. The 'toxicity' of a substance should be counted per unit of mass. Then the radiotoxicity of many short-lived radioactive substances is greater than that of plutonium-239. For example, iodine-131, whose half-life is just one millionth of that of plutonium (8 days compared with 24,000 years), has a much greater radiotoxicity counted per gramme. Even biochemical toxins can be more toxic. Those formed by the bacterium *Clostridium botulinum* are said to have a fatal effect following an intake of only 1 microgramme (for plutonium-239, 1 microgramme was a permissible daily intake). If you ingest it orally, plutonium is no more dangerous than the assassination poison arsenic trioxide; plutonium is particularly dangerous when inhaled.

According to the newspaper articles about the accident, the USA appeared to have lost nuclear weapons for one reason or another on a dozen or so occasions at the time, but only in one case prior to the Thule accident outside the American areas, i.e., in 1966 when a B-52 carrying four hydrogen bombs crashed near the Spanish city of Palomares (the event was described in 'The Labours of Hercules'). Plutonium was also distributed in the environment on that occasion. A number of submarines with nuclear reactors and nuclear weapons have also been lost.

Plutonium has as many as 17 known isotopes. One of them, plutonium-244, occurs naturally in some minerals and has a half-life of 80 million years. However, the most important plutonium isotopes are formed following nuclear reactions with uranium-238. The spent fuel (approx. 20 tonnes per year) from a nuclear reactor in a 1000-MW electric effect power plant contains plutonium-238 (2 %), plutonium-239 (58 %), plutonium-240 (24 %), plutonium-241 (11 %), and plutonium-242 (4 %), a total of approx.

[*] The stated values concerned the recommendations at the time for the protection of those who worked with radioactive substances. The highest permissible oral daily intake (approx. 4 000 Bq) of plutonium-239 is based on the MPC value (Maximum Permissible Concentration) which was stated in ICRP Publication 2 (1959), i.e., 10^{-4} microcuries per cubic centimetre of water. Since then, the estimations of the radiotoxicity and - primarily - the highest permissible annual radiation dose have been changed. The latter has been reduced from 150 mSv to 50 mSv (and later to 20 mSv). ICRP Publication 30 (1979) stated an Annual Limit of Intake (ALI) of 200 000 Bq for plutonium-239 for those working with radiation sources. ICRP later abandoned the ALI values and instead stated the effective radiation dose per becquerel for oral intake. The correlation is 4 000 Bq per mSv for plutonium-239. With an annual dose limit of 50 mSv, this also corresponds to an annual intake of 200 000 Bq, i.e., an average of approx. 550 Bq per day or 0.23 microgrammes per day. With the current dose limit of 20 mSv, the values are 220 Bq per day and 0.09 microgrammes per day respectively. It should also be remembered that the radiation dose is influenced by the chemical form of the plutonium.

250 kg. Isotopes 239 and 241 contribute to the nuclear fission and the energy development in the reactor and the other isotopes can be fissioned with fast neutrons.

Plutonium-239 is used in nuclear weapons (the smallest quantity is approx. 5 kg; every kilogramme has an explosive power corresponding to 17,000 tonnes of Trinitrotoluene with one hundred per cent fission) and together with uranium-238 in mixed oxide fuel (MOX fuel) for nuclear power plants. There are quantities of 500 tonnes or more of plutonium available for each use.

Plutonium-238 is considered to be less environmentally hazardous because of its shorter lifetime (its half-life is approx. 88 years). It has been used in energy sources for satellites and thereby could have been spread in the atmosphere.

2.2. American legislation on non-ionising radiation

Radiation which lacks the capacity to ionise atoms is called *non-ionising radiation.* Risks from such radiation first started to be taken seriously at the end of the 1960s. The first legislation appeared in the USA in 1968. The Radiation Control for Health and Safety Act regulated both ionising and non-ionising radiation. The Federal Supervisory Authority was the Bureau of Radiological Health which came under the Ministry of Health’s Food and Drug Administration. At the start of the 1970s, the problem was noted both internationally (by WHO) and in Sweden.

2.3. Views on the work of UNSCEAR

On 16 February, I wrote the Ministry for Foreign Affairs a nine-page memorandum containing points of view on UNSCEAR’s work and the Swedish delegation’s tasks. I sent copies to the contacts in the neighbouring Nordic countries. I wrote:

> In the [mid 1950s], the international political situation was comparatively tense when it came to nuclear weapons testing and there was also a fear that the interpretation of scientific results regarding the effects of radiation could have been the object of a biased assessment.
>
> In this situation, it was obviously very valuable to have a forum like UNSCEAR where the majority of the most technically and scientifically-advanced countries were represented and where east and west could talk. It was also quickly found that the Committee could work in an atmosphere which was disrupted only very slightly by political differences of opinion. The scientific objectivity was dominant and it was possible to establish a basis of scientific facts which was accepted by everyone. This gave the General Assembly [of the UN] a common basis for the political assessment and meant there was no fear of misunderstandings being hidden behind ostensibly scientific reasoning.
>
> UNSCEAR published its first extensive report to the General Assembly in 1958* and then published reports in 1962, 1964 and 1966. The Committee has met alternately in New York and Geneva, but the bigger work meetings have usually been held in New York for technical reasons while the meetings at which there have been more general discussions regarding the continued activity have been held in Geneva. At the meetings, the work has largely taken place with the Committee divided into two task groups, one for biology and one for physics, which have worked in parallel.
>
> The General Assembly has determined in repeated resolutions that UNSCEAR shall continue its activity. Even if the acute threat of powerful radioactive fallout from nuclear weapons testing in the atmosphere is set aside for the time being, the essential problems regarding the possible harmful effects of small radiation doses remain virtually unsolved. It is possible to estimate the maximum risk can for the moment because of a

* See ‘The Labours of Hercules’.

> certain distribution of radioactivity, but the extent to which the estimate involves an overestimation is not known. The long-term action of the radioactive contamination which has already taken place is also being followed with great interest. However, the most valuable aspect of the Committee's continued activity appears to be the preparedness value: in this context, the UN has made available a forum for the scientific assessment of every sudden change to the radioactivity situation and it is easy to realise the advantages of being able to consult the group when necessary, with said group being well versed in the problems, having good personal contacts and having a good scientific reputation.

I took an historical look back at Sweden's representation in UNSCEAR:

> In a decision of 27 January 1956, the Swedish Government appointed the person who was in charge of the Institute of Radiophysics at the time, Professor Rolf Sievert, as representative of UNSCEAR. Associate Professor *Torbjörn Caspersson* at *Karolinska institutet* (the Karolinska Medical University) was appointed as deputy for the representative and the Assistant professors at the Swedish Defence Research Establishment, Arne Nelson and Bo Aler* as experts. The Swedish Government released Aler from his assignment through a decision of 8 March 1963 and then appointed Licentiate of Philosophy Bo Lindell at the Institute of Radiophysics to take his place as expert to the representative. At the same time, Lindell and Nelson, like Caspersson, were appointed to act as deputies for the representative should the latter not be present. On 15 April 1966, Sievert and Caspersson requested release from their assignments, whereupon Lindell, then Professor and in charge of the National Radiation Protection Institute, was appointed as representative in Sievert's place and Nelson as substitute for the representative in Caspersson's place.

I put forward a number of proposals which are now outdated. One was that the representative and the latter's deputy 'normally take part in all UNSCEAR sessions without needing a special decision in every single case'. I proposed that, with a view to the work in two parallel groups, it was also appropriate, following a decision by the Ministry for Foreign Affairs, for two experts to be part of the delegation. I also proposed that the representative should have access to a special budgetary allocation to facilitate consultation with experts in Sweden. I finally discussed the matter of whether it could be appropriate to also allow another one or more experts from the other Nordic countries to be part of the delegation, as with the arrangement between the Netherlands and Belgium.

2.4. Nuclear medicine and Isotope Committee reports

During his first period at the Radiation Protection Institute, Ragnar Boge made a substantial contribution when it came to the work of the Isotope Committees.† At the Radiation Protection Institute, meetings were arranged between representatives of the different Isotope Committees where the Committee at *Karolinska sjukhuset*, the Karolinska University Hospital, was used as a reference. As of 1968, Ragnar demanded reports from the Committees regarding which radioactive substances were used in nuclear medicine at their hospitals, which types of examination were carried out and which activities of the radioactive substances were used. The information that was received was extensive and valuable. It had sometimes been discussed whether or not the radiation protection authority ought to set limits for the activity to be used in different cases, but such an order was thought to be unrealistic and sometimes detrimental to the patients. In Ragnar's tables, which were published in the Swedish Radiation Protection

* Using UN terminology, the experts are called advisors.

† According to the Medical Board's 'isotope circular' from 1961, hospitals at which there was an x-ray department or a central clinical chemical laboratory should also have a local clinical Isotope Committee (see Chapter 19 of 'The Labours of Hercules').

Institute's activities reports from 1968-1970, it was possible to see what the average, and even the lowest, dosage was. No limits were needed now. Those who gave unnecessarily high doses were embarrassed for being so heavy-handed. Ragnar made a great contribution to 'clearing up' nuclear medicine.

2.5. Per Grande's task group

In the previous chapter I told you about the task group which ICRP had set up with Per Grande as Chair. The group had met at the Swedish Radiation Protection Institute in summer 1967. The next meeting was held in Paris at Pierre Pellerin's *Service central de protection contre les rayonnements ionisante* (the SCPRI) in le Vésinet in the western outskirts of the city. I took part as an observer in my capacity of Chair of ICRP Committee 3, which administered the group. I found that I also needed to get the group going.

The group was quite inhomogeneous. Three of the participants, Grande, Klaus Becker and Kristian Koren, wanted to take it easy. Five were eager to get something done - these were Brian Jones, John Kelley, Charlie Meinhold, Ralph Thomas and Pierre Pellerin. I was forced to intervene when Klaus Becker, who was Deputy Chair of the group, proposed that we spend a day sight-seeing in Paris. The group was actually pushed for time and an extensive assignment lay ahead. It was to draw up a follow-up to ICRP's 'Publication 3' and create a manuscript for what would become 'Publication 15'. It was no small task.

Charlie Meinhold and Ralph Thomas worked as a pair, getting involved in animated discussions. Big bulky Charlie and the slim little Ralph made an unlikely pair. Per Grande sighed once again that he would never have taken on the Chairmanship had he known the work that would be demanded by ICRP. And Klaus grumbled that I was a workaholic - which may have been true but was probably necessary to get the task done.

2.6. Radiumhemmet's high-voltage station

A new premises was needed instead of the old one in the basement in order for the development of radiation treatment with accelerators and teletherapy devices to continue at *Radiumhemmet*. The way in which the new high-voltage station came about was described by Rune Walstam (Walstam, 2002):

> Adequate radiation protection for high-voltage devices requires 'bunkers' with metre-thick concrete walls and heavy, radiation-shielding, mechanically-operated doors or space-occupying radiation labyrinths. The metre-thick walls and ceiling of concrete weigh somewhere around 1,000 tonnes per room and usually need to be located at or below ground level. Comprehensive extension work was necessary for the development to continue. The planning of the 'high-voltage station' was started in the early 1960s under the leadership of Professor Sven Hultberg. Against the background of the cheerless premises in *Radiumhemmet's* western basement, we vociferously maintained that there ought to be some daylight in the control and waiting rooms. The whole plant therefore ought to be at ground level. Premises were prepared for radiobiology research and a couple of two-room apartments for visiting scientists were paid for by the research funds.
>
> Operational reliability is a crucial factor in radiation treatment. Complicated and expensive devices require rapid and advanced support from the supplier or own personnel who are competent in radiation physics and electronics. In the building, premises were therefore fitted out for the department of medical physics, which could thereby be transferred from the provisional premises which was used in *Radiumhemmet's* western loft, previously the x-ray device engine room. Hultberg never got to experience the opening of the plant in 1968. Jerzy Einhorn had taken over the Professorship a few years previously and was now able to influence the final use of the premises.

> 3 high-voltage devices were installed in the building: a 42 MeV Siemens betatron, a 6 MeV Varian linear accelerator and a Siemens Gammatron 2.

2.7. The Nairobi project

In Nairobi, a concrete bunker for radiation treatment was built according to Rune Walstam's drawings. At the same time, they had to obtain a teletherapy device with cobalt-60 as a source of radiation. Rune has written the following about this (Walstam, 2002):

> Negotiations regarding a Gammatron 2 were started and a powerful source of radiation was donated by Gävleborg County Council. In spring 1968 we approved a mirror image of the building to obtain a more suitable entrance and the construction was started. In the summer we were asked to come and 'check' the preparations before the casting of the thick concrete walls was started. Slightly reluctantly, Jerzy [Einhorn] and I travelled one Friday evening in August and arrived – anything but thoroughly rested – early on the Saturday at the construction site. I measured the mould, compared it with the drawing and discussed with the foreman whether the mould would cope with the high pressure that the thick walls would bring since similar work had not been done previously. I also checked the pipes that had been laid out for the electrical installation and for cables between device and control room. I found everything to be OK. The concrete was to be poured into the mould on the Monday morning.
>
> At night I lay imagining what the room with the treatment device would be like. It suddenly occurred to me that the pipes which were meant to be cast into the floor on Monday morning would, in my mind's eye, come out on the wrong side of the mount! Had the installation drawing also been inverted? On the Sunday morning we hurried back and were able to ascertain that this was the case. We succeeded in stopping the concrete casting until the error had been adjusted! The trip really did pay for itself.
>
> At the start of November, the device was in place and the source of radiation on its way.

2.8. Uproar in the USA

In April 1968 I had two tasks in the USA. ICRP's Committee 3, of which I was Chair, was to meet in Washington DC at the start of the month and UNSCEAR would then hold its 18th session in New York. I flew to New York on 30 March, landed late in the evening but was met at the airport by none other than the Swedish Embassy's chauffeur and right-hand man, 'Mr Andersson', who had me taken to the Roger Smith Hotel on Lexington Avenue where I stayed overnight. This politeness towards Swedish heads of delegation had surprised Sievert and me in *Agda Rössel's* period and now lived on during *Sverker Åström's* years as ambassador to the UN.

The following morning I flew to Washington DC and waited there at the airport for a plane which Lars-Eric Larsson had intended to take and did indeed arrive on. We went to the Cosmos Club where Committee 3 was to meet and where we would also be living. The famous club at 2121 Massachusetts Avenue was available to us because both Lauriston Taylor and Harold Wyckoff were members. Formally speaking, all of us were their guests. The members of the club were academics who included various Nobel Prize winners and it was famous because President Kennedy had left it in protest because no black people had been granted membership. It was also not possible to have women as members of course – the Cosmos Club was exclusively a gentlemen's club. We noted these discriminations with interest but assumed that protests from Swedish visitors, or even from ICRP, would not exactly have made any difference to the order of things. From our point of view, the Cosmos Club was an effective meeting place for an international group - but we did give Taylor and Wyckoff to understand that we thought Kennedy had been right in doing what he did. And we wondered what would have happened had there been a female member among us. as there was later on.

The Cosmos Club is near Dupont Circle which is intersected by several major avenues as well as Massachusetts Avenue, such as Connecticut Avenue which runs diagonally south towards the big business street K Street and Lafayette Square in front of the White House. Around Dupont Circle are a number of cafés and second-hand bookshops which would later tempt Dan Beninson and me to pay many a visit. Loudspeakers boomed out hits from the 60s such as Procul Harum's *A Whiter Shade of Pale* and Harvey Smith/Tom Jones' *Try to Remember the Kind of September....*

On the afternoon of Sunday 31 March, we sat in one of the club's rooms discussing the schedule for the next day where the most important task was to discuss the plans for what was to be ICRP Publication 15 about protection against external radiation.

Some of the Committee's heavyweights were there. One was sixty-seven year-old *Dale Trout*, retired from thirty-five years of pioneering work as the head of research at General Electric's x-ray department and now leader of a research programme at Oregon State University. Another was fifty-eight year-old Harold Wyckoff, impressive in terms of size, his white hair and his profound knowledge. Since 1941, Wyckoff had initially been head of the National Bureau of Standards' Section for x-ray standards and then head of the NBS Laboratory for radiation physics and deputy head of the Department for Radiation Physics. After retiring from NBS in 1966, he was the scientific director of the US Armed Forces Radiobiology Research Institute. He had been a member and Secretary of the ICRU since 1956.

The thought of being Chair of a Committee with such strong personalities had caused me concern when ICRP had given me the assignment in 1965. However, my concern had been unwarranted. The big men had been friendly and easy to cooperate with, which was a sign of just how great they actually were.

The Secretary of ICRP, David Sowby, was obviously also present. An odd character in the group at the Cosmos Club was the Californian radiologist Reynold Brown whose job it was to lead the task group on what would become ICRP Publication 16 on patient protection during x-ray examinations.

As we sat there with the TV on, the broadcast was interrupted by a message that the President of the United States had something to say. We listened with a feeling that something historical was about to happen. Lyndon Johnson came up on the screen with a serious expression. His message was surprising – he was not standing as the democratic Presidential candidate in the election. The opposition to the Vietnam War had been too much for him. We listened in amazement and, being in Washington DC, felt as though we were at the centre of world events.

What we did not know at the time was a remarkable coincidence. Just 20-30 metres from us, a 1963 white Buick cabriolet with Arkansas plates and the Red Cross' logo stuck to the doors stopped by the edge of the pavement in front of the Cosmos Club at the same time. At the steering wheel sat a twenty-two-year old lad called *Bill Clinton.* He has described the event in the following words:

> On Sunday night, March 31, President Johnson was scheduled to address the nation about Vietnam. There was speculation about whether he would escalate the war or cool it a little in the hope of starting negotiations, but nobody really saw what was coming. I was driving on Massachusetts Avenue, listening to the speech on my car radio. After speaking for some time, Johnson said he had decided to sharply restrict the bombing of North Vietnam, in the hope of finding a resolution to the conflict. Then, as I was passing by the Cosmos Club, just northwest of Dupont Circle, the President dropped his own bombshell: 'With American sons in the fields far away, and our world's hope for peace in the balance every day, I do not believe I should devote another hour or another day of my time to any party politics causes. … Accordingly, I shall not seek, and I will not accept, the nomination of my party for another term as your President.' I pulled over the curb in disbelief, feeling sad for Johnson, who had done so much for America at home, but happy for my country and for the prospect of a new beginning.
>
> The feeling did not last long. Four days later, in the evening of 4 April, Martin Luther King was killed on the balcony outside his room at the Lorraine Motel in Memphis where he had travelled to give support to striking sanitation workers.

The murder of *Martin Luther King* aroused ferocious indignation and riots in hundreds of cities and smaller towns. More than forty people were killed and hundreds injured. The riots were particularly severe in Washington DC. The area for the black people's business activities, along 14th Street and H Street, turned into near enough a war zone. This happened just as we had finished our meeting and were about to leave the city.

Leaving Washington proved not to be easy. Dale Trout took an early taxi to travel to Baltimore (a distance of over 60 km) and later told us what had happened. The car got stuck in the traffic for a while close to a petrol station. Black youths threateningly filled Coca Cola bottles with petrol. Dale asked his black driver whether he ought perhaps to lie on the floor of the car so that nobody would see that a black man was driving a white man. The driver, who realised that Dale was scared, told him to sit upright and that he was in good hands. He was as good his word and they continued unmolested.

David Sowby, like me, was to go to New York to take part in UNSCEAR's meeting. It was not easy to get to the airport or even to fly from there now. I decided to hire a car and invited David to accompany me.

We picked up the car from an Avis garage which happened to be in the middle of the older central part of the city. It was difficult to get onto the road as it was clogged with cars. We heard on the car radio that the authorities were asking people to leave their workplaces and go home. A good number of buildings burned down. Shop windows were destroyed. Plunderers came out of the shops grasping TVs or other treasures. HGVs with armed black militants drove around and the men were shooting in the air. It was not possible to drive on the streets in all places; we were sometimes forced to drive on the pavements. No-one took any notice of the traffic lights which might as well not have existed as they changed from red to green and back. Bill Clinton writes about the end result:

> Many black families were burned out of their homes and took refuge in local churches. I signed up with the Red Cross to help deliver food, blankets, and other supplies to them. My white Buick [---] cut a strange figure in the mostly empty streets, which were marked by still-smoking buildings and storefronts with broken glass from looting. I made the drive once at night, then again on Sunday morning [---]. In the daylight it felt safe, so we got out and walked around a little, looking at the riot's wreckage. It was the only time I've ever felt insecure in a black neighborhood. And I thought, not for the first or last time, that it was sad and ironic that the primary victims of black rage were blacks themselves.

Going northwards through this bedlam to New York proved to be problematic. We therefore instead decided to take a detour south around the city to finally end up on Highway 95 to New York. The President had clearly called in the National Guard because we met long lines of military vehicles.

David Sowby was going to stay overnight with Swiss friends in New Brunswick. I therefore dropped him off there and continued to Manhattan alone. It was now night-time and I wondered whether black Harlem would be in just as much of a violent uproar as Washington DC. I drove over George Washington Bridge and through Harlem down towards the Avis garage where I was to leave the car. But Harlem was calm and quiet so I had nothing to worry about.

2.9. UNSCEAR's 18th session

The Swedish delegation for UNSCEAR's 18th session in New York on 8-17 April consisted of me, Arne Nelson and Lars Fredriksson. Canadian Gordon Butler was Chair and I had now been made Deputy Chair of the Committee. The Czech representative, Dr. *Vladimir Zelený*, had been given the task of acting as rapporteur. Zelený was a friendly but reticent man whom it was easy to get on with, particularly bearing in mind that the thaw of the 'Prague spring' had started.

I had previously written to Sverker Åström, who was Sweden's UN ambassador at the time, asking for help with arranging a cocktail party at the UNSCEAR meeting, and this did take place as well.

2.10. Gunnar Bengtsson is recruited by the Swedish Radiation Protection Institute

Robert Thoraeus (1895-1970), the old physicist who constructed the Swedish standard chamber for measuring exposure using the roentgen unit, had retired. The temporary manager thereafter of the standard laboratory of which Thoraeus had been in charge since the 1920s had been civil engineer *Lennart Sundbom*, who worked at the Department for Medical Physics. However, Sundbom had now got a job as medical physicist in Eskilstuna, and it was necessary to appoint a manager of the laboratory. The job would soon be available and filled following an expert procedure. We at the Radiation Protection Institute were anxious to have competent applicants. Gunnar Bengtsson, for whose thesis defence I had been faculty opponent last year, was a possible candidate. After defending his thesis he had gone with his family to the USA to do research at Brookhaven National Laboratory under the leadership of Harald Rossi (although his actual institute was at Columbia University).

I had written to Gunnar in mid-March to tell him about the job whose title was first physicist with a monthly salary of 4 271 Swedish kronor. He received the letter on 18 March, which happened to be his birthday, and answered on 19 March that ‘there really is worse news to be had’. He suggested that I visit him when I was in New York in April for the UNSCEAR meeting. During a week-end I therefore went to 72 Maple Avenue in Shirley on Long Island, 5 km south of the Brookhaven Laboratory, and was warmly welcomed. And this was how Gunnar received details of the job.

When the job had been advertised and the application deadline had passed, the Radiation Protection Institute asked Professors *Gunnar Hettinger*, Kurt Lidén and Robert Thoraeus to use their expertise to assess the applicants. Gunnar Bengtsson and Licentiates of Philosophy *Börje Lundberg* in Bromma and *Bert Sarby* in Uppsala had applied for the job. Only Bengtsson and Sarby were declared competent for the task by all three experts, all of whom considered Bengtsson to be the most qualified.

While we were writing to one another before Gunnar was to start, in one letter he gave the following enthusiastic description of one of the two major research assignments he had been working on and would continue with into 1969. It is worthwhile quoting:

> The other major job concerns one of my own ideas that Rossi has most definitely supported. It is about the possibility of using a simple standard proportional chamber with simple electronics to measure the QF [quality factor] to maybe a 20% approximation – which, according to Rossi, could be applied to things like dosimetry for supersonic aircraft. The reason you can make such a simple device is that you can use an approximate connection between voltage variations and QF. Preliminary experiments have at least partially tallied with this connection and it is now a matter of definitely showing how close the connection remains and developing the principles for the electronics. This is actually something that someone else could do but I am very much involved in the really enjoyable work and want to at least follow it so I can see whether or not it is possible to use it in a practical instrument.

Bengtsson would start work at SSI, the Swedish Radiation Protection Institute, on 1 January 1969 with leave up to and including the end of March so he could finish his research projects under Rossi. We agreed that while he was still in the USA he would take a study trip to a number of the most important research institutes there. When I applied for travel funding of 10,000 Swedish kronor for this study trip on his behalf in December 1968, Gunnar had put together a detailed travel plan with the help of Rossi and Harold Wyckoff, among others. It may be worthwhile listing the institutes that would be visited since the list gives a good idea of the way dosimetry research was distributed in the USA at the time:

Sloan Kettering Institute, Memorial Hospital, New York
Radiological Research Laboratory, Presbyterian Hospital, New York
US Naval Research Laboratory, Washington DC.
Radiation Physics Division, National Bureau of Standards, Washington DC.
Health Physics Division, Oak Ridge National Laboratory, Tennessee
M. D. Anderson Hospital, Houston, Texas
Lawrence Radiation Laboratory, San Francisco
US Naval Radiological Defence Laboratory, San Francisco
Stanford Linear Accelerator Centre, Stanford, California
Department of Radiology, Stanford University, Stanford, California
Argonne National Laboratory, Chicago
Department of Radiology, University of Wisconsin, Madison, Wisconsin.

2.11. **The May revolt**

In May 1968 there were simultaneous student riots in a large number of countries. They were protesting against authorities, and most intensively so in France. This 'May revolt' is also of interest in the development of the radiation protection field since it was the start of distrust of politicians, powers and authorities in general. This led to demands for not just the students' but also the public's contributory influence within many areas and would eventually affect the distrust of nuclear power which grew at the start of the 1970s.

The riots were at their most extensive in France and almost caused President de Gaulle to lose control of the situation. He was forced to seek support from General *Jacques Massu* (1908-2002) in a lightening visit to Baden-Baden where Massu commanded the French troops.

In Sweden, the May revolt led to the students occupying the student union at Stockholm University in protest against a new curriculum, 'UKAS', with fixed curricula which the students saw as an attempt on the part of the government to control higher education.

In Argentina, Dan Beninson later said he thought for a moment that, because of the May revolt, he and other higher officials at the Argentinian Atomic Energy Commission would be thrown out through the windows without ceremony. Karl-Erik Larsson aired the same concern as Professor at KTH. He has described the situation (Larsson, 2000):

> The dramatic year of 1968 occurred during my time as Dean (1966-1969). One day in May of that year I sat at my desk dealing with business matters concerning the technical physics section. The door suddenly opened without anyone knocking and three younger men entered the room, lined up in front of the desk and uttered the following words without ceremony: 'We want to talk to you!' in a tone which left you in no doubt as to the importance of the men's business. For a fraction of a second, the image of the Bohemian king who was thrown out through the window into the rubbish on the street in 1618 by rebellious citizens went through my brain. That was the start of the 30-year war. I was on the second floor and a similar ejection method today in 1968 would not have a good outcome for me. But I ignored these alarming thoughts and invited the men to sit down so I could hear what they had to say. It turned out that these young technologists in revolutionary zeal had suddenly discovered that the study schedule they were following was altogether rotten, outdated and inappropriate for the type of civil engineer that they visualised in the new society in which citizens rather than some old-fashioned Professors best knew what was needed for the future. These profound individuals maintained that the research for which I was responsible, for example, was typical 'inbred research'. They triumphantly exclaimed that the research ought to be more orientated towards society. I promised them that I would immediately take up their points of view with a meeting of my teaching colleagues and that perhaps one of them could attend. I escaped with that for the time being.

We at the Radiation Protection Institute were not exposed to the May revolt except that in the long term it did lead to more open attitudes and later (1971) also to colleagues being on first-name terms.

2.12. **ICRP in London**

The ICRP Main Commission met in London at the Park Crescent Hotel on 20-24 May. The ICRP fundamental recommendations had last been published as Publication 9 in 1966. The current task was to draw up application instructions, mainly as Committee reports. There was much to do in this respect. The documents that were published the following year were:

> Report on amendments to ICRP Publication 9. *Health Physics* **17**, 389-390.
> General principles of monitoring for radiation protection of workers. *ICRP Publication 12*, Pergamon Press.

Radiosensitivity and spatial distribution of dose. Reports prepared by two Task Groups of ICRP Committee 1. *ICRP Publication 14*, Pergamon Press.

Paragraph 25 of Publication 14 is worth quoting:

> 25. Both in the setting of dose limits for separate organs and different parts of the body, and in legislating for non-uniform exposure within an organ or specified part of the body, a vital consideration is the range of dose and dose rate over which effective linearity of dose response can be assumed to hold. As discussed earlier, it is not unreasonable to assume that a linear relationship applies at very low doses (or at higher doses with low dose rates). The point at which departure occurs, and the extent of the change, will depend on the precise cellular mechanisms involved and the extent to which abscopal mechanisms come into play.* We are now in the realm of hypothesis, because for radiation tumour induction we are, in general, ignorant of the nature of the cellular mechanisms and often of the nature and importance of abscopal mechanisms, and there is very
> little in the way of direct clinical or experimental data in the relevant region of dose and dose rate.

2.13. **The Congress of Radiology in Copenhagen**

In 1968, the Nordic Society for Medical Radiology held its 29th Congress in Copenhagen with Professor *G. Thomsen* as President. The opening ceremony was held on 29 May in the University's assembly hall in the presence of Queen Ingrid. The Secretary General, Carl-Erik Unnérus, delivered the principal speech and stated that the total number of members in the Nordic national radiological societies was now approx. 1 500, one third of whom took part in the Congress.

2.14. **Spring and Autumn in Prague**

Khrushchev's secret speech at the Congress of the Soviet Communist Party in 1956 had led to the start of 'de-Stalinisation' with some relaxation of the party's bureaucracy and a bit of a cultural thaw. However, the changes were most evident in the Communist satellite states where many leading Stalinists had been removed. The reformation policy was taken furthest in Hungary ('the Hungarian Revolution') which led to a Soviet intervention in November 1956. In the Soviet Union itself, the limits of the relaxation were marked with the appearance of the Berlin Wall in 1961 and with the measures which led to the Cuba crisis in 1962 and Khrushchev's fall in 1964. The collective leadership which then followed with Leonid Brezhnev as the central figure saw the start of what is usually referred to as a stagnation period.

Unlike in Hungary, no consequences of Khrushchev's speech in 1956 were noticed in Czechoslovakia. The man who was head of the Communist Party from 1953 and the country's President from 1958 was *Antonin Novotny* (1904-1975). He operated Stalinist politics which led to economic stagnation and a need for reformation. Reformist Communist *Alexander Dubček* (1921-1992) was therefore brought in to head the Party in January 1968. Dubček introduced a reformation and abolished censure. Czechoslovakia looked as though it was going to join the western world. The Communist leaders in Moscow, East Germany and Poland feared that the development in Czechoslovakia ('the Prague Spring') would eventually rub off on several

* The expression 'abscopal mechanisms' appears to have been coined by Robin Mole of ICRP Committee 1. It is made up of the prefix 'ab' (away from) and 'scop' from the Greek 'scopos' (target) and refers to mechanisms outside the target of the irradiation, i.e., off-target. I could not find the expression in any reference book and when I asked the former Secretary of ICRP, David Sowby, he said that to his embarrassment he was also in the dark. David asked a leading radiologist who said that the expression was still in use, although indirect effects and bystander effects were more common.

Eastern states. Therefore, on the night before 21 August, Soviet, Polish, East German, Bulgarian and Hungarian troops invaded Czechoslovakia. Dubček was taken to Moscow as a prisoner but was released and excluded from the Communist Party in 1970.

21 August 1968 is therefore a date to remember – here, I reproduce the letter which I received in September of the same year from the person in charge of the Institute for Radiation Hygiene in Prague, the well-known scientist Dr. Jan Müller. The letter was sent from Vienna on 10 September and was written in English. It read:

> Dear Professor Lindell,
>
> I left Prague four days ago and travelled with my wife to Vienna. I sent my son, who is finishing his first year of medical education at Charles University in Prague, to Paris a few days ago.
>
> With circumstances as they are at the moment I do not intend to return to Prague and I am trying to find a place where I can work and where my son can finish his medical education. My wife is a paediatrician and has worked at the paediatric department's outpatients' clinic at Charles University so far.
>
> If, my dear Professor Lindell, you think you could assist us in any way in finding some work for us in Sweden, I would be very grateful if you could let me know. I would send all necessary information immediately.
>
> Please write to me at the following address: xxxxxxxxxxx.
>
> I am very much looking forward to hearing from you. Please give my best wishes to your colleagues at the Institute.
>
> Best wishes,
>
> Jan Müller

> If you wish to stay in Sweden long enough for your son to be able to finish his medical studies, and if your wife wants to work as a doctor in Sweden, the language is a practical problem; you would both need to learn basic Swedish. The normal way for those leaving Czechoslovakia for Sweden in the current situation would be to come to Sweden with the groups which are departing from Vienna in the near future and to take part in the approximately three-month intensive courses which are arranged for them in places like Uppsala.

I also warned Müller of the difficulty for his son to be accepted for medical studies and that the possibility of this happening depended fully on his son's previous grades.

It turned out that the Atomic Research Council was able to promise to arrange a temporary but not particularly well-paid research post for Jan Müller. However, it also turned out that Müller had requested work in several countries other than Sweden and was hoping for a visa for the USA. Sweden fell short against that sort of competition. In my following letter I agreed with Müller to discuss his future plans in Menton where ICRP Committee 2, of which Müller was a member, was soon to meet.

2.15. **ICRP and IRPA in Menton**

The Nordic Society for Radiation Protection met at Voksenåsen in Oslo on 3-4 October with Kristian Koren as Chair. The following week, IRPA held a meeting in Menton, which was followed by a meeting of ICRP Committee 2 at the same place. David Sowby and I met over the weekend after the Nordic meeting to discuss policy matters concerning ICRP and Committee 2.

David proposed that we meet at minimum cost to ICRP and had found a cheap hotel in France on our way to Menton. The hotel was called *Hotel des Remparts* and was in the small community of St. Paul de Vence up on a mountain in Alpes Maritimes. I do not remember exactly what we discussed, but I believe it concerned Karl Morgan's unwillingness to replace the MPC values (i.e., the highest permissible concentration of radioactive substances in air and drinking water) with the ALI values (Annual Limits of Intake). There is another risk aspect that I do remember well though. When we were walking in the forest around the hotel, we occasionally found small pockets, like tea bags, hung on tree branches and walls. They contained a few grammes of a white powder. It was a while before we were able to make out the text on the bags; it had been erased by rain, which had also made the content of the bags leak out (which may have been the intention). When we finally succeeded in interpreting the text, we found that the bags contained arsenic! Exactly what for was anyone's guess.

Of those who took part in the IRPA meeting in Menton, I particularly remember *M. Delpla* from *Electricité de France* who stubbornly defended hormesis, i.e., the theory that low radiation doses do fortify the immune system and are beneficial to us. 'It is every person's right to have low radiation doses,' said Delpla, who thought ICRP was doing harm by attempting to eliminate low radiation doses.

Jan Müller also took part in the following ICRP Committee 2 meeting. I discussed his situation with him while we were walking along the beach looking out over a Mediterranean Sea which was now not a romantic blue but a mediocre grey. It was warm and hazy and you could see no horizontal line dividing sea and sky. 'I love the sea!' said Müller, whose abandoned homeland had no sea. He hinted that he was waiting for information from the USA where the family might find sanctuary.

I was delighted to see Carlo Polvani again. One day he showed me around Menton's cemetery where there were plenty of old graves with Cyrillic phrases on the gravestones. They were often for young Russian women who, before the revolution, had been sent by mature relatives to what was assumed to be a healthier climate for those who had been affected by 'consumption'. We were in the company of the Canadian *Art Marko* from Chalk River who was able to interpret the Russian texts and allow us to imagine the tragic fates. Here and there were removed gravestones in conflict with the English inscription which could be read on one of them: GONE, BUT NOT FORGOTTEN.

What shocked me the most was the damage caused by the roots of Cypress and Poplar trees. Graves on slopes and in walls had been pushed apart and caskets had been unearthed and in some cases had tumbled out and split open. Polvani saw that I was disturbed and said: 'You northerners care too much about the body. It's just a shell - the soul is the important thing.' I was evidently experiencing a clash of cultures. There were also many other religious or cultural differences between different countries of course. To what extent did they affect the attitude to the radiation protection philosophy? How would a Chinese or an Indian have reacted to the graves being heaved up? How differently did people value a life?

Carlo realised in any case that the shabby cemetery did not make a good impression on tourists. On the way out we happened to meet the Mayor of the town who had welcomed us to the IRPA meeting. We told him what we had seen and he promised to do something about it.

2.16. **Radiophysicists for the Total Defence**

In 1939, Rolf Sievert along with Manne Siegbahn had already taken the initiative which led to the Swedish National Committee for Physics bringing together the country's physicists for the military physics research which led to the creation of the Military Physics Institute (MFI) and subsequently the physics research within the Swedish Defence Research Establishment (FOA)*. Since that time he had harboured a strong interest in military physics research. He designed measurement instruments to trace radioactive contamination after nuclear weapons explosions and had opinions on how the preparedness ought to be organised.

Sievert's energy and initiative irritated the military leadership who saw it as a disruptive element, and there was an attempt to keep him at a distance. When I succeeded him and became the first head of the Swedish Radiation Protection Institute I inherited this alienation. It bothered me that I did not find any guidelines for the way in which the Radiation Protection Institute ought to function during wartime. I found that in wartime, most of my colleagues would be stationed in such a way that our activities would be forced to cease and the radiation protection expertise at the Institute would not be useful. Because I had no information on the way that war preparedness was organised I had difficulty taking any initiatives

* See 'The Sword of Damocles'.

to improve the situation. Nobody I spoke to seemed to know anything or be prepared to discuss the problem – it felt like a Kafka novel to me.

I discussed the situation with our Ministry of course, the Ministry of Health and Social Affairs, and this eventually brought results. In May 1968, the Ministry of Defence got in touch and assigned a contact person, Lieutenant Colonel *Kåre Svanfeldt* (1922-2011) who was of the same age and who had previously been head of the Engineer Troops' Cadet and Aspirant School. I was invited to take part, with him as a cicerone, in a preparedness exercise in Stockholm for the Total Defence on 29 May together with Deputy Assistant *Ingvar Terstad* (born in 1916) from the Ministry of the Interior (responsible for Civil Defence cases) and head of division *Stig Ogner* (born in 1928) from the Ministry of Defence's coordination department. This is where I had my first opportunity to discuss my problems.

On 13 June, through Svanfeldt, the Ministry of Defence's coordination department sent out a memorandum on lines of action and a circular to the Regional Directors of the Civil Defence and County Administrative Boards to make a list of the personnel who were at their 'radiac centres'. I had worried that the radiac centres often lacked competent personnel. At the same time, I realised that many radiation protection experts had been stationed as medical physicists in wartime without having sufficient competence for this task.

In September I wrote to the head of the Swedish National Board of Health and Welfare's planning and preparedness department*, Medical Officer *Åke Lindgren* (1927-) and pointed out the unreasonable situation where radiation protectionists would be stationed as medical physicists given that there were nowadays plenty of medical physicists and that radiation protectionists would do more good in the radiac centres. Lindgren referred my letter to his scientific advisers Lars-Gunnar Larsson, Kurt Lidén and Bertil Åberg. These all substantiated the proposal to replace the radiation protection physicists. Lidén also proposed a conference to discuss the matter of personnel for radiation protection preparedness in times of peace. Åberg thought the whole radiation protection complex ought to be discussed by a task group with representatives of various Total Defence authorities.

Kåre Svanfeldt invited me to take part in a preparedness exercise on 12 November in Karlskrona. Many of my qualms were confirmed. There was very inadequate contact between the military and the civilian commander; they were in two different worlds which were very isolated from one another. The military used the FOA's radiation protection competence while the civilian commander had a 'radiac centre' with very inadequate competence. The military chose its own path and more or less ignored the civil measures, which was fortunate in some ways. On the advice of his radiac centre, the civilian commander was tempted to make a number of unfortunate decisions based on lack of knowledge and fallacies. For example, people were prepared to reject drinking water and some foods (including sugar beet!) on flimsy grounds without having assured themselves of anything to replace them. I was convinced of how important it was to obtain adequate radiation protection competence. This was also confirmed by the list of personnel at the radiac centres which was compiled the next year and which led to considerable improvements.

2.17. **The Swedish nuclear reactors**

The following can be quoted from the Radiation Protection Institute's 1968 activities report:

> As regards the number of nuclear reactors in operation ... no changes occurred in 1968†. The nuclear power plants in Marviken and Oskarshamn, which are under construction, are estimated to be ready in 1969-1970. However, it was of interest in

* In 1968, the National Board of Health and Welfare was a new authority with *Bror Rexed* (1914-2003) as Director General. It had been formed on 1 January through a merger of the older National Board of Health and Welfare and the Medical Board.

† See chapter 1 for the situation in 1967. The only nuclear power plant was Ågesta, whose reactor had a thermal power of 65 MW.

> 1968 that the power industry produced a programme for a very extensive nuclear power expansion for the immediate future.

Chapter 8 of 'The Labours of Hercules' gives a general idea of the growth of nuclear power. OKG*, ASEA and *Vattenfall* had decided to invest in light water reactors. This was not highly regarded by the advocates of 'the Swedish line', i.e., heavy water reactors with natural (non-enriched) uranium. The MD of *Atombolaget,* Harry Brynielsson, thought it was impossible for Swedish industry to independently cope with big light water projects. He stuck by the Marviken project and the energy policy decisions which had been made in 1956, and also believed that Swedish heavy water reactors could make a profitable export product. *Atombolaget* had contacted India, Pakistan and Egypt. Unfortunately, thought the critics, the problem is that these countries are interested in nuclear weapons.

Vattenfall now definitely intended to invest in a light water reactor. Marviken was not thought to have much of a future. The new reactor would be located in Värö on the west coast. However, it was thought that the name would be too difficult to use in international contexts and the plant was therefore already given the name Ringhals to start with. The first two reactors for this power plant were ordered in 1968, a boiling water reactor from ASEA (Ringhals 1) and a pressure water reactor from Westinghouse (Ringhals 2). Two turbine plants were ordered from English Electric for Ringhals 1 and two from Stal-Laval for Ringhals 2. The government had already given OKG permission to erect and run Oskarshamn 1 on 1 April 1966.

Tore Nilsson wrote the following about the plans at the Barsebäck Nuclear Power Plant in an internal report within the Nuclear Power Inspectorate in 2002:

> The Chairman of the Swedish Reactor Siting Committee, Torsten Magnusson of the FOA, and Committee member Arne Hedgran of the Swedish Radiation Protection Institute, took part in a meeting on 8 May 1968 at the Board of Health in Copenhagen concerning the 'exchange of information regarding current plans to erect nuclear power plants on either side [!] of Öresund'. As well as information from Sweden about Barsebäck, information was given by the Danes about nuclear power plant on Zealand planned for the 1970s. A decision was made to create a relationship in case something happened, at Barsebäck in the first instance but also later in Danish reactors. The question of the preparedness organisation was studied in Denmark. The distribution of the whole of Denmark's population was on computer so it was easy to do studies in circles around the potential sites. The surveys were also done in Öresund. It was also noted that a cooperation group had been formed within the Nordic Council concerning the safety of reactors.

In November 1968, an agreement was reached between the State and Asea regarding the formation of a common company, *AB ASEA-Atom*. The new company would obtain resources from *Asea* and *AB Atomenergi* and was expected to be active in the atomic energy field. It would develop and market reactors and also produce fuel elements. The State's interest in *ASEA-Atom* was bought out in 1982.

In 1968, a decision was made for Sweden to affiliate itself to the UN's non-proliferation treaty. The ideas for Swedish nuclear weapons were thereby definitely dispensed and, with them, what was perhaps the main motive for Marviken. In May 1970, the government decided that the work on the Marviken reactor should be discontinued.

On 1 July 1968, Torsten Magnusson became Director General and head of the FOA. He then left his assignment as Chair of the atomic energy delegation's Reactor Siting Committee and was succeeded by Arne Hedgran.

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* Oskarshamns Kraftgrupp AB

2.18. The problem with radon

The surveys of the presence of radon in Swedish mines were carried out by the Radiation Protection Institute's 'special laboratories' which were run by Jan Olof Snihs. The Institute's activities report for 1968 showed the following:

> Air activity in mines was also measured in 1968. The problem with radon in the uranium mines abroad has been extensively studied and information has also come to light that high radon levels can occur in other types of mine. The Radiation Protection Institute therefore began radioactivity measurements* of mine air in 1967 in the Näsliden and Långsele mines at Boliden. In this connection it was ascertained that the radon level involved no problem provided you had good ventilation while working. In 1968, measurements were carried out in Nygruvan and Knallegruvan in Åmmeberg. The radon levels that were measured there were on average higher than those in Boliden. However, the levels were not high enough to justify any immediate radical measures.
>
> ...
>
> There are no reasons to believe that the mines surveyed so far would be the most radioactive and it must therefore be considered to be justified from the radiation protection point of view to also continue surveying other mines.

2.19. The radiation in our homes

We at the Radiation Protection Institute still had no information to lead us to believe that radon in indoor air constituted a health problem provided the ventilation was good. On the other hand, we were still worried by the knowledge that slate-based gas concrete, primarily Ytong, caused elevated radiation doses because of unusually high levels of radium in the material. The Radiation Protection Act gave us no formal possibility of intervening; a different authority was responsible. However, it was our job to 'disseminate information about dangers and inconveniences which could be caused by ionising radiation'. Sven Löfveberg, who was our information manager, and I jointly wrote two information sheets for the Swedish Institute for Building Research, which published them under the heading 'Radioactivity and building material' I and II in the *Byggforskning informerar* ('Building research information') series. The problem with radon was mentioned but the main emphasis was on gamma radiation from the building materials. International organisations such as the ENEA's Health and Safety Committee were still not looking into the problem.

2.20. Chinese nuclear charge tests and the return of Apollo 8

The Apollo project was the name of the American space project from 1961–1972 whose purpose was to investigate the moon and get people to land there. The first test flight with people aboard an Apollo craft should have taken place in February 1967 but a fire broke right on the launch pad and the three astronauts died. Before Apollo 11 landed on the moon in 1969, test flights took place with Apollos 7–10. The trip with Apollo 8 was carried out at the same time as China carried out its new nuclear weapons testing. This led to press headlines. *Dagens Nyheter* wrote the following on 28 December 1968:

> With fantastic precision, actually exceeding the perfection which characterised the whole of the Apollo project, Frank Borman, James Lovell and William Anders landed just after 16:50 Swedish time on the Friday only 5000 metres from the salvage fleet's lead ship. The new target shooting record was noted in the southern Pacific Ocean.

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* A lapse: yon cannot measure radioactivity; *radioactivity* is a phenomenon, not a magnitude. It is the *activity* of the radioactive substance that is measured - but we are often careless and express it wrongly!

Dagens Nyheter's science reporter Arne Karsberg wrote on the same day:

> At around 8:30 Swedish time on Friday, the People's Republic of China carried out its eighth nuclear weapons test. Eight hours later, the American space capsule passed almost exactly over the test site. However, there was still no message late on the Friday evening to say that the test had had any impact on the American project.

And nor had the test had any impact. However, like France, China had not signed what was known as the Limited Test Ban Treaty which was entered into by the USA, the Soviet Union and the UK to prevent nuclear weapons testing above ground. The Chinese detonated their nuclear charges above ground, and it was therefore possible to show that radioactive material from the Chinese tests was all over the northern half of the globe and thus also in Sweden. However, the radiation doses were very minor – the charges were small. On the other hand, the astronauts could have received high radiation doses from three other sources: the radiation belts around the earth (the van Allen belts), cosmic radiation (i.e., radiation from outer space) and proton radiation from the sun. However, the measurement instruments on Apollo 8 did not show any high radiation doses. The greatest risk had been the proton radiation from solar eruptions that could come without much forewarning.

2.21. **The Non-Proliferation Treaty (NPT)**

The Non-Proliferation Treaty (NPT) is an international agreement that is intended to limit the proliferation of nuclear weapons, nuclear weapons technology and fissile material. The signing of the agreement started in 1968 with Finland.

According to the agreement, the nuclear weapon states (France, China, the Soviet Union, the UK and the USA) were to undertake disarmament. Other countries would be able neither to receive nuclear weapons, nor to develop them. In order to ensure that fissile material in these countries was used for peaceful nuclear power only, IAEA would check (in accordance with a special Safeguard agreement) by inspecting their nuclear energy plants and every State would undertake to permit such a check.

The NPT was propelled by the powers which were armed with nuclear weapons to counteract a change in the balance of power. The agreement had been signed by 140 States by the start of the 1990s. It was made valid for 25 years and a follow-up conference was agreed for 1995.

3. THE YEAR 1969

3.1. Competence of the radiophysicists

On 3 January, I wrote a disgracefully late response to a couple of letters from Kurt Lidén from the previous year. The annual meeting of the Society of Radiophysicists on 20 November 1968 had discussed which competence was required for radiophysicists in conjunction with the report which had been completed on behalf of the society by Holger Sköldborn, *John Svedberg* and Lennart Sundbom. They had decided to follow up the report with a questionnaire to be answered before the end of January 1969. Kurt had written to me and given his points of view on the matter. He thought that formal competence in radiophysics should be required for both medical physicists and personnel within the nuclear power industry's radiation protection departments. My response was (note that at the time I wrote as though it concerned only men):

> I believe that our objective is principally the same (what else?), i.e., to employ the most competent person for the purpose in each individual case and ensure that he has sufficient competence and that he can take care of the job adequately. I also believe we agree that sound knowledge of radiophysics is very important. However, I then believe that our views diverge. The general trend of modern society appears to be to place greater emphasis on factual knowledge rather than formal knowledge. The contrary would be unfortunate. I do not need to take such a drastic example as someone from Pakistan who came to us to read radiophysics with a four in physics who could not calculate the volume of a cylinder (but I only mention him as an anecdote). Nowadays we are not usually unfortunate enough to see the formal competence failing to actually reflect the factual, but there are important exceptions. And that is when *I* think the factual competence should be decisive.
>
> There is also a purely professional point of view. I believe it is inadvisable to seek to strengthen the position of the radiophysicists through coercive measures. If it does turn out – which I assume neither of us believes it will – that the radiophysicist has a low level of factual competence although he fulfils the formal competence requirement, the requirement will soon be given the boot (as will the radiophysicist). If on the other hand the factual competence obviously follows on from the formal – and that is what I assume we would hope for – you do not need any additional requirements to the formal one.
>
> In other words, the best way of 'selling' the radiophysicist is to train him such that he becomes indispensable, at least in the longer term. So, it ought to be important to make it general knowledge that it is a radiophysicist who has all the capacities required for a specific job.
>
> The situation where we have cause for concern is when someone who actually has inferior or dissatisfactory competence is employed for a specific job. However, in several of the cases where dissatisfaction has been expressed, the 'incompetent' person concerned has had completely adequate factual competence. And being able to obtain such competence without formal examinations in the subject is something that both you and I (I hope!) have evidence of.

On 7 May, the Secretary of the Society of Radiophysicists sent out a summary of the questionnaire responses. Responses had come from 50 radiophysicists. 42 of these thought that a licentiate degree in radiophysics ought to be an absolute requirement for a job as a medical physicist.

3.2. **Contact with the Ministry regarding the Barsebäck Nuclear Power Plant**

On 17 January, the Chair of the DFA, Secretary of State *Hans Lundström* of the Ministry of Finance, wrote a letter to the head of department at the Danish Atomic Energy Commission, *H. H. Koch*. The letter was a response to a letter from Koch of 21 November which I have not been able to find. Lundström wrote:

> Many thanks for your letter of 21 November 1968. As I told you when we last met, *Sydkraft's* application for a licence for the Barsebäck Nuclear Power Plant has now been submitted to the Swedish Government. It has been referred to the Delegation for Atomic Energy Issues, which in turn requested a statement from a number of authorities, etc. no later than 31 July 1969. The delegation will then provide its own opinion on the basis of these statements and of the technical review by the delegation's Reactor Location Committee. It is not possible to give a more detailed schedule today regarding the delegation's review of the case. Due to the Reactor Location Committee's great workload, it probably cannot start dealing with the safety issues until the summer. I have asked the Chairman of the Committee, Assistant professor Arne Hedgran, to get in contact with the relevant Danish authorities as soon as we can establish our work schedule. A copy of the application and of the delegation's referral are enclosed.

3.3. **Closing of the Czech books**

On 31 January 1969 I received the following letter from Jan Müller, sent from Toronto in Canada:

> Dear Prof. Lindell,
>
> I feel deeply ashamed that I have not written to you for so long, particularly since you so generously offered me the possibility of working at your Institute.
>
> When we met in Menton I thought that a decision regarding the US would be made very quickly, but that was not the case. The bureaucratic procedures concerning the type of visa that I requested took a very long time and when new difficulties arose and I would have been forced to apply for another type of visa, I decided to travel to Canada. So, it was just before Christmas when we were all pretty depressed and homesick. Something needed to be done quickly. I dared not ask you for work at your Institute again so we made a quick decision and we were in Canada within three days. This was a fact – the reasons are sometimes difficult to explain because they are beyond reason and are partly emotional. We quite simply felt miserable and tired of everything.
>
> We are therefore now in Toronto. I am working at the Province of Ontario's environmental office in Toronto. Here there are a few interesting problems as well as some laboratory resources. It is also possible that I may take part in some projects at the University of Toronto in the future but it is still too early to say. My wife will start work here as soon as she has taken the exams required for foreign doctors in Canada. Our son hopes to be accepted at the University of Toronto next semester. We now also have an apartment here; there isn't much furniture in it at the moment but that is not all that important and will be resolved in time.
>
> I wold like to emphasise, my dear Prof. Lindell, how deeply I appreciate your assistance during the most difficult period after we had left my country. It was not always easy for me to keep my morale up but your letters gave me plenty of support – many thanks.

3.4. **Radon in mines**

Jan Olof Snihs began to suspect that radon in mines could be a serious problem and prioritised the special laboratories' efforts with radon measurements. He started a cooperation with the Swedish Board of Occupational Safety and Health which was directly responsible for employers (the Radiation Protection Act was not yet directly applicable at the time). Snihs also contacted the Mining Research and the Swedish Mining Association. The latter initiated a cooperation group within mining research. Assistance was required to organise the increasing number of measurements. Bengt Håkansson used to tell animated stories of how he climbed up steep slopes with heavy measurement equipment to find, on one occasion when he had reached the top, that the hatch he was going to go through had been closed.

The following was written in the Radiation Protection Institute's activities report for 1969:

> Air activity measurements in mines were also taken in 1969. Results of previous surveys (see the activities report for 1968) have shown that there is reason to continue the activity measurements in mines. In 1969, a further 5 mines were therefore surveyed: Dannemora, Stripa, Stråssa, Blanka and Mangruvan. Two of these showed radon daughter levels* which were lower than 10 pCi/l [i.e.,10^{-11} curies per litre] on average, i.e., clearly satisfactory from the radiation hygiene point of view. The others had radon daughter levels in excess of 30 pCi/l, i.e., ICRP's MPC value for radiological work. In one case, the levels were close to 300 pCi/l.
>
> ...
>
> These mines had been selected by the mining research cooperation group which had been formed at the initiative of the Swedish Mining Association.
>
> The selection took into account things such as the geological conditions for finding high radon levels. However, it has turned out that the results do not always tally with expectations.

So, geology was not the phenomenon that could explain the highest radon levels. Snihs would find out the real reason later on. If he had not stubbornly let the measurements continue, the worst ever radiation exposure of workers in Sweden would not have been revealed and the reason would not have been discovered. However, there will be more about this in the following Chapter.

On 18 February, I received the following letter from Kristian Koren:

> Dear Bo,
>
> Thank you for your letter of 6/2/69 in which you discuss the problems with radon-222 in mines. We would very much like to be kept informed of the development in the field in Sweden, and even if you and your colleagues did not have anything particularly concrete to submit in Copenhagen this March, we would like to see the subject mentioned.
>
> Many years ago we had major problems with the Søve Mines in Telemark which contained both radon and thoron. We had to take drastic measures with protection equipment and demands for ventilation, blasting on Friday evening, etc. Fortunately, the operation became unviable, not because of our demands but because of international economies, so the operation has now been closed. But we must understand that there may be problems with radon in many places and we would not like to see big headlines in the press without us having been able to find out how great the risk is in advance.
>
> Yours sincerely,
>
> Kris

* The radiation dose in the lungs comes only to a very small extent from the radon itself – it comes from the decay products, the 'daughter products', which are suspended in the indoor air and accumulate in the lungs (see Chapter 1 of 'The Labours of Hercules').

3.5. The radiation in our homes

In 1969 there were no efforts to further investigate the problem with radiation in our homes from radioactive building material. The Radiation Protection Institute, which was not an authority with any responsibility in this regard, thought the duty to provide information had been fulfilled with the two information sheets compiled by Löfveberg and me. The problem was not mentioned in the Radiation Protection Institute's activities report for 1969. ICRP had not discussed the issue and nor had UNSCEAR. I had not yet succeeded Arne Hedgran as Swedish representative of ENEA's Health and Safety Committee and had not yet seriously started to seek international support for more detailed reports. Gun Astri Swedjemark, who would play a significant role in the research into the radiation in our homes, was still fully occupied by the measurements of contaminated foods following the big nuclear weapons tests at the start of the 1960s.

3.6. Radiophysicists for the Total Defence

On 4 April, Senior Administrative Officer *Erik Lindell* (born in 1921) of the Swedish National Board of Health and Welfare sent out a form to list the personnel at the radiac centres and, as he put it, 'get the right man in the right place'. At the end of April, Colonel Svanfeldt wrote the following to *Gunnar Lindblom* at the FOA:

> Bo Lindell and I have examined the material which arrived from Civil Defence cabinets and the CABs [County Administrative Boards] as regards the access to radiac specialists. A compilation is enclosed.
>
> ...
>
> As previously noted by you, there is a very uneven distribution of real experts. A desire for fortification is expressed in several cases.
>
> It now appears to be possible for the FOA to prepare the list of the radiac personnel's assets which the FOA should come up with in consultation with the Swedish Radiation Protection Institute.

The list showed just what a lack of expertise there was. Among the 6 radiac centres which were available to civilian commanders, 2 had excellent expertise, 2 acceptable and 2 completely unacceptable. Among the 25 radiac centres at the County Administrative Boards, just 2 had good expertise. Those who were at the other radiac centres were largely either surveyors or architects.

In May 1969, Erik Lindell produced a summary of what had happened. He reported the statutory background to the stationing of radiophysicists, including medical physicists. He also took up Kurt Lidén's proposal to fit medical physicists into the group of 'medical personnel' and wrote that the Swedish National Board of Health and Welfare had no objections to this. He gave an account of the desire I had expressed for radiation protection physicists who were now stationed as medical physicists to be replaced by real medical physicists and instead be stationed out and given radiation protection assignments. He summarised the referral response to my letter and made the following proposal*:

> As shown by Professor Lindell's letter, a review of the access to personnel is currently taking place within the Total Defence's radiac protection organisation, which should probably include *both* the radiation protection technicians who are now stationed within the civil war healthcare system owing to a previous lack of medical physicists, *and* the conscripts who have radiophysics education who are now stationed within the army in posts other than radiac protection posts.

* With reservations regarding the fact that I am quoting from a draft and have not been given the final letter.

In 1969, Kåre Svanfeldt became head of the Svealand Engineer Regiment and the Ministry of Defence's interest in the Total Defence's radiac protection organisation thereby fell away and the contact was continued with the Ministry of Health and Social Affairs.

On 15 October, a memorandum written by Jerzy Einhorn came from the Swedish National Board of Health and Welfare regarding the stationing of radiophysicists and radiotherapists within the civil war healthcare system. Einhorn referred to my letter (including the referral responses) and Erik Lindell's summary. Einhorn wrote the following about the need for radiation treatment during wartime:

> Scientific adviser Professor L. G. Larsson says that 'certain qualified radiotherapeutic activities ... ought also to be run during times of war'. County doctor Dr. *Norman*[*], Chief Medical Adviser Dr Åkerrén[†] and scientific adviser Professor Åberg, concur fully with this. Chief Medical Adviser Åkerrén said that, partly for psychological reasons, it is inappropriate not to plan for the radiation treatment of patients with malignant tumours within the civil war healthcare system.

Einhorn wrote the following about the need for personnel:

> In a letter of 30/9/1968 to the Swedish National Board of Health and Welfare, Professor B. Lindell says that every Civil Defence and County Administrative Board should have a radiation protection specialist available.
>
> The first to be assigned to these positions should be physicists who also hold administrative radiation protection posts during times of peace.

3.7. The Nordic meetings in Copenhagen

On 17-19 March, representatives of the Nordic countries' radiation protection institutes met in Copenhagen to discuss the formulation of national radiation protection provisions. On 20-21 March, a 'Nordic Council'-type meeting was also held there. The following people from Sweden took part in the latter meeting: from Atombolaget Thor Wahlberg, from the FOA Gunnar Lindblom, Arne Nelson and *Gunnar Walinder*, from the Swedish National Board of Health and Welfare Bertil Åberg and from the Radiation Protection Institute Ragnar Boge, Arne Hedgran, Carl-Gösta Hesser, Stig Johansson, Bo Lindell, Jan-Olof Snihs and *Bernhard Tribukait*. The subjects included UNSCEAR's activity, continued fallout reports to the UN, action levels if iodine-131 were released, exemption regulations for low-activity waste and problems concerning the medical use of radioactive substances.

The first meeting discussed a proposal that I had sent out in a letter on 29 January. Since the proposal was accepted and ended up leading to valuable results (the 'Flag Book'), I quote a fairly long section of my letter here:

> My proposal is that at the meeting of 17–19 March in Copenhagen we discuss the conditions which can lead to the common translation and processing of ICRP recommendations for application within the Nordic countries.
>
> Only a translation of the ICRP documents seems to be less important since we can refer to the English text perfectly well. However, the ICRP recommendations are aimed at every country's radiation protection authority with the intention that each country should do additional work on the instructions and regulations which are required in the sense of the recommendations with the local conditions.
>
> ...
>
> In Sweden, like the authorities in most countries, the Radiation Protection Institute has declared itself willing to apply the ICRP recommendations. However, no formal undertaking has been made. Nor should it be possible for Sweden to commit itself 'in

[*] It is unclear to me what 'Dr Norman' Einhorn is referring to; he gives him the initial 'A'.

[†] *Bo Åkerrén* (1925-2005)

blanco' to that which ICRP may recommend. A more practical way is to take on the recommendations now made (or that are soon to be expected) and point by point determine whether we are willing to apply them.

A translation into 'Scandinavian' could thus involve only the recommendations which are agreed should be applied within our countries (let us hope that it is the majority). In the 'translation', each paragraph should be changed so that it actually complies with ICRP but in its application is designed for the Scandinavian conditions. Where we cannot comply with ICRP, we should instead replace the text with something which corresponds to whatever we may determine.

The document which can be created in this way will have some similarities to the documents drawn up by IAEA, ILO, etc. as safety rules or model codes on the basis of the ICRP recommendations. The particular recommendations of these organisations should naturally also be observed and 'translated' where appropriate.

Any common document should also reflect the requirements set by the ILO Convention and should also include already-existing regulations that are not too detailed to the extent that we can reach inter-Nordic consensus regarding these.

The advantage of using a number of ICRP publications as a basis when drawing up a Scandinavian collection of recommendations is that very substantial editorial work has already taken place on these documents. In using this skeleton, we may be able to perform a task which would otherwise be near enough impossible.

I imagine that the result could be a book which could be jointly published by our Institutes as practical proof of the good Nordic cooperation. In this form, the result would not constitute any formal connection as regards the application, since a common 'book' can scarcely be characterised as a regulation in any of our countries. On the other hand, it may be conceivable that we, in Sweden for example, issue a provision which says that that which has been written in the common book shall apply. I still cannot take stock of the legal and administrative difficulties - we should discuss them in Copenhagen.

An ICRP 'translation' of this type obviously requires a lot of work. This can take place in smaller task groups which undertake different sections. The possibility of organising such work and the question as to whether we have personnel resources for it should also be discussed.

However, the most burning issue that we should first discuss is this: is it a reasonable proposal? Is it worth the trouble and can we reach an adequate level of consensus?

My view of the matter is optimistic. It will probably be a long time before we have the same opportunity as now to come up with common guidelines. As far as Sweden is concerned there is a very acute need for new general application regulations and we must find a solution to that problem under any circumstances. However, it would be a waste of work efforts if each and every country were to draw up its own interpretations of ICRP, assuming we were easily able to agree that is.

So, what was the position regarding the ICRP recommendations at this point in time, March 1969? ICRP's fundamental general recommendations in Publication 9 had come out in 1966 and were discussed by IAEA, ILO and WHO. A number of application recommendations were to be expected in 1969–1970, primarily Publication 15 on protection against external radiation, but also Publication 16 on patient protection during x-ray examinations.

At the meeting in Copenhagen, my proposal was accepted and Sweden was given the task of acting as the coordinating country in the agreed cooperation. Eleven sub-areas had been identified and distributed between Denmark, Finland, Norway and Sweden. The first draft would be finished at the end of 1969 or the start of 1970. The project led to what we called the 'Flag Book', a work whose cover displayed the flags of the Nordic countries.

3.8. UNSCEAR's 19th session

UNSCEAR's 19th session was held in New York on 5-16 May 1969. As was the case at the 18th session, Gordon Butler from Canada was Chair and I the Deputy Chair, while Dr. V. Zeleny from Czechoslovakia was rapporteur. During the session, it was decided that I would be Chairman of the 20th and 21st sessions with Zeleny as Deputy Chairman and Brazilian *L. R. Caldas* as rapporteur. During the session, the main discussions concerned the plans for the continued work. The Swedish delegation included Arne Nelson as the substitute for the representative and Lars Fredriksson as expert. But two other Swedish experts were also present, as consultants to UNSCEAR's Secretariat, namely Kay Edvarson and Börje Larsson. This gave me the opportunity to play table tennis with Börje during the good lunch breaks.

Gordon Butler, Zeleny and I as the Committee's Officers discussed the matter of whether or not it would be appropriate for UNSCEAR to make a contribution to the UN's forthcoming environmental conference in Stockholm 1972. The Committee asked us to write a contribution regarding the value of applying UNSCEAR's experiences within general environmental protection as well.

Sverker Åström was Sweden's UN ambassador in 1964–1970. I had written to him on 20 May, i.e., immediately after UNSCEAR's meeting, saying that my board assignments for both ICRP and UNSCEAR ought to make it easier to plan participation from these organisations at the environmental conference in 1972, but that it ought to take place with caution. I wrote:

> ... The radiation protection experts I have spoken to from different countries have agreed that they have experiences which may be valuable and relevant but, at the same time, they are anxious to emphasise that they will not take any initiative that may be misinterpreted as a desire to dominate the development. The radiation issues *per se* constitute just a small part of the problem complexity; on the other hand, opinions already held and methods already developed can in some cases be transferred for further application.

In his report to the Ministry for Foreign Affairs of 27 May, Sverker Åström wrote:

> The more immediate reason why the Committee ended up informally discussing matters concerning the UN Conference on the Human Environment was that in an address to the Committee, the Secretary General [*U Thant*] said its work was directly related to the preparatory work for the UN Conference.

Åström gave a report of what the Secretary General had said, which included:

> Although it was not the intention for the UN Conference to become a purely scientific conference, the Committee's report would provide an invaluable background for a preliminary discussion of some of the most important problems that the Conference is expected to handle. This was not just because of the significance of the atomic radiation problem but also because, while working, the Committee had developed a method that could serve as a model when it came to dealing with other environmental problems which require scientific analysis at an international level.

I had started writing a paper myself for similar purposes for publication in the Radiation Protection Institute's activities report for 1970, entitled *Can* the *experiences of the radiation protection field be useful within general environmental protection?* One of my conclusions is shown in the following subsection:

> Two organisations have been very important in radiation protection work. One of these, UNSCEAR, ought to be an exemplary model for what can be accomplished within the framework of the UN. The other, ICRP, is so unconventional that it unfortunately appears to be impossible to copy it within the other fields.

By this I meant ICRP's organisation and way of working, while I felt that many of its recommendations and concepts ought also to be applicable as regards non-radioactive environmental toxins.

In 1969, *Rolf Björnerstedt*, 'Nalle', came to the UN in New York as head of its department for disarmament matters, an operation which was later (in 1976) developed into the UN Centre for Disarmament.

3.9. **Swedish nuclear power, Värtan and Ågesta**

On 1 January 1969, *AB Atomenergi's* fuel production resources were moved to *Asea-Atom*. At the same time, the Delegation for Atomic Energy Issues was transferred from the Ministry of Finance to the newly-formed Ministry of Industry, whose first head, the Minister of Industry, was Krister Wickman.

The Radiation Protection Institute's activities report for 1969 shows the following:

> As regards nuclear reactors in operation ... the change [that] took place was that the maximum power for R2 [the research reactor in Studsvik] was changed from 30 to 50 MW and for the Ågesta reactor from 65 to 80 MW. It was not possible to complete the Marviken project in accordance with the plans. It is estimated that the nuclear power plant in Oskarshamn will be commissioned in 1970.[*]
>
> Otherwise, it is now possible to predict an extensive nuclear power expansion. At the end of 1969, the following plants were ordered or being constructed: two units at Ringhals, another unit at Oskarshamn and one unit at Barsebäck. The question of 'proximity location' of nuclear power plants, i.e., whether it is possible to design a plant so that its location in close proximity to densely-populated areas can be permitted has been brought to the fore through *Stockholms Elverk's* application to erect a reactor to produce electricity and heating in Värtan. Since the Reactor Location Committee has taken the view that permission for this should not currently be granted, a committee has been set up to produce a basis for an assessment of requisite location restrictions for future plants. Although the safety factors are the first thing to control the location requirements, it is very important in this context to also look at how the terms for emissions of activity with flue gases and wastewater must be formulated for nuclear power plants close to dense developments.[†]

Thanks to Arne Hedgran the Värtan project was put off. As Chair of the Reactor Location Committee he did not want to support the project, which immensely irritated the powerful industry commissioner *Gösta Agrenius* (1914-2000) and the Director of *Stockholms Energiverk*, *Jan-Erik Ryman* (1922-2009). The following was said in an interview given by Arne Karsberg for *Dagens Nyheter* before the Committee had spoken (probably Karsberg's words): 'The main thing that remains to be seen is what the so-called Reactor Location Committee ends up saying about the project. If it approves the plan, it will be considered to have made a pioneering achievement which will echo throughout the world.'

On 1 May 1969 there was a mishap in the Ågesta reactor which is usually referred to in jest as the 'First of May demonstration'. A water pipe broke which ought not to have had any bearing on the safety of the reactor. An arc of water sprayed out and it happened to hit an electronics cabinet containing relays to control valves and pumps in the emergency core cooling system. The arc created a short circuit or conduction. This resulted in cooling water pumps starting to pump water into the reactor, but it was not possible for them to actually pump because the reactor pressure was still high. The reactor's heavy water started to be pushed out through leaking check valves and some heavy water was lost. No danger ever

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[*] See 'The Labours of Hercules' for the arrival of the first reactor at the Oskarshamn plant.

[†] Here, the author has been careless; the physical quantity 'activity' of a radioactive substance is the number of nuclear disintegrations per unit time: the word 'activity' must not be used as a synonym of 'radioactive substance'. You should therefore write 'emission of the radioactive substances'. On the other hand, 'Radioactivity' is not a physical quantity but denotes the phenomenon that causes activity.

arose in terms of the safety of the reactor, but the course of events was not exactly predictable, and this shows just how difficult it is to state a relevant value for the likelihood of a reactor accident happening. Since the pumps were not intended to pump against high pressure, they were not designed to tolerate the high pressure. The pumps could therefore have caused a break in the emergency cooling system. Even though it could have been possible to overcome such a situation, the incidence was really serious.

According to modern requirements, the level of information on the event was dissatisfactory but probably more so due to a lack of procedures and operative resources for reports than a desire to keep matters secret.

3.10. **Barsebäck 1**

Sydkraft ordered Barsebäck 1 with an electric power of 570 MW from *Asea-Atom* at a cost of approximately one billion Swedish kronor. At the same time there was an option for Barsebäck 2. *Sydkraft* had assured itself of an adjustment agreement with Danish *Elkraft*. The agreement meant that the Danes, in addition to a continuous power exchange, undertook to purchase energy from Barsebäck for four years.

3.11. **ICRP in Oxford**

In April 1969, the four ICRP Committees met at St. Catherine's College in Oxford. 'Bill' Pochin was to step down as Chair at that year's Congress of Radiology in Tokyo and be succeeded by the Canadian Gordon Stewart, and I would become Deputy Chair, but I would also continue to be Chair of Committee 3. The choice of Stewart worried David Sowby. David was loaned by the Canadian government to be Secretary of ICRP. It seemed natural to Stewart to suggest that David ought now to return to Canada to be close to the Chair. However, David had settled down in England and did not think it was a good idea for the Secretary to always follow the Chair. He thought ICRP ought to have a fixed point of reference, irrespective of who the Chair was.* Another factor in the case was that there was not the best of interpersonal chemistry between Sowby and Stewart. Stewart took up the matter at the Main Commission's meeting but, to David's relief, the decision was that the Secretariat should remain in England.

Six months after the meeting in Oxford I received a letter from David in my capacity as Deputy Chair. He was worried about the fact that Stewart had accepted the Commission's decision only on condition that it concerned a trial period during which they would see whether the arrangement with Chairs and Secretaries in different countries led to any practical problems. David now recognised that there were problems but that they were caused by Stewart who did not answer his letters. Were Stewart to claim that the arrangement was not working, David wanted me to know that it was not his fault since he had done everything he could to facilitate the cooperation.

In Oxford, Committee 3 was now discussing the proposal from Grande's task group for the wording of the forthcoming ICRP 'Publication 15'. The Committee made many changes which meant that Lars-Eric Larsson, Secretary of the Committee, and I had a mountain of paper and notes which needed editing before the Main Commission was to consider the proposal. I had substantial assistance from Lars-Eric who was very keen to put himself to the trouble. We sat up one night until four in the morning editing the manuscript, which also involved writing a number of new paragraphs which the Committee wanted. Lars-Eric had placed a bottle of whisky on the table and declared that we should take a break for a drop every n-th paragraph that we finished (I no longer remember which number the n represented). So, by four o'clock we had finished and, as far as I recall, we were still pretty sober but sleepy. The Commission

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* The current solution is that, as a registered charitable organisation, ICRP 'belongs' in England, whereas the Secretariat, irrespective of where the Chairman is domiciled, had been located at the Swedish Radiation Protection Institute in Stockholm for some time until it recently moved to Canada following the replacement of the Secretary.

later approved the manuscript and it was possible to release 'Publication 15' on protection against external radiation the following year.

The Main Commission discussed the representation of ICRP at the forthcoming Congress of Radiology (the 12th ICR) in Tokyo. Many argued that the Commission ought to meet in Japan during the Congress. This would confirm its international status and be appreciated in Asia. But Pochin thought it would be too expensive and seemed to suspect that enthusiasm on the part of the members for a Tokyo meeting was partly down to a personal desire to go to the far-off country of Japan. He refused to agree to a meeting in Tokyo. It was a difficult and dictatorial decision since the majority were against him, but he said that if the majority got its way he would step down as Chair. He later cried at having been forced to make such an unpopular decision which was even more difficult for him because, according to what the Congress required, he was forced to travel to Japan to represent ICRP as departing Chair.

3.12. 50 years of the NSfMR – the 30th Congress in Finland

This year's Congress of the Nordic Society for Medical Radiology should have been held in Otnäs outside Helsinki. It became an anniversary Congress. This was the Society's 30th Congress but also its fiftieth anniversary. The rumour spread around the world but the Society's bylaws did not permit the participation of radiologists who were not members of the NSfMR.

This led to a serious conflict. It is described in its history (Unné, 1984) as follows:

> A large group of radiologists from the USA had decided to simply come to the anniversary Congress in 1969 and take part and while simultaneously holding lots of presentations on this occasion. The group – of more than 200 people – had already arranged its own hotel rooms, etc. The Congress management simply received a message stating that the group would be arriving at the Congress. This led to a whirlwind of letters back and forth with these Americans. The latter in turn had difficulty understanding why they should not be able to take part since the Nordic radiologists had always been welcome to their equivalent meetings, for example. The conflict was reaching uncomfortable proportions where we in the Nordic countries were accused of anti-Americanism, etc. The basic reason for these misunderstandings could subsequently be found in a couple of prominent Swedish radiologists' promises to the Americans. It was then possible to prevent the American 'invasion' at the last minute.
>
> In the end it was the Secretary General himself who had to carry the can because the Americans could not take part, and who was also treated badly by some of the more prominent Nordic radiologists even though the majority supported the view which corresponded to the Society's bylaws.

Otnäs, which is in Esbo outside Helsinki, is the home of Finland's University of Technology where the Congress took place. The President of the Anniversary Congress was Professor *Pekka Virtama*.

The Congress was opened on 11 June. The President of the Republic, Urho Kekkonen, made time to attend, as did the ambassadors of the Nordic countries.

The presentations bore witness to a greater understanding of the biological impact of ionising radiation. *Erik Poppe* ascertained that million volt therapy was superior to treatment with (what was then) conventional qualities of radiation. *László Révész* gave an esteemed overview of the biological conditions for preoperative radiation treatment. Jerzy Einhorn and colleagues spoke about autoimmune reactions after local radiation treatment. In the physics section (eight presentations), *Hans Svensson* and Gunnar Hettinger gave an account of the results of a dosimetry survey of different accelerators in the Nordic countries.

In all, 120 presentations were given and there were a good 600 participants.

3.13. **Irradiation accident at *Radiumhemmet***

In the summer of 1969, a calculation error by a physicist at *Radiumhemmet* led to twelve patients being exposed to higher radiation doses than was planned. The device that created the radiation was a new betatron which had been calibrated for both electron radiation and x rays. It was commissioned in April for electron radiation and on 4 June for x rays once it had been calibrated by the physicists. The calibration was technically correct in terms of measurement but, when calculating the setting values which would emit the intended radiation dose of x rays, the physicist who was responsible made a mistake. The calculation required him to use numbers from a table which showed the calibration results. The physicist read from the wrong column in this table. The setting recommended by him therefore emitted radiation doses that were too high, although the doses were not high enough to be immediately noticeable. Every patient was irradiated for a good month in 20-35 sessions, and only after some of the patients had had many irradiation sessions was the overdose noticed. By then, four of the patients had received a higher radiation dose than the total planned dose. The remaining patients had received doses that were too high on each occasion but had not been irradiated enough times to be injured. It was possible to adapt the remaining irradiation sessions to turn the total dose into the desired dose. On the other hand, the four over-irradiated patients did suffer from non-predicted radiation injuries (specific injuries to healthy tissue cannot be avoided if the tumour is to receive a high enough dose for it to be destroyed). Regarding at least a couple of the deaths – they concerned very ill patients – it was thought likely that the overdose was the reason. The event was tragic.

The over-irradiation was discovered on 27 July and the Swedish National Board of Health and Welfare was notified in accordance with ‘lex Maria’ (the Patient Safety Act) and, as was required at the time, it was also reported to the police. The question of who was responsible was difficult to determine because of the strange arrangement where the administration of medical physics at *Radiumhemmet* came under the Radiation Protection Institute whereas the work was a part of healthcare for which the head of *Radiumhemmet* was responsible. This meant that I was also summoned to be questioned by the police to find out whether there were shortcomings in the physicists’ instructions. However, the question of liability had still not been answered after a couple of years’ investigation.

3.14. **Sternglass**

In the summer of 1969, a number of articles by the American Professor Ernest J. Sternglass attracted considerable attention. Sternglass was Professor of Radiophysics at the University of Pittsburgh and was active as a medical physicist at the University’s radiology clinic. The articles appeared in *Bulletin of the Atomic Scientists* (*Infant Mortality and Nuclear Testing*), *New Scientist* (*Has nuclear testing caused infant deaths?*) and *Esquire* (*The Death of All Children*). The latter-mentioned article made the greatest impact on the public.

Sternglass maintained that one in three cases of infant mortality in the USA was caused by the radioactive fallout from the atmospheric nuclear weapons testing. He supported this claim with an interpretation of the official statistics on American infant mortality and used a diagram to illustrate his conclusion. It was shown that infant mortality during 1934–1951 could be described as a descending straight line in a log-linear diagram, which meant that fatality had fallen by the same percentage every year. Sternglass continued to draw out (‘extrapolate’) this straight line over the next few years until 1968. However, the observed fatality now no longer followed the extrapolated line but was higher. Sternglass thought the infant mortality ought to have continued to fall at the same rate as before and that the difference between the observed fatality and that which corresponded to the extrapolated line was due to a new risk of death which corresponded to the nuclear weapons testing in terms of time. This risk would then be much greater than the one assumed by UNSCEAR and ICRP.

Sternglass’ hypothesis led to big headlines and general unease. However, he faced strong criticism, even from many of those who used to criticise UNSCEAR and ICRP for underestimating the risks. One of these was the controversial, argumentative Oxford scientist *Alice Stewart*, who made a contribution to *New Scientist* under the heading *The Pitfalls of Extrapolation*. She wrote:

> [Sternglass] should consult pages 30 and 31 of *Facts and Figures* (Moroney, Penguin, 1960) where he will learn that this is not the first time that a reputable scientist has fallen into the trap of over-confident extrapolation, or asked his readers to believe in an implausible situation.
>
> The most likely explanation of the observed change is that it is a reversion towards normality of a death rate which had, for 20 years, been experiencing booster effects – first from the introduction and dissemination of sulphonamides, and then from the introduction and dissemination of antibiotics.

It was easy for us to ascertain that it was not possible to prove any corresponding extra risk in the Swedish fatality statistics; on the contrary, there was a sharper decline in the risk after 1960. Sternglass had been too eager and gullible.

At the Radiation Protection Institute, we still thought that most of the criticisms (but not Alice Stewart, who had endeavoured to refute him) had dismissed Sternglass too hastily, as though unreasonable statements *a priori* must be incorrect. I wrote in our collection of press cuttings called *Strålskyddsnytt* ('Radiation protection news') (no. 5, 1969):

> As far as the Radiation Protection Institute is concerned, it is safe to say that every serious statement that is made regarding the idea that radioactive environmental contamination has killed hundreds of thousands of children per year is at least worth a review, discussion and statement.

3.15. **Risø physicists visit the Reactor Location Committee**

The Risø scientists *Henning Jensen* and *Poul Emmersen* visited the Reactor Location Committee's Secretariat in Stockholm on 25 August to find out how the Swedish authority was structured and to discuss the licence application for Barsebäck. In their view, the probabilistic safety analysis was too brief.

3.16. **Budding environmental debate**

Rachel Carson's (1907–1964) polemic book *Silent Spring*, the Swedish edition of which came out in 1962 as *Tyst vår*, marked the introduction of the more extensive Swedish environmental debate which initially concerned chemical pesticides, primarily DDT and mercury. In Sweden, synthetic methylmercury was used until 1966 to treat sewn seeds, which led to significant bird mortality. The environmental problems from a wider perspective were discussed by Assistant professor in Chemistry *Hans Palmstierna* (1926–1975) in the book called *Plundring, Svält, Förgiftning* ('Plunder, Starvation, Poisoning') in 1967. The fact that authorities and experts were surprised by the problems also led to a distrust of radiation protection and many people assumed that many risks had also been disregarded here. In the case of radiation protection, the distrust was less justified, although the risk estimates over the years have gradually been revised.

Hans Palmstierna shared this distrust. He took Sternglass' misinterpretations of infant mortality seriously and criticised (quite rightly though) the American Atomic Energy Commission for its reaction:

> True to form, you might say, the American Atomic Energy Commission is protesting strongly against this interpretation of the statistics. It faithfully follows the pattern to which so many other authorities automatically resort, worldwide, when they feel that their interests are threatened by evidence that is too disadvantageous.

Palmstierna's method of debate did some good by fanning the flames of the problems and provoking reflection, but it did also irritate many. He acknowledged his deliberate use of hyperbole in an interview in *Ny Teknik* ('New Technology') (1969:23):

> *Ny Teknik*: Have you deliberately exaggerated in order to cause a debate?

> *Palmstierna*: There are times when you are unfortunately obliged to exaggerate, but you do then hope that the oscillations of the debate will gradually balance out. There may have been big arguments in the Rigello debate but they are now starting to become healthier.
> *Ny Teknik*: So has the debate been unhealthy?
> *Palmstierna*: The fact that some incorrect figures were spread at an early stage of the debate sent it in the wrong direction.
> *Ny Teknik*: Will you continue to exaggerate in these types of debate?
> *Palmstierna*: I will exaggerate with moderation.

Someone who disliked hyperbole was Director General of the Swedish Environmental Protection Agency *Valfrid Paulsson* (1925–) who wrote in the March issue of *Svensk Natur* ('Swedish Nature'):

> We are all interested in keeping the environmental protection debate clean. We have strong, factual arguments. Let us develop them, but let us crack down on exaggerations, irrelevancies and errors. We need an enlightened - not a misguided - opinion. Our environment needs to be cleaned up. It should not be necessary to set the same requirements for the environmental protection debate.

In another context, Paulsson is meant to have said that 'it's good to have alarm clocks but you do need to be able to turn them off'.

In September 1969, Tage Erlander stepped down as Prime Minister and was succeeded by Olof Palme.

3.17. The Congress of Radiology in Tokyo

The 12th international Congress of Radiology was held in Tokyo in September. It was the first time that the Congress was held in Asia. More than 3000 people took part. The industrial reconstruction of Japan had just begun but most of the presentations were given by North Americans and Europeans. The sole representative of ICRP was its Chair, Bill Pochin.

A powerful typhoon passed the area in which the meeting was held just a few days before the Congress.

3.18. Daring to debate

Gordon Stewart, who had just taken up his post as Chair of ICRP, had responded to a letter from John Dunster, who proposed that ICRP ought to take part in a current discussion on the Commission's recommendations. Stewart was not in favour of the proposal and thought it could easily lead to negative publicity. I had received copies of the letters that were exchanged and wrote the following to Stewart:

> Many thanks for your letter of 3 September. As you wrote to John Dunster, 'It is always a pleasure to hear from you, even if I do not agree with what you are proposing!' My view is that ICRP might make a fool of itself by taking part in a panel to debate its recommendations, but I also think it is what we would deserve if we were that incompetent. If we believe in what we have recommended and see it as fairly easy to defend, we should not be afraid to discuss it in public. This could at least help us to remove some of the current misinterpretations and misunderstandings. I therefore strongly support John in this regard. I hope that this support will also be given by all the others so that we succeed in convincing you. I look forward to meeting you on the panel and in Oxford and later on, but particularly at the Commission's meeting in London.

3.19. **The seed of optimisation thinking**

On 16 October 1969, an interesting article was published in *New Scientist*. It was written by a scientist at the University of Sussex, *Craig Sinclair*, and was called *Costing the hazards of technology*. It was a follow-up of David Sowby's article, *Radiation and other risks* in *Health Physics* in 1965 and discussed the consequence of the risk estimates. Sinclair led a research project paid for by the British Social Science Research Centre. Projects set out to study the best way of handling the health and safety resources by finding quantitative measurements of benefit and risk.

As we had done in the ICRP group which produced Publication 8 in 1966 on the assessment of radiation risks, Sinclair used a Gompertz diagram to illustrate the age dependency of the mortality for different causes of death. A Gompertz diagram is a diagram which shows the logarithm for the annual total likelihood of death as a function of age. For ages over 30, the equivalent curve in a log-linear diagram is a straight line, which usually means that the annual total risk of death is doubled for every seventh year. I mention the Gompertz diagram since it ended up playing a crucial role in the ICRP recommendations twenty years later.

Sinclair used the Gompertz diagram to illustrate the fact that accidents are the dominant cause of death up until the age of thirty. He stated a cost-benefit analysis as the method to find the optimum allocation of resources. After having discussed the practical problems of an apparently simple matter like the handling of protection against fatal accidents with overturning tractors, Sinclair wrote:

> This example illustrates the complexity of safety considerations even in a traditional industry. However, by application of cost-benefit techniques across industry and within an industry it is possible to allocate resources rationally and to move towards a maximisation of welfare without paralysing innovations.

To illustrate cost-benefit techniques, Sinclair used the now well-known diagram which shows that the optimum allocation of resources corresponds to the case where the sum of the cost of the protection and the cost of accidents is at its smallest. The problem was translating what were usually unquantifiable quantities like human injuries and deaths into monetary quantities.

3.20. **The Environmental Protection Act**

The first Environmental Protection Act (SFS 1969:387) was adopted in 1969. When it came to considering the emissions of environmentally-hazardous substances, the water courts were replaced by the Licensing Board for Environmental Protection.* An exception was made for radioactive substances since these were covered by the Radiation Protection Act. The Radiation Protection Institute therefore took over from the water courts the responsibility for establishing limits for permitted emissions of radioactive substances in water. It then became necessary for the Radiation Protection Institute to create a fundamental policy for this purpose.

At the Radiation Protection Institute, the responsibility fell to its nuclear physics department of which Arne Hedgran was in charge. This took place in a situation where the requirements for the limitation of emissions and discharges had become increasingly important.

3.21. **The radiation exposure per unit of an activity**

I had long discussions with Arne Hedgran about which requirements we ought to set regarding protection against the emission of radioactive substances from the impending nuclear power plants. What might be a reasonable requirement for an individual plant could perhaps be an inadequate requirement

* When the Environmental Code (SFS 1988:808) superseded the Environmental Protection Act in 1999, the Licensing Board for Environmental protection was replaced by the Environmental Courts.

for the future if many plants were to jointly contribute to environmental contamination. In this instance, you could not expect that which was adequate protection for the most vulnerable individuals from an individual plant to also serve as adequate protection against the overall contamination in the future.

Arne warned that in Canada, requirements had been set regarding the limitation of the collective radiation dose from each reactor. The collective dose is the average individual dose multiplied by the number of irradiated individuals. We could do something similar, said Arne. Together, we wrote an article in English for the Radiation Protection Institute's 1970 activities report with the long title *On the Swedish policy with regard to the limitation of radioactive discharges from nuclear power plants: An interpretation of current international recommendations*.

We worked on the basis of ICRP Publication 9 which gave a limit for the genetic 'population dose', as it was known at the time, of 5 rem over 30 years (a generation), i.e., an average yearly dose of 167 millirem. However, ICRP did not expect the generation dose from environmental contaminations and sources of radiation in our surroundings (wristwatches, TVs, etc.) to exceed a fifth of this value, i.e., 33 mrem. In order to prevent ICRP's expectations coming to nothing, we proposed that the average annual radiation dose to the public from the nuclear power industry should not exceed 10 mrem (0.1 mSv). The population dose ought therefore to be kept below 100,000 man-rem (10 mrem multiplied by 10 million Swedish people).

We then worked on the basis of the forecast that was soon to be published by the Swedish power companies' central operational management where it was estimated that the electric power in the year 2000 could amount to 100,000 megawatts. At the start of the noughties, it would not be possible to produce 100,000 MW for a radiation dose exposure greater than 100,000 man-rem per year. We assumed for safety's sake that all electrical energy would come from nuclear power plants. This meant a requirement for an average collective dose limit of *1 man-rem per MW electric power and year*. By expressing the limit in this way, we thought the future radiation exposure was under control.

Although this proposal was not published until 1970, I had already written a letter to Professor *H. H. Seliger* at the McCollum-Pratt Institute at Johns Hopkins University in Baltimore in October 1969, in which I advised him to express the limitation of emissions and discharges per unit of electric power. Seliger wrote:

> Many thanks for your letter of 6 October. Your proposal as regards the allocation of the genetic dose from the use of nuclear waste is excellent. It achieves precisely what I was trying to establish the other way round by applying risks. And it is actually the only completely logical way of dealing with the problem.
>
> ...
>
> I must confess that I did not think of expressing it like that. All I can say in my defence is that our current AEC rules mean that the nuclear power industry can monopolise the whole of the total dose of 5 rem, and I have been unable to see the wood for the trees.
>
> Thanks once again for your advice. Is this the current method in Sweden?

It would end up being so thanks to Arne Hedgran's plan. The presentation method of stating radiation doses per unit of the activity was rapidly taken on by UNSCEAR, and its 1972 report states radiation doses per MW and year for the public and, in an appendix written by David Sowby, for employees of the nuclear power industry.

We also received support for our proposal the following year from John Dunster, who had estimated the size of the different components of the collective dose. He wrote the following in a letter of 19 March 1970:

> It is possible to conclude from all of this that we will probably not exceed 1/10 man-rem/MW$^-$year compared with the number proposed by you, 1 man-rem/MW$^-$year.

Civil Engineer *Pelle Isberg* from *Asea-Atom* wrote that he had calculated the collective dose from krypton-85 and got it to 0.6 man-rem per MW of electric power and year - a big slice of the cake in other words.

We also received a number of other positive responses to our proposal. Professor G. Hoyt Whipple at the University of Michigan wrote to Arne Hedgran:

> The copy of the paper *On the Swedish Policy …* that you sent me has arrived. I have two comments:
>
> 1. It is the clearest statement on the subject that I have ever seen… If it is a translation from Swedish I must somehow set about learning Swedish.
> 2. It is the most reasonable assessment of the problem I have ever seen. This will of course result in the world crashing down around you.
>
> You may think that my comments are encouraging: you will probably not think they are helpful but, in all honesty, I cannot find any inadequacy or error.

The Radiation Protection Institute's board adopted our proposal as policy in 1970.

3.22. **Better PSA for Barsebäck**

On 19 September, a meeting was held in Stockholm to discuss the Danish criticism that the probabilistic safety analysis for the Barsebäck Nuclear Power Plant was too brief. The following all took part in the meeting: from *ASEA-Atom*, MD *Lars Halle*, Technical Director *Lars Leine* and Safety Manager *Pelle Isberg*, from Sydkraft Technical Manager *Anders Björgerd* and Lic. Tech. *Arvid Persson,* and from the Reactor Location Committee its Chair Arne Hedgran, consultant *Gustaf Edling* and the reactor inspectors *Erik Jansson* and *Tore Nilsson*.

Hedgran warned that at a previous meeting it had been said that something extra was needed owing to Barsebäck's sensitive position. There were grounds for improving the safety analysis bearing in mind that Danish criticism had also been levied. The industrial representatives' response was that there was not much time owing to fixed schedules, but that it was in principle right to improve the report. Hedgran then decided to set up a task group with a representative for each of *ASEA-Atom*, the Reactor Location Committee and *Sydkraft*. The group was to agree on how the probabilistic safety analysis should be worded. A report was to be ready by 1 November.

3.23. **Saltholm, aviation and Barsebäck**

The Reactor Location Committee had previously (on 27 August and 9 September) discussed the risk that crashing aircraft would hit the Barsebäck reactor bearing in mind that there were plans to locate a major airport on the island of Saltholm in Öresund. The matter was further discussed at the meetings of 16 October and 17 November and was found to be so important that it ought to be discussed by the Delegation of Atomic Energy Matters (DFA). This took place on 19 November when Arne Hedgran gave an account of the RLC's positive assessment of the aircraft issue. Hedgran had then travelled to Copenhagen on 13 November concerning this and informed Danish authorities of the way the reactor location issues had been dealt with in Sweden. On 21 November, the RLC decided to invite a delegation of Danish authorities to come and receive information on Barsebäck in mid-December. The invitation was sent by Arne Hedgran to the Danish Board of Health and the Atomic Energy Commission in Copenhagen on 1 December, and the information meeting was held at the Ministry of Industry on 17 December. Prior to this on 28 November, Hedgran had sent Juel Henningsen a report from Sydkraft on aircraft accidents, the Civil Aviation Administration's referral response regarding the location of the reactor in Barsebäck plus a supplement to the licence application for a probabilistic safety analysis.

3.24. **Information meeting with Danes and Swedes about Barsebäck**

An information meeting was held with the Danes at the Ministry of Industry in Stockholm on 17 December. The Danish Atomic Energy Commission was represented by *Hans von Bülow*, *H. L. Gjørup*, *Henning Jensen* and *Poul Emmersen*. From the Board of Health came *Niels Oehlenschlæger*, *Jörgen*

Koch and Per Grande. The Swedish RLC members and experts taking part were Arne Hedgran (Chair), *Bertil Aronsson*, Lars Carlbom, *Göran Dahlén*, *Gustaf Edling*, *Berndt Hargö* and *Lars Wallin*. *Paul Ek*, Erik Jansson, Tore Nilsson and *Frigyes Reisch* from the RLC's Secretariat also participated.

The agenda included:

1. Information on the RLC's composition and way of working
2. Report on the problems at the Barsebäck Nuclear Power Plant
3. Report on the issue of aircraft risks
4. Report on the control issues
5. Overview of the impact on the Copenhagen region in the event of an extreme accident at the Barsebäck Nuclear Power Plant

3.25. **ID cards**

In October 1969 I received a letter from Juel Henningsen. He asked about the Radiation Protection Institute's position as regards radioactive ID cards. We had discussed this matter in 1967 following an enquiry from *AB Atomenergi*. I was able to tell Henningsen that the Institute's board had said in December 1967 that it 'had no objections to a similar use of radioactive material under the conditions stated in the letter'. A 'similar use' had applied to identity documents issued by an instructed bank.

Henningsen had enclosed an application to the Danish authority from 'the Danish financial institutions' on 1 January 1970 to be able to introduce an ID card marked with a radioactive substance. The application referred to a letter from a newly-formed Swedish *AB ID-kort* whose ambition was to extend the use of the radioactive ID cards. *AB ID-kort* referred to the Radiation Protection Institute's 'positive response' in 1967 and wrote that 'The cooperation with the Radiation Protection Institute has been excellent and, on that basis, it will be possible to approve both the production technology and the right to distribute these radioactive ID cards to the Swedish public'. However, this was probably optimistic because the Radiation Protection Institute's board had not made a decision on the distribution of the radioactive ID cards to a wider public.

3.26. **Danish radiation protection**

In November 1969, Juel Henningsen wrote to me about another matter entirely. He was concerned about whether the Danish radiation protection was efficient. Unlike Sweden, where the Radiation Protection Institute was an independent authority directly under one Ministry, the Danish Board of Health's Radiation Hygiene Laboratory was a body which came under the Board of Health in a similar way as before 1958 when Sievert's radiophysics institute for radiation protection had, as regards radiological protection, been a body which came under what was then the Medical Board. The difference was that Sievert was a forceful manager who was not inhibited by any requirements from the Medical Board, while the strong man in Denmark was Medical Officer Juel Henningsen of the Board of Health rather than the phlegmatic Per Grande, the Norwegian who was head of the Radiation Hygiene Laboratory.

Juel Henningsen wanted to come to Stockholm to discuss the organisation of Swedish radiation protection with me. He wrote the following about the Danish circumstances:

> ... I am slightly concerned about the administration of our Radiation Hygiene Laboratory here in Denmark. Per Grande, who is my good friend, does his best and works hard. He has good employees but it is as though they cannot quite get into arranging an administrative pattern for this Laboratory. We have got them one employee after another. The assignments have grown but not to the same extent as the workforce.
>
> ...
>
> It is obviously difficult for me in my day-to-day work as head of a department at the Board of Health under which the Radiation Hygiene Laboratory has been placed to keep

> up with the work out there* and to adequately influence this. I have also wanted to give Per Grande all the freedom and authority that he should have so he does not feel that his day-to-day work is 'under my administration'. I believe this was successful and that we have the best relations with one another. However, on the other hand, I do believe that it has had some degree of impact on the efficiency of the laboratory.

In short, the nice Per was a little too unenterprising to be efficient. Juel Henningsen clearly wanted Per to be a more vigorous manager or someone who was better at enthusing his colleagues into being efficient. Unfortunately, I do not remember Henningsen's visit, assuming that it did take place, but hope that he benefitted from it.

3.27. **ICRP Committee 3**

At the end of the year I wrote to the members of ICRP Committee 3, of which I was still Chair, and informed them of the situation. The Committee had, like the other Committees and the Main Commission, gained new members at the time of the 12th International Congress of Radiology in Tokyo in the summer. The Committee's members were now:

Bo Lindell, Chair
E. E. Smith, Deputy Chair
Lars-Eric Larsson, Secretary
Frederick Cowan
John Kelley
E. E. Kovalev
Raymond Oliver
Pierre Pellerin
K. A. Rowley
Shinji Takahashi

Dale Trout was no longer a member (at his own request), and nor was Harold Wyckoff, whose age and experience from the start made me uncertain whether I would be able to cope with being Chair of such an impressive group.

I said how far the work had progressed. Per Grande's task group for revising Publications 3 and 4 had finished its work with the new recommendations on protection against external radiation, and both the Committee and the Main Commission had approved the result. The Appendices with diagrams and tables were on the other hand far from finished. The group had been hit hard when its Secretary Brian Jones had suddenly and unexpected died on 28 November. Brian had been very popular with everyone, was very competent and had worked hard with the assignment. We missed him a great deal.

It was now obvious that the Appendices had to be published separately from the recommendations. The latter were in the process of being finally edited by David Sowby and were published in 1970 as ICRP Publication 15 on protection against external radiation.

Eric Smith had been kind enough to offer assistance from the Radiological Protection Service in Sutton to complete the work with the Appendices which Brian Jones had begun. They ended up being published in a special volume as ICRP Publication 21 in 1973.

The task group which was led by Dr. Reynold Brown concerning patient protection during x-ray examinations had also completed its work and the report was now being edited by Sidney Osborn and Ken Rowley, both of whom had been in the task group. The report was published in 1970 as ICRP Publication 16.

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* The Laboratory was in the north-western outskirts of Copenhagen.

In a third task group, Dale Trout and Eric Smith had compiled recommendations for protection against school pupils up to the age of 18 with a view to radioactive sources being used in teaching. Their report was released as Publication 13, also in 1970.

The Committee was provisionally summoned to a meeting in Stockholm in April 1970.

3.28. **ICRP in general**

I have given a separate account of Committee 3's activities because I happened to be Chair of the Committee. The time of the Congress of Radiology in Tokyo obviously involved new set-ups for members of both the Main Commission and the three other Committees. The new composition of the Main Commission was then:

Gordon Stewart, Chair (he succeeded Bill Pochin)
Bo Lindell, Deputy Chair
Dan Beninson
Otto Hug
Henri Jammet
John Loutit
Andrew McLean
Karl Morgan
Russel Morgan
Yuri Moskalev
Howard Newcombe
Edward Pochin
Brian Windeyer
Lauriston Taylor, Emeritus Member
David Sowby, Scientific Secretary

The Committees were made up of the following people:

Committee 1
Howard Newcombe, Chair
Arthur Upton, Deputy Chair
G. W. Barendsen
A. M. Brues
L. Eldjarn
J. Lejeune
R. W. Miller
R. H. Mole
V. Zeleny

Committee 2
Karl Z. Morgan, Chair
W. G. Marley, Deputy Chair
G.W. Dolphin
M. Dousset
W. Jacobi
J. Liniecki
L. D. Marinelli
P. E. Morrow
J. Müller
W. S. Snyder
R. C. Thompson
J. Vennart

Committee 3
(see previous section)

Committee 4
Henri Jammet, Chair
Dan Beninson
G. C. Butler
H. T. Daw
H. J. Dunster
K. Koren
D. Mechali
A. A. Moiseev
C. Polvani
P. Recht
L. Rogers
D. J. Stevens
E. G. Struxness

A few comments are needed regarding the list of members. Dan Beninson was formally a member of Committee 4, although he was also a member of the Main Commission. This was slightly strange since the members of the Main Commission were entitled to take part in the Committees' meetings if they wanted to. For example, I also took part in Committee 4's meetings, but Dan felt it was his duty to point out that he was a member of the Committee.

All Committees apart from Committee 4 also had a Deputy Chair, although not elected by the Main Commission but by the Chair of the Committee. Henri Jammet did not want a Deputy Chair, but in reality David Mechali functioned as such, despite French being his only language. Jammet's Committee did not enjoy good cooperation with Committee 2, and there were a good number of occasions when Mechali and Walter Snyder, who was Secretary of Committee 2, had to intervene to calm down Jammet and Karl Morgan, who found it easy to end up quarrelling about which tasks their Committees ought to concentrate on.

Some of the documents that were being written at the end of 1969 and the discussions that were held are particularly worth mentioning. The Main Commission had difficulties with the radiation protection policy in Publication 9 from 1966. It had not involved any particular innovation as regards the application since Failla's task group had drawn up Publication 1 in 1958, work was still being done on critical groups and critical organs and the MPC values for permissible concentrations in drinking water and breathing air. However, it had introduced the concept of risk and thereby a fundamental consideration of *stochastic* harmful effects where the occurrence of an injury (cancer or hereditary defects) at a given dose in each individual case was not unavoidable (*deterministic*) but random. It had also introduced a dose limit for the irradiation of 'the public' and adhered to 5 rem as a limit for the 'genetic dose' (gonadal dose per generation) from all radiation except for natural radiation and that which patients are exposed to during medical diagnostics and radiation treatment. On the other hand they had abandoned the example (illustrative apportionment) of the way in which this dose could be distributed among different sources of radiation. The radiation dose was expected to increase with the increase in the use of nuclear power plants but was not thought likely to end up exceeding 1 rem (10 millisieverts) per generation.

This was all well and good, but how would the protection be administered in practice? Critical organs and MPC values were remnants from the time when calculations were performed using only deterministic effects of radiation. And how would paragraph 52 of Publication 9 be interpreted, which said:

> As any exposure may involve some degree of risk, the Commission recommends that any unnecessary exposure be avoided, and that all doses be kept as low as is readily achievable, economic and social considerations being taken into account.

his was the problem with which the ICRP Main Commission battled in autumn 1969. The Commission had also set up its own one-man 'task group' consisting of Dr. Roy Ellis to draw up a report on patient protection during nuclear medicine examinations, an equivalent of Committee 3's report on patient protection during x-ray examinations. Ellis' report was published as Publication 17 as early as 1969.

Committee 1 had just completed a report on sensitivity to radiation and the spatial distribution of the radiation dose in different tissues. It was published as ICRP Publication 14. It is interesting to read what was written about linear dose-response relations in paragraph 25:

> Both in the setting of dose limits for separate organs and different parts of the body, and in legislating for non-uniform exposure within an organ or specified part of the body, a vital consideration is the range of dose and dose rate over which effective linearity of dose response can be assumed to hold. As discussed earlier, it is not unreasonable to assume that a linear relationship applies at very low doses (or at higher doses with low dose rates).

Committee 1 thus adhered to the linear dose-response relation which had already been adopted in Publication 8 in 1966.

It may be of interest to point out that in Sweden, the term ‘dose rate’ for the dose per unit time was comparatively new. The term ‘dose speed’ was still being used in the mid-1960s as the Swedish translation of the English term ‘dose rate’.

4. THE YEAR 1970

4.1. X rays in the broader sense

Over the years, the concept of an ‘x ray’ has come to have meanings beyond the use of x rays. In popular portrayals, an ‘x-ray image’ often refers to a depiction which shows the internal - not usually visible - structure of an object such as a car. Within medicine, x-ray examinations constitute the first method of producing images and open the door for other methods that have the same purpose but which sometimes have nothing at all to do with x rays or even ionising radiation. In such cases, the word ‘x ray’ should not be used – it should be used only in cases where x rays are actually used.

Splendid new tools for diagnostics using images of specific layers of the body (*tomography* is from the Greek *to'mos*, meaning ‘section’) have been developed over the past thirty years. They are often referred to using acronyms such as CT, ET, MR, PET and SPECT, which are useful to the specialists but less easy for other people to understand. These tools are of interest in my depiction because they sometimes emit comparatively high radiation doses (CT) but in other cases offer an alternative to the use of x rays or radioactive substances (MR). A common factor of the tools is that they use advanced computer technology which makes it possible to process the large amount of information that is needed to produce slice images of internal organs and tissues.

I provide the following overview in this chapter because 1970 can be seen as the introduction of a new era for medical examinations using images, not least because of the rapid development of information technology (IT) thanks to the increasing speed and memory capacity of computers. The meanings of the acronyms are explained with reference to the later chapters where the phenomenon is discussed in greater depth.

CT (*computed tomography*) or transmission computed tomography is described in the chapter on 1972, the year when the method was announced in London. The method is also called CAT scanning (for computed axial tomography, or computer-assisted tomography). It produces x-ray images of specific consecutive slices of the body. As with conventional x-ray diagnostics, the method is based on the different transmission of the x rays through different tissues, but in this case the radiation does not fall perpendicular to the irradiated layer – it comes from the side. Advanced computer software is therefore needed to create the final x-ray image.

ET (*Emission tomography*), a summary name for *PET* and *SPECT*, which use radiation that comes from radioactive substances inside the body (as opposed to a CT where images are created using x rays which come from outside and penetrate the body, a transmission tomography).

PET (*positron emission [computed] tomography*) is described in the chapter on 1977 when the first PET camera was installed at *Karolinska sjukhuset*. Here, the source of radiation is a short-lived radioactive substance which emits positrons. These are annihilated almost immediately close to the source and their energy is taken over by a couple of energy-rich photons, ‘annihilation quanta’, which are emitted in opposite directions. These can be detected outside the body using coincidence technology and the position of the source of radiation can be identified because it has to be on a line between the registering detectors.

SPECT (*single-photon emission computed tomography*) is described together with the PET in the chapter on 1977. In this case, the source of radiation is a gamma-emitting radioactive substance which has been conveyed to the blood, for example. The gamma radiation can be registered outside the body in gamma cameras or other detection systems which provide an image of the distribution of the radioactive substance.

MR (*magnetic resonance tomography*) is based on the physical phenomenon of nuclear magnetic (spin) resonance (NMR) and has nothing to do with ionising radiation or x rays. The 'R' unfortunately lures non-specialists into talking about 'magnetic x ray', which is completely wrong. On the other hand, the popular name of 'magnetic camera' for the equipment is acceptable. The method is based on specific atomic nuclei selectively absorbing radio waves in a magnetic field. The method is described in the chapter about 1982, the year in which it began to be used on a much more widespread scale.

4.2. The preparations for the 1972 environmental protection conference

Just before the end of 1969, the daily press announced that Tage Erlander, who had been succeeded by Olof Palme as Prime Minister in 1969, had been appointed Chair of the National Committee that had been set up to prepare the 1972 environmental protection conference in Stockholm, the first international Environmental Protection Congress. Senior Administrative Officer *Jan Mårtensson* (1933-) was appointed as Secretary. What the papers did not say was that Mårtensson was on the way to becoming a popular detective novelist. I was one of the many others on the Committee, probably because I was Sweden's UNSCEAR representative.

4.3. Letter from Hans von Bülow of the Danish Atomic Energy Commission

On 15 January 1970, Hans von Bülow of the Danish Atomic Energy Commission wrote to Arne Hedgran. I quote the following from the letter:

> First of all, thank you very much for the meeting in Stockholm on 17 December, which was pleasant and very useful for both the Atomic Energy Commission and the Board of Health. We are very grateful for your promise of ongoing information on the way in which Swedish authorities deal with all of the safety matters concerning the Barsebäck plant and we will obviously contribute to the best of our ability to the exchange of information, etc. regarding this plant. The continuous contact should probably be technical in the first instance. We have considered the best way to do this as far as the Atomic Energy Commission is concerned, and have agreed to appoint Civil Engineer Henning Jensen – whom the Swedes already know and who is chairman of a technical committee set up on Risø to coordinate the technical handling of questions on reactor safety and act as contact person, as you have appointed reactor engineer Tore Nilsson on behalf of the Swedes.
>
> As contact person, it will be up to Henning Jensen to keep himself updated on the way Swedish authorities deal with the nuclear safety problems in the Barsebäck case and, as far as we are concerned, he is of course authorised to meet Mr. Tore Nilsson in person when and where it is deemed appropriate. We have asked Henning Jensen to submit regular reports to Risø's management and to the Secretariat of the Commission, who will then ensure that these reports and other information are given to the Board of Health.
>
> I understand that when we met in Stockholm we agreed to hold a new meeting of representatives of the Reactor Location Committee and the Atomic Energy Commission and the Board of Health when this is deemed necessary.

4.4. Nordic points of view regarding UNSCEAR's work

On 23 January I wrote to Juel Henningsen, Reidar Eker, *Aulis Isola* and Gudmundur Jonsson, asking for their desires and points of view on the continued work of UNSCEAR. I thought Sweden had a duty to put forward views from the other Nordic countries. Juel Henningsen's response was polite and friendly: 'we feel that we are very well represented through you taking part in the Committee's work on the part of the Swedes'. Following a meeting with the National Council on Radiation Hygiene Matters, Eker put forward the following four things that he wanted:

1. **Reactor radiation hygiene**
   With the expected increase in the number of mainland reactors and also ship reactors in the next decade, it would be good to have an assessment of the radiation hygiene consequences to which such a development may lead. This concerns those who are exposed at work as well as the exposure of the surrounding population – both individuals and populations groups. Reactor radiation hygiene includes waste disposal, uranium processing plants, storage facilities, transportation and discharges.

2. **Effects of large quantities of radioactive fallout**
   It would be good to have an assessment of both the acute and the late effects of a local injection of quantities of radioactivity that can give doses of more than 100 rad in external radiation over limited land areas. As well as the health consequences to which such a situation can lead for different age groups, the psychological and social effects ought to be analysed as well, plus the countermeasures that may be relevant. The next step should be to deal with the same questions on the assumption that there are large quantities of fallout all over the globe.

3. **Effects of small doses and of low dose rates**
   With reference to the debate which is now ongoing regarding the ICRP values, it would be good to have another assessment of the effects of doses lower than 10 rem and dose rates below 1 rem/year. This concerns somatic and genetic effects. An assessment of iodine is of particular interest because of the critical role of iodine in the preparedness for reactor discharges and radioactive fallout.

4. **Ecological impacts**
   Due to the conflicting views expressed regarding possible effects of low radiation doses to maritime organisms, it would be good to have an overall analysis of this problem. It would also be interesting to have an assessment of the impact of heat emissions (thermal pollution) on the sea and fresh water.

Isola expressed the following desires from Finland:

1. Somatic and genetic effects of ionising radiation (update of the 1958 UNSCEAR report).
2. Somatic and genetic effects after the medical use of ionising radiation.
3. Quantitative models of dose-effect relationships for use in planning in connection with radiation accidents and the Civil Defence.

4.5. **Sternglass – continued publicity**

Professor Sternglass' claims regarding a hefty increase in infant mortality due to radioactive fallout were still being given substantial publicity in 1970. He had visited London where the publicity led to a critical article in *Nature* written by the two British scientists, Patricia Lindop and Joseph Rotblat. Since Rotblat had initiated the Pugwash movement along with *Albert Einstein* and Bertrand Russell in 1955 (which led him to win the Nobel Peace Prize in 1995) he could not exactly be suspected of belittling the radiation risks. Another nuclear weapons critic was quoted as saying 'If Sternglass can't convince Joe Rotblat that he's right, who can he convince?'

On 1 February, *The Sunday Times* carried a big article on Sternglass with the headline *The man who cried wolf*. But Swedish newspapers were less critical. On 27 January there was an article in *Aftonbladet* with the headline '**Millions of children die every year** from radioactivity after the nuclear tests – Sweden also affected'. This led me to immediately write a letter to the newspaper's chief editor *Gunnar*

Fredriksson with reference to some of the scientists who refuted Sternglass (Alice Stewart and *Leonard Sagan* in *New Scientist* and Lindop and Rotblat in *Nature*). I completed the letter with:

> Either the reporter has never believed Sternglass' information (which is a sympathetic interpretation). In that case it would be dishonest to the readership to bring it to them in this manner. Or else, the reporter may have been neutral towards the content or even thinking that the information may have been correct.
>
> In the latter case, the reporter and the chief editor have demonstrated a frightening level of insensitivity as regards the attitude to human suffering. In such a case, how can someone, without thinking further about what has happened, pass on information that millions of children per year are killed by radioactive environmental contamination yet at the same time accept it as a piece of news without contacting an expert or looking more closely into the case himself? Are journalists so insensitive as to be able to write a report about a million children having been killed one minute and the next minute move on to talk about something else?
>
> If the newspaper is serious in communicating its claim, it has a duty to follow up what has happened. If it does not believe what it is saying in its headlines, how can it really expect to retain the trust of its readership in the long term?

Fredriksson's response was as follows:

> Obviously, neither I nor our journalists know the details of the scientific debate on these matters or have an idea of conflicting perceptions of different scientists. However, *Aftonbladet's* article clearly shows that it constitutes a report on Professor Sternglass' address in London. However you look at this discussion, it is still clear that Sternglass is one of the authorities, albeit not undisputed. Scarcely any scientist in this area can claim not to be undisputed, and we must assume that our readers are generally sufficiently well-educated to know that different scientists now and then present different findings where these things are concerned. I therefore cannot see that there is any serious error in occasionally referring to this type of statement, although *Aftonbladet* cannot reasonably be fully consistent when it comes to reporting news in these areas. All we can do is refer to what prominent experts say.

As so often happens in debates, Fredriksson missed the point. I had a vision of the old story where at a cocktail party you rarely listen to what is really being said when you are toasting one another. 'I've just hung my aunt in the loft!' 'Oh, nice to meet you.'

4.6. Barsebäck gets Government approval

On 6 February 1970, the Swedish Government gave *Sydsvenska Värmekraftaktiebolaget* ('*Sydkraft*') permission in accordance with the Atomic Energy Act to erect, possess and run a nuclear reactor in the Barsebäck plant.

4.7. Gofman and Tamplin

In the 1960s, the head of radiation protection research at the Lawrence Livermore National Laboratory in Berkeley in California was Dr. John Gofman. He obtained a PhD in Physics from Berkeley during the time of the Manhattan project and had demonstrated the fissibility of uranium-233 and assisted with the production of plutonium at the request of Robert Oppenheimer. In 1946 he had also become a medical doctor, this time at the University of California Medical Centre in San Francisco. He was respected as a very knowledgeable scientist. His closest colleague was physicist Dr. Arthur Tamplin. The Livermore Laboratory was run by the American Atomic Energy Commission (AEC). The AEC had asked Gofman and Tamplin to research radiation risks. This was of great importance to the AEC which had long been criticised and accused of harming people with radioactive fallout from nuclear weapons testing.

When Ernest Sternglass began his campaign against the AEC in 1969 with wildly-exaggerated and completely unfounded risk estimates (*The death of all children*), the AEC asked Arthur Tamplin to write a reply. Tamplin wrote a critical review of Sternglass' claims and found them to be unjustified and heavily exaggerated. However, in the same reply he presented his own appraisal which showed the possibility of thousands of deaths. This agitated the AEC and it asked Tamplin to leave out the appraisal. However, Tamplin was supported by Gofman who considered the appraisal to be reasonable. This led to a conflict between the two scientists and the leadership of the AEC.

The authority that was responsible for Federal radiation protection instructions in the USA in 1970 was the Federal Radiation Council, which had been formed by President Eisenhower in 1959 and had issued 'guidelines' in 1960 and 1961[*]. The Managing Director of the FRC was Dr. Paul Tompkins. The FRC had picked up on the ICRP recommendation that the genetic dose, i.e., the radiation dose to the genitalia, ought not to exceed 5 rem during the fertile years. With a 30-year generation time in mind, the FRC had therefore recommended a Radiation Protection Guide of 170 millirems per year. This was the same default value from which Arne Hedgran and I had produced a maximum permissible annual *average dose* of 10 mrem from the nuclear power industry. With UNSCEAR's and ICRP's risk estimates at the start of the 1970s (you need to read between the lines), there would have been approx. 5000 deaths per year in the USA *if* everyone received 170 mrem per year. Tamplin's estimate had therefore not been unreasonable, given the conditions.

However, the conditions were of course not realistic. ICRP had assumed that the overall limit of 5 rem per 30 years would be apportioned for different purposes and had expected just small fractions of this dose to come from each type of radiation source. The AEC could also have stated the limitation of the contribution from the nuclear power industry that we had counted on in Sweden. Not doing so left it open to critics – for now, Gofman and Tamplin were wronged and critical – to speculate what would happen if the AEC were to use the whole of the genetic dose limit.

The conflict led to the research grant for Gofman and Tamplin being reduced and finally withdrawn so that they had to leave the Livermore Laboratory. The unfair treatment annoyed them and they began expressing themselves using increasingly strong language, which was a shame because in principle their thoughts were of value.

At the end of 1969, the American Senate's Sub-committee on Air and Water Pollution held a hearing at which Gofman and Tamplin gave evidence. They said:

> We wish to advise you that, in our opinion, the most crucial and pressing problem facing everyone concerned with any and all burgeoning atomic energy activities is to secure the earliest possible revision *downward*, by *at least a factor of ten,* of the allowable radiation dosage to the population from peaceful atomic energy activities. The Federal Radiation Council allowable dose of whole-body ionizing radiation is 0.17 rads per year. We shall present to you hard evidence that leads us to recommend that this be reduced now to 0.017 Rads or even less.

This caused the Chair of the sub-committee, Senator Edmund Muskie to write to the Secretary of ICRP, David Sowby and ask for comments. He had found that Gofman and Tamplin had given an 'impressive analysis of the need for the review' and he asked for comments owing to 'the merits of the witnesses'. So Gofman and Tamplin were still reasonable and did not even demand that the AEC reduce the dose limit as far as we had in Sweden.

But then things started to rocket. The two scientists began to accuse ICRP and others of basing their radiation protection policy on the existence of a threshold dose so that there was no need to count on low radiation doses. This was completely wrong of course. On 14 January 1970 I wrote to Paul Tompkins

[*] See page 269 of 'The Labours of Hercules'.

asking for information on the background to the outbursts of the scientists. On 15 January, David Sowby wrote to Senator Muskie and reported the ICRP policy. On 23 January I wrote to the Secretary of UNSCEAR Francesco Sella.

It was now clear that Gofman and Tamplin had not just overestimated the possible radiation doses but that they now also saw the risk of cancer from radiation as significantly higher than ICRP had accepted. The reason for this was that they adopted a 'doubling dose', i.e., a *multiplicative* connection between radiation dose and increase in the likelihood of cancer. A given radiation dose would increase the incidence of cancer by a specific percentage instead of with a constant amount (*additive* connection). This was largely what UNSCEAR and ICRP also later assumed. I asked Sella what he thought about it.

Sella answered a trifle haughtily:

> I do not think Gofman and Tamplin's statements are more scientifically serious than Sternglass'. Gofman and Tamplin maintain that they have revealed much higher risks of malignant tumours than had previously been felt. They have actually looked at information which is well-known (mainly ABBC* and Court Brown and Doll†) and have been totally confused in trying to calculate relative risks of different types of tumour from data that is incomplete or inadequate. I do not believe that anyone who is in the slightest bit used to risk estimates, and the problems they bring, ought to concern themselves with Gofman and Tamplin's argument.

I found Francesco's attitude unnecessarily supercilious. Placing Gofman and Tamplin on an equal footing with Sternglass was unreasonable. Sternglass was an uncritical amateur whereas Gofman and Tamplin were professionals, although they did start failing to hit the mark. This irritated me enough to get me to write a letter which I sent to Dan Beninson, John Dunster, Henri Jammet, Bill Pochin, Francesco Sella and Paul Tompkins. I thought that I had a special responsibility as Deputy Chair of ICRP. I began by writing:

> As regards Gofman and Tamplin, I do not agree with the almost automatic reaction from most people, that the statements from these gentlemen are completely stupid and that their assumptions are arbitrary. This appears to me to be a defensive reaction that is really not justified. I can see very few points where Gofman and Tamplin do not present their case very reasonably, and I was interested in Tamplin's thorough criticism of Sternglass in *Bulletin of the Atomic Scientists* (a very proficient feature).

As regards the demand for the AEC's dose limit to be lowered, I wrote:

> If this [that the whole dose limit of 5 rem over 30 years is not available for individual activities] is not clarified to the public, it will be easy to understand how people will believe that we are simply intending to lay our hands on the whole limit value and immediately use it solely for the nuclear power industry. I have realised that Gofman and Tamplin have demanded that the share for this purpose be 0.017 rem per year and I find that this concurs with what we think ourselves and with ICRP's philosophy and, last but not least, also with the actual safety planning that is currently taking place.

As regards the claim that the risk of cancer is underestimated:

> My guess is that the risk is greater than we thought but not as great as Gofman and Tamplin believe. However, as Gofman and Tamplin indicate, science can work with guesses but long-term radiation protection must be based on safety (although I ought to

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* Atomic Bomb Casualty Commission, see page 239 of 'The Sword of Damocles' and page 271 of 'The Labours of Hercules'.

† See pages 159, 206, and 272 of 'The Labours of Hercules'.

say that in both directions, safety can also be used to the detriment of something if it is overplayed).

Should the ICRP dose limits be revised?

> Not necessarily for this reason, but they may need to be revised because of Publication 14. We should remember that there is a great possibility that it is not the whole-body dose which is the limiting factor when it comes to emissions from nuclear reactors.

I received a rapid response from Sowby, Pochin, Sella, Dunster and Tompkins. Sowby wrote:

> It appears to me that you have summarised the situation very well and I do not have many comments to make.
>
> Personally, I cannot get particularly worked up about the difference between the risks that have been calculated by ICRP/UNSCEAR or by Gofman and Tamplin. With our methods, we would estimate 3000-8000 cases of cancer per year in the USA if everyone received 0.17 rem. This is comparable with Gofman and Tamplin's estimate of 16,000, which they now say should be higher. But they are both estimates and we still do not know whether the linearity remains at low doses. This remains the most important unsolved problem in this area.
>
> ...
>
> However, as you say, these are questions that should have come up under any circumstances, with or without Gofman and Tamplin, and which ICRP Publication 14 will force the Commission to address.

Pochin thanked me for my 'careful and valuable letter' and maintained that there would always be difficulties with an upper limit which was not intended to be used as anything other than a safety valve. He completed his letter by saying that: 'I agree that it ought to be completely clear that a value such as 5 rem per generation is a value that we should avoid work up towards rather than one which we should work down from'.

Most of what the letter that Sella sent in response contained consisted of criticism of Gofman and Tamplin's calculations, but he had not let go of his dismissive reaction. He wrote:

> I find G and T's numbers totally unacceptable and not worth discussing within any international body whose primary task is to assess factual information rather than claims made by harassed people on the basis of only parts of the factual material. It is obviously not for me to tell the Commission what it should do, but you can be assured that arguments such as those set out by G and T at the hearing in November will not be mentioned in our documents.

John Dunster's response was long, wise and interesting. He started his letter with:

> Dear Bo,
>
> I find that nowadays, I open letters from you with a very ambivalent feeling. On the one hand the subject under discussion is very appealing, but on the other hand your letters lead to a complete halt of my normal activities.

He continued:

> First and foremost, I think it is important to differentiate between two sides of Gofman and Tamplin's arguments. Their work with risk estimates is certainly not foolish, although I do think it is misguided in some respects. However, when all is said and done, there does not appear to be more than a factor of between 3 and 10 between their opinion and the one that can be understood from ICRP Publications 8 and 14.

...

On the other hand, I am less convinced of the quality of the thinking behind the way in which G&T use risk estimates. The do not appear to be in a position to differentiate between the use of risk estimates as a basis for choosing maximum permissible doses and as a method of estimating the likely number of deaths according to a given dose situation. I am very strongly convinced that the use of risk estimates for the first purpose does not mean it is justifiable to make statements such as 'As a result of this exposure there will be X number of deaths'. I think all we can say at the moment is that the number of deaths will be between 0 and X.

Tamplin's use of the Federal Radiation Council's number 170 mrem/y as a dose level which legally, and thereby in practice, could be given to the whole of the American population provoked me into using the adjective 'foolish' in a public appearance. He ignores the dose limit for individuals, which in practice ensures that the average dose to the population will be way below the FRC's limit.

He has a point in that it would have been wiser for the FRC to avoid this form of limit. The approach in this country is to say that each component of the population dose must be kept as low as is practically possible and that under no circumstances must a limit of 5 rem over 30 years be achieved. I do not believe that this is a subtle distinction.

I agree that G&T need to be taken seriously, but I am becoming increasingly disturbed by their obvious incapacity to approach people or the subjects without exuberant feelings.

Tompkins wrote:

You are absolutely right in thinking that the FRC's numerical recommendations to protect the whole population were never intended to be applied solely to the nuclear power programme.

...

In this country we are very concerned about how the slanderers of atomic energy use different radiation risk estimates. I have interpreted the order of risk * which is stated in ICRP 8 as an estimate of the area within which the upper limit for stated effects is expected to fall. The lower limit could be zero, at least for somatic effects.

Since we are using language which may mean that the number of cases is real rather than hypothetical, we find ourselves accused of having passed judgement that the calculated cases of cancer are acceptable. The general opposition to nuclear power in the United States (aside from Gofman and Tamplin) can be described approximately as follows: 'How can you have the cheek to install a nuclear power plant that you know will cause leukaemia and cancer? Who do you think you are to determine how many deaths are acceptable - God?'

This point of view which is now gaining more rather than less support in the United States is the real problem that we must get to grips with. I believe it would be advisable for ICRP to accept the fact that the attack on the radiation protection standards is a political attack against the AEC in the United States and not take it as being based on good science.

Gofman and Tamplin felt even more insulted by the AEC and began to abandon scientifically-sustainable arguments for heavy overestimations of the radiation risks. The revised their estimate of the possible harmful impacts of the nuclear power industry to 32,000 cases of cancer annually and 1,500,000 deaths due to hereditary injuries. At the end of 1970 they published a book with the provocative title *Population control through nuclear pollution*.

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* Order of risk according to ICRP Publication 8 (see pages 348-349 of 'The Labours of Hercules').

4.8. **The expertise of the Civil Defence's radiac centres**

The question of competent personnel for the Civil Defence at the radiac centres was closer to being solved during that year. I wrote to the Ministry of Defence's coordination department in January, proposing that the Ministry of Defence make a statement regarding the suitability of stationing personnel with radiation protection training as experts in radiac centres as per an enclosed proposal. I also proposed that the Civil Defence Board should be asked to allow said experts to take part in the Rosersberg course that was planned for the following year and, in connection with this course, that a special radiation protection conference be arranged to which the heads of the radiac centres should also be summoned.

In April, the Civil Defence Board sent out a circular containing the following text:

> The Civil Defence Board has been informed privately by the Ministry of Defence/the Coordination Department that the National Radiation Protection Institute and the FOA have examined the availability of personnel with radiation protection training who may be suitable to be stationed in regional radiac centres.
>
> This has been examined on the basis of the fact that, in a war situation, it would probably not be possible to rely totally on the radiation protection expertise that is available nationally. It appears to be appropriate to supplement the competence at the operative follow-up of a radiac situation which is currently available at the radiac centres with competence within the radiation protection field. The Civil Defence Board would therefore recommend that the civilian commanders and the County Administrative Boards look at the possibilities of placing a specialist in radiation protection matters in the radiac centres. In an Appendix there is a proposal for suitable people for radiac centres where, according to information, such specialists are lacking.
>
> The personnel need to be withdrawn until spring 1971 when the board is planning to hold a course for personnel at regional radiac centres whereby the intention is to devote one day of the course totally to radiation protection matters.

4.9. **ICRP's entertainment funds**

It may be interesting to see how an organisation like ICRP has tried to solve the problems of covering entertainment expenses. One particular problem has been to find funds to arrange dinners or other friendly get-togethers for the members. Both Sievert and Pochin as Chair had been careful not to dip into funds that ICRP had received for its primary activity for such purposes. When Gordon Stewart had succeeded Pochin as Chair he asked me for advice on the matter. Since I was apprehensive that he would be tempted to use some of the ordinary funds for this purpose, I was anxious to give advice that could not be misunderstood. I wrote):

> You are asking a question which I am sure has constituted a concern not just for you but also for the previous Chair. I know, for example that Rolf Sievert, like you, thought that the friendly, relaxed meetings of ICRP members outside the Committee rooms as well constituted a crucial method of, as you put it, creating the friendly harmony that is so characteristic of ICRP. He was so convinced of this that he made significant efforts to have special funds reserved to cover this type of expenses. Unfortunately, he was only successful when it came to special occasions when he could point out the meetings that were about to take place.
>
> I share the view that almost everyone should be put to the test to make it possible for those who take part in ICRP meetings to be able to meet each other under pleasant circumstances in an enjoyable environment. I believe that all efforts to make the meetings relaxed are greatly appreciated and serve the good purpose of making it easier for members to get to know one another well enough to make the more formal the meetings less formal and more productive.
>
> When I say that almost everyone should be put to the test, I have one reservation in mind. Under no circumstances must the current ICRP grants be used for this purpose. Let us view them as taboo. I could give you plenty of good reasons for this, but unless

> you want to pressurise me, I would prefer not to list them all. I think that you and all of us should make further efforts to find other means of maintaining the relaxed atmosphere.

4.10. **IRPA in Brighton**

IRPA's 2nd big Congress was held at the Metropol Hotel in Brighton at the start of May 1970; I was staying at the more modest Queens Hotel on the Kings Road. Before I came to Brighton I had stayed overnight at David and Sheila Sowby's in Wimbledon. IRPA's General Assembly was held on 6 May. At the time, the Nordic Society for Radiation Protection was represented by:

Denmark:	Eigil Juel Henningsen
Finland:	Olli Castrén
Iceland:	Gisli Petersen
Norway:	Per Oftedal
Sweden:	None (Bo Lindell had a personal right to vote as member of the board)

The General Assembly decided to accept an invitation from the USA to hold its 3rd Congress in Washington DC in 1973. Of the many presentations, two in particular included a step forward for the radiation protection thinking. They are dealt with in a later Section (4.12). After the IRPA Congress came a meeting of The ICRP Main Commission in London.

This was the first time I had been to Brighton and everything I knew I had read in *Brighton Rock*. I therefore felt as though I were entering 'Greeneland' as I left the train and looked out over the descent down to the sea. However, this is where the ICRP Committees would meet during the 1970s; it was difficult to find a meeting place in London that was large enough. The problem was that we needed five conference rooms for groups of twenty people and also a larger assembly hall which could accommodate a hundred or so people. Strangely enough it was easier to satisfy this condition in Stockholm than in London thanks to the Birger Jarl Hotel. And the space at the Bedford Hotel in Brighton proved to be just what ICRP needed.

4.11. **ICRP in London**

The ICRP Main Commission met on 10-17 May at the Ciba Foundation on Portland Place.* It was the second time that the Commission met there; the first time had been in 1964. Several of us who did not know about the Society's background were slightly worried about coming in as dependents on a commercial company, but we found that our worry was unfounded and knew that ICRP also had no determining influence in this company.

One of the matters that involved a certain amount of heated debate was whether ICRP should continue to publish MPC values, i.e., maximum permissible concentrations of radioactive substances in air and drinking water. These values were initially stated to protect those working with sources of radiation and were calculated so that, in the event of exposure to the MPC values for the whole of their working life, they would not receive a radiation dose which exceeded the ICRP limit values for critical organs (i.e., the organs which led to the greatest radiation risks because of the irradiation). The majority of members, including myself, did not think there was any reason to accept such high levels of contamination in the workers' drinking water. It was also considered inappropriate to continue to use the term 'MPC', i.e., Maximum Permissible Concentration, since the primary limit values concerned radiation doses rather than activity concentrations. The decision was to use the concept derived working limit instead in order

* The Ciba Foundation (now the Novartis Foundation) is a foundation that offers scientists from all over the world a possibility to meet at a place where 15 bedrooms are available at a reasonable charge.

to emphasise that the values were secondary and were derived from the dose limit for workers. None of the values would continue to be given for concentrations in water.

ICRP's finances raised concern. The Commission's regular annual income was limited to $ 20,000 from WHO, $ 9,000 from IAEA and $ 2,000 from the International Society of Radiology while the annual expenses for the Commission's and the Committees' meetings in 1969 had amounted to $ 50,000. It was solely thanks to the funding that Sievert had previously succeeded in obtaining from the Ford Foundation that the deficit could be covered, but that would not last beyond the end of 1972.

4.12. **Introducing the cost-benefit analysis into radiation protection**

Two of the presentations at the IRPA Congress introduced cost-benefit analysis for the first time in a radiation protection context. One was held by John Dunster and Andrew McLean and was entitled *The use of risk estimates in setting and using radiation protection standards*. Dunster and McLean recommended a cost-benefit analysis which balances 'the marginal costs of reducing doses and the benefits of avoiding future detriment, either somatic or genetic. It is shown that this is a more satisfactory basis than a comparison, for any operation or project, of total costs, including detriment, with the overall benefit'. They performed the necessary 'translation' of radiation doses into money by combining the biological risks with the insurance companies' levels of compensation for serious injuries. This was simple and direct but required biological assumptions and gave a low compensation (insurance companies do not like paying out large sums). The authors considered the cost-benefit analysis to be unnecessary if the cost of dose reduction exceeded 'a few pounds Sterling per man-rad' (i.e., approx. 500 $ per man-sievert from gamma radiation).

The second lecture, written by Arne Hedgran and myself, had the cryptic title *PQR – A special way of thinking*. Arne was the one who had come up with the suggestion for the article. There was still no established basis for risk estimates when it came to low radiation doses. But Arne found a way out. Irrespective of whether or not there was any risk, small radiation doses were a nuisance which put many people off slightly. This aversion could be valued in monetary terms and associated with the radiation dose.

We came up with a questionnaire which asked people to give their opinion on how low a radiation dose (from building material in the home or from a radioactive wristwatch, for example) ought to be in order not to make them worry about the radiation dose if they were to buy such an item. We also asked what the additional cost would need to be for it to be considered in the event of a decision. We sent the questionnaire to a hundred or so colleagues in several countries and received an encouraging response. We assessed the responses to arrive at an 'aversion cost' per unit of radiation dose. This was what we called 'PQR', an arbitrarily selected combination of letters, and it enabled us to 'translate' a given radiation dose into a sum of money which we called a 'PQR cost'. Since people are more used to dealing with money than with radiation doses, this enabled us to communicate a sense of the radiation dose's practical significance better than any risk estimate could have done.

From the responses to our questions we were able to derive a value of 500 $ per man-rad (approx. 50,000 $ per man-sievert) which reflected the intuitive valuation of a radiation dose on the part of the people who were asked.

Our presentation also mentioned the direct method using risk estimates (as Dunster and McLean had done). We thought that this method, with the current risk assumptions led to a value PQR = 100 $ per man-rad (10,000 $ per man-sievert), which was approx. 20 times the amount that Dunster and McLean had arrived at.

Hedgran and I published a revised version of our presentation in *Acta radiologica* in 1971[*] where we really thoroughly examined the optimisation principle for radiation protection inputs. We started by writing:

[*] *Acta radiologica* Supplement 310 (1971), pp. 163-172.

> [Certain] decisions involve elements of benefit and risk which are not easily commensurable with the direct or indirect costs which can be measured in money. A risk implies injuries and loss of human lives, and it is a very controversial matter whether human life has a price.
>
> It is comparatively easy, however, to make an assessment of another quantity, Q, which we may call the implied dollar equivalent of a human life. This is merely what we find that society does pay in order to save a life, and it carries no moral implication as to whether this is right or wrong.
>
> A certain decision on a particular action (*i*) will commit society to a total cost W_i, which can be expressed in dollars. This cost is composed of direct or indirect costs (C_i) which can be calculated more or less easily and a component (R_i) which is a measure of the risks and harmful effects which are not directly convertible to a cost expressed in dollars. This may be written
>
> $$W_i = C_i + R_i$$

We also emphasised that the use or benefit (B_i) from a decision has components which are not easy to quantify. You could perceive W_i and B_i to be complex numbers, each with a real and an imaginary component. In order to be able to do an optimisation analysis, we must also express R_i in dollars. This, we said in the paper, can take place in two ways. You can either do as Dunster and McLean did and seek a dollar equivalent (Q) for a human life – you would then obtain R_i as

$$R_i = 2 \times 10^{-4} \times D_i \times N_i \times Q$$

were we to assume, as ICRP did in those days, that the likelihood of deaths and corresponding hereditary injuries was 2×10^{-4} per rad and the average radiation dose (D_i) to N_i irradiated people was stated in rad. We estimated the value of Q as 500,000 dollars. This gave us the already-mentioned value of PQR = 100 $ per man-rad (10,000 $ per man-sievert).

Alternatively, you could use our way of directly finding an 'aversion cost' of a man-rad where the answer from our questionnaire was 500 $ per man-rad (50,000 $ per man-sievert). In our paper we recommended a compromise of 200 $ per man-rad (20,000 $ per man-sievert), but recognised that in that choice we had been influenced by the fact that the value expressed in Swedish kronor at the time would be 1000 Swedish kronor per man-rad (100,000 Swedish kronor per man-sievert), i.e., 100 Swedish kronor per person and mSv. This simple connection ought to provide clear information to people like radiologists but also for the assessment of radioactive environmental contaminations.*

4.13. **The work with the 'Flag Book'**

As agreed among the Nordic Radiation Protection Institutes at the meeting in Copenhagen in March 1969, drafts of eleven sub-projects on the advice regarding the application of international radiation protection recommendations were to be ready before end of the year. When I asked about the situation on 5 November 1969 I was informed of delays, but also forecasts that the drafts would be complete before 1 February 1970. On 17 February I was able to ascertain that just one draft (about radon in mines) was ready. I then wrote again:

> We must not be discouraged because the work is starting to be delayed; our schedule was an optimistic one. However, I would be grateful to receive information soon from each country which now foresees a considerable further delay to any task. I propose that Sweden, as coordinating country, compiles the drafts which will be submitted within the near future and edit them to a first draft document in such a form that it can give a good idea of what we are in the process of creating. We should then perhaps aim for a joint meeting to discuss this draft and the continued work before we continue with

* The Swedish Radiation Safety Authority now recommends values that are ten times higher, partly because the estimate of the risk of cancer now leads to higher values, partly because a higher Q value is preferred.

> details and refining within small groups that may be formed by the coordinator and contact persons for each sub-assignment.
>
> ...
>
> If we pool the time to finish the sub-assignments with the time spent on editing the first draft and the time spent reading this within every country and take into account disruptions for summer holidays, etc., it is probably realistic not to aim towards any joint meeting until the start of November. Is this a suitable time?

On 1 June, I was able to say in a circular that the first drafts were starting to come to the Swedish Radiation Protection Institute. I appealed to receive all material before 15 June and enclosed a form with a request for proposed days to meet in November.

On 23 June I wrote to Eker, Juel Henningsen, Gisli Petersen and Isola and proposed a 'Nordic Council-type' meeting, also in November, to discuss the nuclear power industry's environmental protection problems and Nordic points of view regarding UNSCEAR's work.

On 6 July I was able to use a new circular to give all relevant persons a preliminary invitation to the two meetings in Stockholm, namely:

16-18 November	Meeting with representatives of the Radiation Protection Institutes for continued standards work.
19-20 November	Nordic Council-type meeting

The meeting on 16-18 November was to be held at the Radiation Protection Institute. We would be able to use the big party venue in Parliament House for the meeting on 19-20 November.

On 10 November we were able to send out from Stockholm a working document for discussion on 16-18 November. It contained drafts of all of the eleven sub-projects. We had decided to have the text in English, partly in consideration of our Finnish colleagues and partly for convenience since it meant that we did not have to bother translating the ICRP paragraphs that we thought could be applied directly.

In the covering letter I wrote:

> The compiled document includes nearly 800 paragraphs. Experience of work within ICRP task groups and ICRP Committees shows that a small, active group with a week of hard work, partly in the evenings, will have time to examine and discuss in detail approx. 300 paragraphs. Such an examination of this document is therefore not possible during the three-day meeting that is planned for Stockholm. ... The discussion must therefore be based on the principles for the continued work rather than on an endeavour to finally edit the document.

I now had concrete proposals regarding the purpose of the document. The final document (the 'Flag Book') would be viewed as a *record* of an *agreement* on the principle for the radiation protection work in the Nordic countries. The agreement would not apply to the formulations that would be needed in each country in statutes and provisions; on the other hand, it would concern the *factual content* of the rules we agreed to apply. The record could formally be seen as a *proposal from the Radiation Protection Institutes* to the authorities that finally establish regulations and standards in each country.

30 or so people took part in the meeting at the Radiation Protection Institute on 16-18 November. From Denmark there were Per Grande, *Ole Berg*, *Erling Lassen* and *Binte Lewinsky*. From Finland there were Aulis Isola, *Leif Blomqvist*, *Olli Paakkola* and *Timo Viitaniemi*. From Norway came Kristian Koren, *Helge Aamlid*, *Leiv Berteig*, *Finn Devik* and Jon Flatby. Sweden had a dozen people taking part, the most active of whom were Ragnar Boge, *Lars Lorentzon*, Sven Löfveberg, *Åke Persson*, Bengt Pettersson and Jan Olof Snihs. Sven Löfveberg was in charge of a technical Secretariat together with radiation protection inspector *Birgitta Olofsson*.

At the meeting, 14 task groups were set up whose tasks would be to draw up recommendations within the 24 sub-areas. The result was confirmed in a circular on 3 December:

Task group	Sub-area	Coordinator
A	1. Foreword	Lindell
	2. Introductory chapter	
B	3. Exception regulations	Olofsson
C	4. Classification of work	Koren
D	5. Health problems	Devik
	6. Trial persons	
E	7. Dose limits	Grande
	8. Activity limits	
F	9. Monitoring	Suomela
G	10. External radiation	Berg
H	11. Internal radiation	Paakkola
I	12. Clinical applications	Flatby
	13. Mobile x rays	
	14. Image intensifiers	
	15. Veterinary applications	
J	16. Industrial applications	Berteig
	17. X rays and gamma radiogr.	
	18. Accelerators	
K	19. School problems	Aamlid
	20. Various uses	
L	21. Transport	Lassen
	22. Luminous paint	
M	23. Mines	Snihs
N	24. Reactors	Grande or Berteig

It was thought that proposed texts would be ready in spring 1971. The chapters that formed the final work did not correspond to the original sub-areas - there would be a considerable amount of re-editing to do.

4.14. **Radon in mines**

The Radiation Protection Institute's activities report for 1970 contains a paper, 'Radon in Swedish mines', in which Jan Olof Snihs gives an overview of the problem. It is well worth quoting:

> The currently ongoing extensive measurements of the level of radon in Swedish mines began with a survey of a couple of Norrland mines. The survey was planned in cooperation with the mining company which had also simultaneously proposed such a survey. The results of this were surprising to some extent and showed that there was cause to also survey other mines, particularly those where significant radon levels could be expected for geological reasons. Since, at least initially, the surveys largely had to be for investigative and research reasons, a special Research Committee for 'radioactivity measurements in mines' was formed at the initiative of the Swedish Mining Association. The objective of this Committee was to define and analyse the problems that were associated with radioactivity, particularly radon, in mines and, on that basis, to plan continued surveys. This task was and is coordinated with the Radiation Protection Institute's investigation and research programme which includes, e.g., performing surveys of our natural radiation environment.
>
> This Committee was subsequently dissolved and replaced by two new Committees named 'radiation protection' and 'the distribution of radioactive materials in Swedish mines' with a representative of the Radiation Protection Institute as Chair of both of the Committees. The objectives of these Committees are partly illustrated by their names and tally largely with the objective of the first Committee. The Committees are made up of medical, geological, metrology and radiophysics expertise.
>
> Owing to the wording of the Swedish Radiation Protection Act, the formal and legal assessment of radon in mines does not come under the jurisdiction of the Radiation

Protection Authority (the Radiation Protection Institute) – it comes under that of the Swedish Board of Occupational Safety and Health. The Radiation Protection Institute and the Swedish Board of Occupational Safety and Health have therefore already been cooperating closely on these matters right from the start. Aside from the formal aspect, this cooperation is a very natural set-up because the phenomenon of radon in mines in terms of worker protection is so closely associated with other worker protection problems in mines such as gases, dust, etc.

After the first surveys which were completed with surveys in a couple of mines in mid-Sweden, an informative measurement series was taken in all mines in Sweden during the 69-70 winter. Air samples were taken by the mining companies themselves and submitted to the Institute to be measured. The results of these measurements were presented at an information conference in Örebro in March 1970 with representatives of employees, employers, safety representatives, construction authorities, etc. and the press and radio and TV. In the summer of 1970, the same survey was repeated, whereupon it was possible to make a preliminary estimate of the radon daughter levels at workplaces in Swedish mines. The result is shown by [the following table]:

Radon daughter level*		No. of mines	No. of workers
<10	pCi/l	25	1120
10 - 30	“	13	1740
30 - 100	“	17	1740
100 - 300	“	5	130

The result was spectacular. No fewer than 1870 miners worked in a radiation environment that exceeded the ICRP limit value for radon in equilibrium with its daughter products, 30 pCi/l. There was no equivalent high exposure in any other ‘radiation work’ within either healthcare or the nuclear power industry.

Surprisingly enough, the culprit was the ventilation method. Powerful ventilation is needed to keep the mine air fresh but this also means that surroundings are cooled down, which is a nuisance. They had therefore often led the ventilation air through shafts with rockslide areas to heat it up. However, there is a large radon-emanating surface in the rockslide areas and the air can also come into contact water that has a high content of radon. Once these links were realised they could get on top of the situation and probably save a number of human lives. Snihs’ achievement in this connection is the greatest radiation protection achievement in Sweden of modern times.

4.15. **Meeting of ICRP Committee 3 in Stockholm**

On 6-10 April, ICRP Committee 3 met at the Radiation Protection Institute in Stockholm with me as Chair, Eric Smith as Deputy Chair and Lars-Eric Larsson as Secretary. As well as the Committee’s members Per Grande also took part as Chair of the task group which was in the process of drawing up Publication 15. Dr. Wallauschek from the ENEA and two representatives of the International Electrotechnical Commission also attended. The Radiation Protection Institute also provided a Secretariat consisting of Sven Löfveberg, Torborg Hammarberg and Margareta Rydell. The Committee discussed primarily the technical supplement to Publication 15 which would be published as Publication 21, but it also discussed the need for a publication on protection during radiation treatment; there were signs of inappropriate irradiation for benign ailments. Another problem discussed was the distribution

* The radon is dangerous because of its radioactive decay products (daughter products) which are suspended in the air. You therefore state the activity of the daughter products which, depending on the ventilation, is usually 20-80 % of the radon’s own activity. See also Chapter 1 of ‘The Labours of Hercules’. 1 picocurie per litre (pCi/l) is the same as 37 becquerels per cubic metre (Bq/m^3)

of small sources of radiation which certainly did not constitute a problem in themselves but which, together, could lead to difficulties.

4.16. Debate with Björn Gillberg in *Dagens Nyheter* regarding the risks of nuclear power

In the spring, there were animated discussions regarding the radiation risks from the nuclear power industry in *Dagens Nyheter*. On 8 April, Björn Gillberg wrote an article under the ironic heading of 'Radiant Future' on what he perceived to be the hazards of nuclear power. I refuted the article on 16 April, writing that Gillberg was wrong in thinking that nuclear reactors could explode like atomic bombs. On 5 May, Gillberg countered with a new article in which he recognised: 'I exaggerated when I maintained that a reactor could, figuratively speaking, explode like an atomic bomb'.

We had different opinions regarding the risks of the high activity waste. When I wrote that 'the technical development is approaching a concentration of the waste in such a form that it will be unsolvable in the long term', Gillberg promptly countered that the technique ought to have been developed before the go-ahead was given to build the reactor. A letter from one reader, *Friedemann Lüdke*, thought he had not received enough information on the risks of nuclear power and his outburst came in the headline 'Tell us what we are risking!' *Vattenfall's Dag Jungnell* responded to this on 9 June, whereupon I had an article published on 10 July with the headline 'This is what we are risking!' I mentioned that even with an unrealistically large expansion of nuclear power, the number of extra cases of cancer owing to the scattering of radioactive substances would be no more than around ten. About this I wrote:

> We may never know whether the supposition is correct; it is impossible to use the random variations in the number of 'normal' cases of cancer to show how many additional cases may be caused by low radiation doses. It is an extreme feeling of responsibility which makes us presuppose that they could occur.

4.17. Meeting of the Swedish Society of Nuclear Medicine in Malmö

On Friday 12 June, the Swedish Society of Nuclear Medicine met in the assembly hall at the General Hospital in Malmö. Most of the seven presentations concerned scintigraphy. Bertil Nosslin reported on the production and control of radiopharmaceuticals with generator-derived nuclides.

4.18. The Radiation Protection Institute requests a report on non-ionising radiation

The Swedish Radiation Protection Institute started to worry about the increasing problems with protection against non-ionising radiation, primarily specific electromagnetic radiation and ultrasound. The Institute therefore wrote to the Swedish Government on 2 September and proposed that the problems be investigated

4.19. Robert Thoraeus dies

On 11 September, Robert Thoraeus died of a malignant tumour behind his nose. He was born in Mönsterås on the coast of Småland in 1895 and became Rolf Sieverts first academic colleague. Thoraeus had studied ship building at KTH and then been an assistant to Manne Siegbahn at the latter's Institute of Physics in Uppsala. In 1927 he was employed by Sievert to take care of the ambulatory supervision of the country's installations for x-ray therapy. The need for as 'hard', i.e., penetrative, x rays as possible made him design the 'Thoraeus filter', a radiation filter which consisted of 0.44 mm tin, 0.5 mm copper and 1 mm aluminium in said order, where the two outer filters filtered out the characteristic x rays from the previous filter. The filter was presented at the International Congress of Radiology in Stockholm in 1928. At the Institute of Radiophysics, Thoraeus built up a standard laboratory for measuring the exposure in *roentgen* units; this work led to him defending his thesis in 1932. Until the reorganisations at the start of the 1960s, Thoraeus was head of the Institute of Radiophysics' department B for the supervision of x-ray therapy and a bit later on head of medical physics at *Radiumhemmet*. Rune Walstam has written the following about him: 'We all have our inherited characteristics and attitudes that are difficult to influence. Thoraeus was sometimes perceived as being old-school, dominant and a know-it-all, even in the day by day coffee conversations'. At the end of his career, Robert Thoraeus was conferred the title of Professor.

4.20. **Expansion and development of the Radiation Protection Institute and the Institute of Radiophysics**

On 15 September, a meeting took place at the Radiation Protection Institute with representatives of construction managers regarding the reconstruction and demolition work at the Institute of Radiophysics' and the Radiation Protection Institute's buildings. The construction started on 28 September with the demolition, excavation and blasting work. New premises for a library, conference room and lunchroom were being added. The premises had been planned so that they could form a separate advice centre in the event of a reactor accident or fallout from nuclear weapons tests. One particular room was reserved for telex connections.

4.21. **UNSCEAR's 20th session**

UNSCEAR met in Geneva on 21-25 September for its 20th session. I was now the Chair of the Committee and Vladimir Zeleny was Deputy Chair. The Swedish delegation included Arne Nelson, who was my deputy. K. G. Lüning took part in the meeting of the genetic 'sub-sub-group' where Professor Sobels was Chair. Kay Edvarson and Jan Olof Snihs were new members of the Swedish delegation.

Bo Lindell chairing UNSCEAR in 1970.
At his side, the head of the UNSCEAR Secretariat, Italian Francesco Sella, and one of the scientific secretaries, New Zealander Bernie O'Brien.

From the UNSCEAR meeting in Geneva, 1970.
At the table, cigar in mouth, the Argentinian delegate, Dan Beninson. At his side, the Australian delegate, Don Stevens. To the right of Stevens, the delegate for Belgium, Dutch geneticist Professor F.H. Sobels.

Zeleny was not present at first and the Czech Embassy could not explain why. The Committee which had no Deputy Chair selected him as Chair of the Biological sub-group in protest, with Bill Pochin as Chair for as long as Zeleny was absent. Don Stevens was Chair of the physics sub-group.

This meeting saw the introduction of the work on the report that was to be published as two volumes entitled 'Ionising Radiation: Levels and Effects' in 1972. On page 1 of volume 1 (Levels) it says that 'The names of those experts who attended the twentieth, twenty-first or twenty-second sessions of the Committee as members of national delegations are listed in Appendix I'. This was unfortunately not the case; Zeleny's name was missing. He had not existed for political reasons. Czechoslovakia was not going to allow UNSCEAR's Deputy Chair to come to the meeting at the twenty-first session, which was a disgraceful intervention. The new Czech representative for 1971, Dr. Klimek, was a friendly man but he emanated fear.

As regards UNSCEAR's contribution to the 1972 environmental conference in Stockholm which the Committee's Officers (Lindell, Butler – the former Chair, Zeleny and Sella) had been given the task of putting together, the Committee decided to also allow I. L. Karol from the Soviet Union and Don Stevens from Australia to join the preparatory group. After the UNSCEAR meeting, Gordon Butler, Francisco Sella, Zeleny and I generated ideas and proposed texts for a subsequent meeting of the group which took place at the Radiation Protection Institute on 29 November. Butler was exhausted following a visit to London and Paris and gave us the unique experience of seeing him fall asleep while he was talking to us. However, he was well prepared and was able to send us a well-considered draft report after the meeting. We were to present UNSCEAR's methods for estimating the dose commitment and, if possible, also the injury burden using the distribution chain *injection → the atmosphere → the ground → foods → body tissues → dose → injury* and introducing the linear, no-threshold dose-response relationship.

4.22. **Swedish nuclear power**

Since the Reactor Location Committee thought that permission ought not to be given to *Stockholms Elverk* to erect a reactor to produce electricity and hot water in Värtan, a committee was set up in spring 1970 to provide a basis for assessing necessary location restrictions for forthcoming plants. The report came to be known as *The Urban Siting Investigation*. More is written about this in Chapter 8 (1974).

Another committee, or rather a task group, was set up in April 1970 under the Ministry of Industry of which Krister Wickman was head at the time. The group's task was that 'carry out a study of the significance of reprocessing to the continued expansion of nuclear power in Sweden and the conditions for a Swedish plant for reprocessing nuclear fuel'. The person convening the group was Senior Administrative Officer Jan Thyberg and the Secretary was Ph. Lic. Åke Hultgren. A draft report, 'Study of the conditions for a Swedish reprocessing plant' was discussed at a hearing at the Ministry of Industry on 30 November with representatives of the delegation for Atomic Energy Issues, the Swedish Environmental Protection Agency, the National Board of Physical Planning and Building and the Radiation Protection Institute.

I put forward the Radiation Protection Institute's points of view that it was not clear why a reprocessing plant would be needed in Sweden (implied at Sannäs) when there was capacity abroad. Thyberg's response was: 'We haven't been asked to consider this - we want preparedness.' Both Hedgran and I criticised the less-than-satisfactory treatment of the waste problem, which ought to have been dealt with separately.

At this time, Hedgran represented the Atomic Energy delegation. This had first come under the Ministry of Trade and Industry, was then moved to the Ministry of Finance and finally ended up within the Ministry of Industry, with the Reactor Location Committee as operational authority. However, in 1970, became the Atomic Energy delegation became an independent authority and Hedgran, who had been Chair of the Reactor Location Committee since 1968, was elevated to being the head of, to give it its full name, the delegation for Atomic Energy Issues.

In 1970, according to the Radiation Protection Institute's activities report for 1970, the situation regarding the Swedish nuclear reactors was as follows:

In operation	R2, Studvik	50 MW thermal power
R2-0, Studsvik	1 MW	"
Ågesta	80 MW	"
Under construction	Oskarshamn 1	440 MW electric power
Oskarshamn 2	580 MW	"
Ringhals 1	760 MW	"
Ringhals 2	820 MW	"
Barsebäck	580 MW	"
Licence applied for	Forsmark 1	800 MW electric power
Forsmark 2	800 MW	"

For the nuclear power plants, thermal power is approx. three times that of the electric power. The nuclear reactors that were built at or planned for the four Swedish nuclear power plants Barsebäck, Forsmark, Oskarshamn and Ringhals in 1970 were all boiling water reactors supplied by *Asea-Atom*, except for Ringhals 2 for which a pressure water reactor was built and supplied by Westinghouse.[*]

Prior to the anticipated start of Oskarshamn 1, the County Administrative Board arranged a number of meetings in the county of Kalmar for discussions and information. On 10 September, an information meeting with medical personnel was arranged in Oskarshamn where I was asked to give an account of radiation risks and protection regulations. I was able to refer primarily to ICRP Publications 8, 9 and 14 and said, among other things, that 'A correct interpretation by ICRP involves long-term planning which

[*] There is more about these types of reactor in Chapter 8 of 'The Labours of Hercules'.

from the start takes into account the long-term expansion of nuclear power and overlay effects of small amounts of activity from a large number of sources of radiation spread over large areas.'

When it came to reactor accidents, I said:

> Only the Windscale accident in England in 1957 has distributed substantial activities [I ought to have said 'large quantities of highly-active radioactive substances'] to the surroundings. Five reactor accidents have claimed four human lives so far since the personnel were exposed to radiation. Acute radiation injuries in the surroundings are highly unlikely, although injuries among the personnel are conceivable. Medical measures will therefore apply to personnel if they become necessary. Any radiation component at the time of an accident must not prevent the normal treatment of injured people. If an accident leads to overdoses in the surroundings, the source of radiation is likely to be radioactive iodine, which irradiates the thyroid gland. If there are accidents within the reactor, the personnel may also be exposed to gamma radiation. The radioactive 'contamination' of injured personnel in the way that is dangerous to the surroundings is unlikely.

What bothered us from the radiation protection point of view was that for fear of radiation from the patient, doctors and care providers would not dare to treat personnel who had been injured in another way. We thought it highly unlikely that any injured person could be so contaminated with radioactive substances that this would lead to a risk for the healthcare personnel.

On 27 October, the County Administrative Board in the county of Uppsala arranged an information meeting about Forsmark's nuclear power plant in *Frösåkersskolan* in Östhammar. The meeting was led by County Governor *Ragnar Edenman* (1914-1998). After the meeting, *Vattenfall* circulated a 38-page A4 stencil showing minutes of the meeting.

The first to speak was *Vattenfall's* technical director *Ingvar Wivstad* (1924-1999), who said:

> The planning work for Forsmark is now being run with said parties in cooperation [*Vattenfall*, *Mellansvensk Kraftgrupp AB* and *Bålforsens Kraft AB*[*]]. The final decision on forming a company and erecting the first unit will probably be made in 1971. Requisite official permits are of course required in order for the cooperation to be fulfilled so that financing can be arranged, etc.
>
> Forsmark's power plant already has rather a strange prehistory called Trosa. As is known, we at *Vattenfall* were intending to locate the first major commercial nuclear power plant on the east coast at Käftudden in Vagnhärad Municipality near Trosa. With regard to necessary power line extensions, Trosa was a somewhat more economically advantageous alternative for *Vattenfall* than Forsmark.
>
> There is probably no power plant location in Sweden that can demonstrate such a slow and complicated birth as Forsmark. There have been fairly extensive underlying reports and considerations. In May 1969, the previous discussions resulted in *Vattenfall* publishing an extensive report which is called 'Nuclear Power on the East Coast' and it contained an account and assessment of the various conceivable locations for major nuclear power plants. Following a referral, the Minister of Industry that Trosa ought not to be used for the next big nuclear power expansion and that *Vattenfall's* continued the work ought to concentrate on Forsmark. This was a declaration of intent regarding the direction of the continued work.

When after that Chief Engineer *Tage Nytén* had described the design of the power plant, the County Governor handed over to *Carl-Eric Holmquist*, *Vattenfall's* radiation protection expert. Holmquist was a complicated person, a brooder who ended up writing a couple of books on risks and people's

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[*] *Mellansvensk Kraftgrupp AB* was a merger of *Gullspångs Kraft AB*, *Stora Kopparbergs Bergslags AB*, *Krångede AB* and *AB Svarthålsforsen*. The latter was owned by the City of Stockholm and *Värmlands Lednings AB*. *Bålforsens Kraft AB* was a subsidiary of *Svenska Cellulosa* Group [the Swedish Cellulose Group].

apprehension. He gave a committed presentation but irritated the largely sceptical audience with his unsuspecting enthusiasm. He said:

> So, you can – and I believe that it *is* absolutely possible – take the view that (to use a distorted cliché) 'nuclear power is beautiful'. Quite simply that nuclear power is a beautiful thing. It needs to be more than that of course. It needs initiative on the part of the planners and some good Swedish architects are needed, not just one good architect in Sweden. An exciting design for the building structures and adaptation to the surrounding environment can make the Forsmark power plant more famous and architectonically-inspiring than many traditional 'beautiful' tourist destinations. There need not be any real difference in architectonic beauty between the Guggenheim Museum in New York and the Forsmark plant in Uppland, and this is also completely in line with what I believe the modern landscape is crying out for.

After a coffee break there was information from a number of protection authorities: the SMHI, the Swedish Environmental Protection Agency, the Atomic Energy delegation and the Radiation Protection Institute. Arne Hedgran spoke about the Atomic Energy delegation's 'safety philosophy' and its endeavour to find a 'defence-in-depth'. I spoke about the Radiation Protection Institute's application of the ICRP recommendations.

At the end of the 1950s there was an action group against Swedish atomic bombs (AMSA, see 'The Labours of Hercules'). It inspired the formation of an action group against nuclear power (AMA) at the end of the 1960s, which was largely represented by a friendly engineer by the name of *Rune Jönsson* who, when he had the opportunity to speak before a public audience, could work himself up to make statements that he never made in private. The AMA was represented in Östhammar and meant that the County Governor faced a practical problem:

> We have received a large number of questions from representatives of the AMA group and there is nothing to say about it. It is just that this sort of discussion is very difficult to settle, that one person writes and the other person speaks. I have [...] told Mr. Rune Jönsson that he will have the opportunity to give a verbal statement. Before we conclude, I propose that one of the AMA representatives be given the opportunity, once they have travelled up here, to say a few powerful words. I believe that the public here will have the patience for it and if we then unite in the usual parliamentary fashion of an extended reply, Mr. Jönsson, a lot can be achieved. Over to you!

Rune Jönsson used the opportunity for a longer contribution in which he recounted the American nuclear power opposition's details of elevated incidences of cancer and frogs with extra legs around the nuclear power plants, details that we knew had no basis but which were expressed through the justifiably critical attitude to the American Atomic Energy Commission. After a while, Jönsson realised that he may have spoken for too long and asked the County Governor whether he ought to stop. Edenman answered: 'Well, if there is something that you would really like to say, I'm not going to stop you. Oh no.' Jönsson continued for a good while longer, saying that nuclear power was available only because specific countries wanted atomic bombs and that there was plutonium in the fuel which might be used as war material. We have no need for nuclear power, said Jönsson; we have fossil fuels that will last us for 700 years. He then said:

> We need no nuclear power plants. I don't know whether you knew of such things before you came here? Did anyone know about it? Nobody knew about it? I bet you did!

Edenman now intervened, saying: 'We might like to draw things to a close now.' Jönsson thanked him for the opportunity to give his opinion. The County Governor's summary was:

> We would like to thank Mr. Jönsson who represents the AMA group, and in this country there is freedom of opinion and we all have the chance to continue. I am simply convinced that this matter has already been discussed a few times here in Östhammar,

> particularly by the municipal authorities, in any case before pronouncing a unanimous yes. If it is of any comfort to the AMA, which I pretty much doubt, I live in Öregrundsgrepen, the secluded section of the Gulf of Bothnia, so I will see what happens.

In his concluding speech, Edenman's final words were:

> ... we have nothing against people from the AMA group warning us. Nothing but good can come of further pressurising our skilled experts to do their utmost. Continuously pushing for guarantees can only be a good thing. But it is also obvious that we need new sources of power, and if one could be located in this sparsely-populated area of Uppland, I believe it would please this district very much.

In other contexts, Rune Jönsson was a calm, wise man. In February 1970 he asked me for advice regarding a disturbed woman who had written to him thinking she was constantly monitored by aircraft and exposed to radiation. After having received my comments, Rune wrote a nice letter in which he 'completely dismissed' the suspicions about the aircraft; 'I see several planes in the air every day and they are definitely not up in the air to do you or me any harm'. He also wrote that the radiation doses she had stated 'corresponded to the natural background radiation and you should not be scared by them'. Finally, he advised her to contact 'a good psychiatrist who could help [her] to disconnect from the 'forced connection' between aircraft and [her]self and who might be able to help [her] return to 'perfect health'. No such balanced answer could have come from a fanatic.

In 1970, *Sydkraft* ordered the second reactor for Barsebäck, also a boiling water reactor for an electric power of 570 MW. The turbine and generator were ordered from Stal-Laval.

4.23. The Swedish National Board of Health and Welfare's X-ray Committee

On 6 February 1969, the Swedish National Board of Health and Welfare had set up a task group consisting of Medical Officer Sven Alsén, Chair Professor Osborne Bartley, Chief physician Sven Ydén and me to investigate safety issues in connection with x-ray examinations. The group had been set up at the request of the Radiation Protection Institute in a letter of 25 October 1968. A situation report written by Sven Ydén and me was available on 13 October 1970. It contained a number of proposed measures and asked the Swedish National Board of Health and Welfare to give its point of view on the group's continued work. The report contained a large amount of good advice and points of view.

4.24. IVA meeting regarding the environmental problems of nuclear power

On Thursday 29 October 1970, an all-day conference was held on 'The environmental problems of nuclear power' at the Royal Swedish Academy of Engineering Sciences. The following was written in the invitation to the conference:

> Nuclear power has gained a broad reputation of being a serious destroyer of the environment; people have pointed out radioactive emissions, cooling water discharges and loss of aesthetic natural values through the erection of enormous power plant buildings.
>
> However, unlike many other technical developments, all of these environmental protection aspects have previously been observed in the nuclear power expansion to the extent that the latter is currently so heavily regulated that the expenses for environmental protection and safety measures constitute a significant sum for the economy.
>
> This situation is largely down to the uncertainty in the assertions regarding the environmental impact factors of nuclear power. However, commercial nuclear power has now been in use in many countries, including Sweden, for such a long time that it is possible to assess these factors more reliably. At the same time, the environmental impact of the conventional sources of power has started to be observed to an increasing

> extent. This will result in difficult counterbalancing problems in continuing to expand the country's energy supply.

Irritation was now becoming increasingly evident among the industrial people. A huge task had been taken on and accomplished brilliantly. They were quite rightly proud of their expertise and achievements. But they were met with distrust and criticism rather than appreciation. It felt tough and unfair - after all, they had honoured and accomplished what the politicians wanted.

4.25. **The radioactive ID cards**

In edition 15 of *Läkartidningen*, a letter to the editor asked questions about radioactively-marked ID cards. The questions were answered by Assistant professor Peter Reizenstein but were raised again in the daily press, which also led me to provide the press with information. The low activity of the radioactive substance and the weak penetration capacity of the radiation (alpha radiation) meant that even if you constantly wore the ID card directly against bare skin you could not receive a harmful radiation dose. You could eat ID cards without being in any danger. However, those of us at the Radiation Protection Institute were still doubtful. We were in principle against the distribution of objects that were supplied with radioactive substances. Our negative attitude in turn worried the National Police Board which, together with the Post Office and the banks, wanted to push forward with the radioactive marking of staff ID cards. On 28 August, *AB ID-kort* asked the Radiation Protection Institute to accept radioactively-marked staff ID cards in the same way as the banks' and the post office's ID cards had been accepted. On 4 September, *AB ID-kort* informed the Radiation Protection Institute that the Institute's board would deal with the matter on 8 October, but also wrote that the board would probably consider it inappropriate to accept the radioactive marking of staff ID cards. This led the National Police Board to write to the Radiation Protection Institute on 7 October asking for the marking to be approved. Reference was made to the fact that we at the Radiation Protection Institute said that the radioactive ID cards were not at all dangerous and in doing so we had given our opinion on what we understood. However, emphasised the National Police Board, the use of the cards lay outside our area of competence. This put us in a situation where we had no obvious grounds to prevent the marking of the staff ID cards other than a vague feeling of unease. We could not see how marking them with radioactive substances was a good idea in practice and we had doubts about the future of the measurement boxes that *AB ID-kort* reckoned it would sell large numbers of. It turned out that we were right. There was no future for radioactive ID cards – but it took until 1974 for this to become evident.

4.26. **The emergence of the NRPB**

In October 1970, the National Radiological Protection Board (NRPB) was formed in the UK through the merger of the radiation protection responsibility at the Medical Research Council's Radiological Protection Service, the Radioactive Substances Advisory Committee and the Radiation Protection Division within the Atomic Energy Authority.* The personnel from the RPS felt they were being completely disregarded by those in the RPD, particularly Eric Smith who was fairly unhappy. Another radiation protectionist from the RPS was Michael O'Riordan, who later described the situation in the NRPB's Bulletin. He links the event to the presentations at IRPA's Congress in Brighton in May:

> The constitution which established the NRPB in 1970 is a simple and direct piece of legal text which has held its own over the years. It is obvious that the ministers and officials who thought out the policy had a clear picture of what they wanted to create – a sound basis on which to protect people against the risks of radiation within the general framework of public healthcare in the UK. The personnel who originally came from the

* See Chapter 14 of 'The Labours of Hercules'.

MRC's Radiological Protection Service plant in the outskirts of London were initially not worried about coming to work in the middle of 'the wasteland' and with work colleagues who were more at home with reactors than with radiology. But they came to love the location with the impressive view over the open, aged landscape with its rolling hills and to respect the dedication to the new company from those who came from the UK Atomic Energy Authority.

People from both directions had met at the IRPA Congress in Brighton in May 1970. Two memories of the occasion are still alive: the perplexing receipt of Bo Lindell's presentation on the new subject of optimisation and the fantastic presentation by Andrew McLean and John Dunster during a lively plenary meeting. Dunster would of course go on to succeed McLean as manager. David Richings, the first Secretary of the board and the architect behind a successful administrative structure, also attended. Some participants were distracted from the programme by the presence in the city of Diana Rigg, the most glamorous actress of the time. In October, when the NRPB was installed, the USA, the Soviet Union and China detonated nuclear charges within hours of one another. Radioactive fallout was to remain an interest for some time to come.

4.27. **Communication by letter with Joshua Lederberg**

Professor *Joshua Lederberg* (1925-2008) was a world renowned geneticist, Professor at Stanford University (in Palo Alto in California) 1959-1978 and, as a pensioner, manager of the Rockefeller Institute for Medical Research in New York from 1978-1990. He had already been awarded the Nobel Prize in Medicine in 1958 along with *George Beadle* and *Edward Tatum*.

Lederberg had written to me at the suggestion of K. Z. Morgan to ask about some of my papers and presentations, and primarily about Arne Hedgran's and my estimate of the 'PQR value' (see Section 4.10). I answered on 4 November and enclosed some Swedish Radiation Protection Institute reports. Lederberg had already answered by 11 November. His response is of interest, so I am reproducing it here:

> Thank you for your rapid response. I was also very satisfied with the way our conclusions concur. Before that I had only a vague intuition that the radiation protection inputs would generate a number in the area of \$10 - \$100 per man-rad, but certainly with many idiosyncratic and irrational deviations.
>
> You 'PQR' approach is one with which I, obviously, strongly concur. Do you also know of Chauncy Starr's paper (Science, 9/19/69), although I believe it is completely inadequate in terms of concept? He does not address what people are willing to pay for small safety improvements subject to reasonable information.
>
> William Gorman, who is now President of the Urban Institute in Washington DC., insisted on a series of investigations when he was Deputy Secretary of HEW[*] which HEW published as Program Analysis/Disease Control Programs, '1966-5'; they estimated the current value of expected income for an 'average 27 year-old man' as \$125,000, and calculate the cost-benefit of other programs thereafter.
>
> I did not include direct nonmonetary expenses in my calculations. Had I done so they could have exceeded the GDP! My attempt, like yours, instead observes the economic behaviour of people who actually make decisions.
>
> ...
>
> I totally accept your point about dose commitment, which was also well covered by the UN Committee's fallout analysis.
>
> PS re. SSI:1970-027[†]

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[*] Health, Education and Welfare

[†] The report from Hedgran and me discussed the fact that it would be preferable to limit the annual dose commitment (as it is now called) rather than the annual dose.

> The extrapolation for final levels of energy production (pp. 18 onwards) may be a bit too rigorous. In principle, today you can choose to build reactors that leak slightly more and use the economic gain and experiment with the structure to be able to build even better-regulated reactors in the future. But this requires a rigorous plan (and economic viability … like PQR…) for the future just as for current programmes.
>
> ...

4.28. **Nordic Council-type meeting in Stockholm**

On 7 October, I had sent a circular to a number of authorities, industries and organisations. The letter concerned who ought to take part in the ‘Nordic Council’-type meeting. I wrote:

> In order to obtain representation from Sweden corresponding to what can be expected from the other countries, it is probably appropriate if experts from the following bodies take part in the meeting:
>
> the atomic energy company
> the Swedish Defence Research Establishment
> the Swedish Environmental Protection Agency
> the Atomic Energy Delegation
> the Radiation Protection Institute.
>
> On the other hand, it would probably conflict with the framework of the meeting were participants also extended to cover representatives of the nuclear power industry or the manufacturing side. For this reason, a preparatory Swedish meeting will be held on 12 November to which such representatives have been invited for a discussion regarding the standards issues. The Swedish participants in the Nordic meeting on 19-20 November are expected, time and interest permitting, to also take part in the preparatory meeting.

The preparatory meeting was held at the Radiation Protection Institute on 12 November. Seven of those people for whom the meeting had been arranged took part. They were *Pelle Isberg* and *Lars-Olof Wredberg* from ASEA-ATOM, *Harald Westerlund* from *Oskarshamnsverkets kraftverk AB*, Carl-Eric Holmquist from *the Swedish State Water Power Board*, and *Tommy Cervin* and *Jörgen Thunell* from *Sydsvenska kraft AB*. In addition, a larger number of people from the authorities which were to take part in the meeting of 19-20 November also participated, including Ragnar Boge, Bo Lindell and Jan Olof Snihs from the Radiation Protection Institute, Lars Carlbom from Atombolaget, Kay Edvarson from the FOA, *Ulf Grimås* from the Swedish Environmental Protection Agency and Arne Hedgran from the Atomic Energy delegation.

The circular that was sent out from the Radiation Protection Institute on 5 November gave the following subject for discussion:

> The fundamental standards for activity emissions in accordance with the interpretation of the ICRP recommendations by Arne Hedgran and Bo Lindell in a stencilled report that was previously sent out.[*] The main content of the proposal is that not only the individual maximum dose but also the total population dose sets limits, and that one should calculate using the annual dose commitment rather than the annual radiation dose.

This meant a paradigm shift for radiation protection. ‘The population dose’ later ended up being called the ‘collective dose’. There was no Swedish expression for dose commitment as yet, but one was given later on.

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[*] This was the same paper that was reproduced in the Radiation Protection Institute’s activity report for 1970 entitled ‘On the Swedish policy with regard to the limitation of radioactive discharges from nuclear power plants: An interpretation of current international recommendations’.

At the 'Nordic Council'-type meeting on 19-20 November, a report was drawn up for the healthcare authorities in the Nordic countries. The report was to be signed by Juel Henningsen, Isola, Eker and Lindell. The following addition was proposed: 'The Icelandic experts who unfortunately could not take part in the meeting have read the above report with interest and share the points of view shown therein'.

The report was introduced with a discussion regarding the radioactive fallout from the big nuclear weapons tests in 1961-1962. The summary was:

> Routinely-continued measurements in the Nordic countries show that the level of radioactive substances in the most commonly-occurring foods has fallen considerably since the highest values were measured in 1963-1964, but that, owing to special transport mechanisms, the same levels as in the mid-1960s may still occur locally in certain foods. However, no measurement results indicate the presence of levels which are of any significance from the health point of view.

What was not said in plain language was that the special transport mechanisms concerned the fallout on lichens and that 'certain foods' were in fact reindeer meat.

The following was said about the biological effects of radiation:

> The basis for the current assessment of the radiation risks constitutes documentation which has been compiled and published by UNSCEAR on the basis of data collected from the member countries, and the interpretation of this material which was undertaken by the International Radiation Protection Commission (ICRP). Behind both UNSCEAR's and ICRP's risk assessments lies the assumption that the connection between radiation dose and risk of late injuries (carcinogenic and genetic effects) is linear and that there are no radiation dose threshold values below which the risk is zero.
>
> This assumption is generally accepted within the radiation protection activities in the absence of evidence that the body can react to the effects of radiation with very low intensity. However, while the experts support this cautious attitude, it is necessary to warn against a unilaterally-harsh assessment of the radiation risks in dilemmas where you are forced to compare activities which lead to radiation doses with activities which lead to other inconveniences, i.e., the cautious attitude may involve an overestimation of the radiation risks even if you do not dare to expect that this is the case.

Head of research Hvinden was primarily responsible for this reservation. The Norwegians were anxious about being forced to take action against people who could be exposed to particularly high radiation doses from milk, reindeer meat or contaminated water in regions where the fallout and the uptake of radioactive substances could conceivably be particularly high. Intervention could lead to more tangible risks.

The following was written about environmental protection against emissions of radioactive substances from nuclear power plants:

> The meeting spent most of its time on a discussion regarding the assessment of emissions and discharges of radioactive substances from forthcoming nuclear power plants. It was emphasised that it is important to comply with valid recommendations not only as regards permissible radiation doses for the individuals who are exposed the most, but also as regards the population dose. In the latter case, it is important to decide which population dose a nuclear power plant can be permitted to cause, based on forecasts for the total number of nuclear power plants in the future, e.g., at the start of the noughties. This means we realise that the limits recommended by ICRP for the genetic radiation dose to a population may not be used for one purpose alone, such as nuclear power production, and nor may be used in the near future, but should instead be used as a guideline for long-term planning.
>
> Preliminary calculations have shown that taking into account the population dose as per these principles may mean that this is what becomes crucial to the limitation of activity emissions rather than the radiation doses to the individuals who are exposed the closest to the plant. It also appears to be possible that a large share of the population

> dose may be derived from the irradiation of people who live a long way away from the plant, even beyond the country's borders. Long-term planning thus requires international solidarity and uniformity as regards the fundamental principles for the limitation of emissions and discharges.
>
> ...
>
> One important consequence of this approach is that activity measurements for the customary types of surrounding environment check may become less important. If the population dose sets limits and consists of very small radiation doses to a large population at great distances from the point of source of the emissions, the only effective control option is to check the emissions directly at the source. The usual surrounding environmental checks must then largely be replaced by targeted radioecological research where the measurements are not intended to check the level of the radioactive substances in air, water, plants and animals but to check that the assumptions on which the decisions for permitted emissions are based are correct.

These were important conclusions and formed the basis for the radiation protection policy that would apply to nuclear plants for the remainder of the century. The next radiation protection work took place in contact with the industry's experts. These emphasised the significance of operational experience before commitment to technical solutions for the purpose of complying with the new principles. We at the Radiation Protection Institute found this to be reasonable, bearing in mind that the actual emissions had been very low. It was deemed to be beneficial from the radiation protection point of view to wait until the international standards work (on which Sweden had a considerable influence) and principle discussions with the other Nordic countries were finished before designing the new Swedish regulations.

The report said the following about the level of radioactive substances in the air in mines:

> It has become apparent that the level of these substances is heavily dependent on the ventilation and that, in some cases, the situation cannot be adequately considered from the health point of view. The situation does not involve a new problem - radioactive substances have always occurred in mines. However, we have not previously been aware that the presence thereof could lead to health problems other than in mines for mining minerals containing uranium and thorium.

The experts finally apologised for the information problems:

> The experts finally discussed the difficulty in disseminating information on levels of radiation and risks of radiation in such a way that the public does not gain a misleading picture of the problems. It is an unfortunate development that the high level of caution in radiation protection activities, as well as the consideration which is shown for risks which are usually not observed at all as regards other types of environmental contamination, lead to the perception that radiation and radioactivity involve particularly substantial problems. It is understandable that the way in which radiation protection activities report all the different types of risk that they want to take into account may seem like a scary catalogue of risks by the side of the unawareness of similar risks which mean that other activities apparently seem to be free from risks.
>
> In the radiation protection activities, the development of quantitative risk assessments has come a long way. However, society has hardly been prepared to take a stand on which risks can be seen as acceptable under different circumstances. At the meeting, a hope was expressed that the development would lead to better possibilities of observing the overall risk to which the individual is exposed from all different risk sources.

4.29. **Two engineers**

When I worked with low-activity measurements in the 1960s, I had the privilege of receiving assistance from two very competent engineers, Jorma Suomela and Nils Hagberg. Jorma was a chemist and cooperated with John Hursh when John spent a sabbatical year at the Radiation Protection Institute in the 1960s. He also cooperated with Sven Löfveberg in developing a rapid analysis method for strontium-90. He unfortunately died as early as 1998. Nils Hagberg was employed in 1962. To start with he helped me with measurements of caesium-137 in milk and other foods which had been contaminated due to the nuclear weapons testing, and he was later given the responsibility for radon measurements where he took part in the international standardisation work. Nils knew where he was with electronics and was very much esteemed for his ability and helpfulness. He was missed by many when he died in 2009 after 47 years at the same workplace (albeit one that had changed its name).

5. THE YEAR 1971

5.1. The Nordic Radiation Protection cooperation – review of the meeting in 1970

On 11 January I was able to send my colleagues in neighbouring countries a proposed report from the meeting of 19-20 November in Stockholm. It was proposed that the recipients should state the publication date they wanted, and I wrote that the last of these proposals should apply; the date ended up being 15 February.

The report was approved by everyone and signed by Juel Henningsen, Aulis Isola, Reidar Eker and Bo Lindell. It was sent to 'the healthcare authorities in the Nordic countries'. As agreed, reference was made to the fact that the Icelandic experts, who had unfortunately not been able to take part in the meeting, shared the points of view put forward.

5.2. 'Radiant Environment'

During the year, the first edition of the book called 'Radiant Environment' was published, written by Kurt Lidén, Sören Mattsson and Bertil Persson. It went on to be published as a second, extended edition which concentrated more on the radiation protection problems of nuclear power. Kurt Lidén sent me a copy of the first edition for which I thanked him on 15 January with the following words:

> Thank you for 'Radiant Environment' compendium which I received today. It is really enjoyable, easy to read, comprehensible and the pictures are extremely illustrative.

The opinion applies to a greater extent to the second edition, which also became course literature for a 10-point course on environmental protection.

5.3. Relaxing the formalities

'The formalities were not relaxed suddenly, but gradually over a period of maybe five years. This was started in Sweden by the new head of the Medical Board, Bror Rexed, inviting all staff in 1967 to call him by his first name because he wanted to 'get on more familiar terms' with his personnel. At the Radiation Protection Institute, people generally also suddenly stopped using titles, but not until 1971. Dan Beninson told me that at around the same time, most people had started to address one another using first names rather than 'Dr Xxx' in Argentina, which was another strange harmony between our two countries. Relaxing the formalities did much to increase the sense of affinity and make life easier. The more recent tendency towards returning to enjoying the use of titles is unfortunate.

Sven Löfveberg and I had discussed various options for the general dropping of titles at the Radiation Protection Institute when addressing someone. Nothing could be expected to take place of its own accord. The Institute had grown up from Rolf Sievert's radiophysics institute where Sievert's principle was to drop the use of titles with academics and where no-one was expected to start being less formal with women, and the women did not dare to take the initiative since women were not expected to take initiative either. As for me, I would never have dared to take the initiative of dropping the titles with the stern Nurse Ingeborg, although I always was on first-name terms with all men since Sievert had dropped the titles in addressing me.

In the end, we thought that a big office party would offer the right opportunity. We thought a dinner on board a ship ought to give the right environment. The efficient Sven got to work, assisted by the practised *Kerstin Lundmark*. Kerstin's memory of this is:

> Regarding the boat party, Sven Löfveberg and I were the ones who arranged it (I don't think anyone else was involved). The boat, *M/S S:t Erik*, lay still at Strandvägen. The date of the party was Friday 29 January 1971.
>
> We had a very enjoyable time and ate steamboat steak. Sven and I had made a small box for all participants with a sign telling them to drop the titles and use first names, and a colourful serpentine, serviette, toothpick, headache tablet, etc. Everyone was also given a song sheet of boating songs.
>
> *Per Einar Kjelle* had to leave the party to go to the maternity ward.

5.4. Continuing work with the 'Flag Book'

On 4 February I confirmed decisions made during many phone conversations regarding the continued work with the 'Flag Book' in a circular and stated places and times for the impending task group meetings. In Stockholm on 2 February we had completed a report on our meeting in Stockholm on 16-18 November. It had been written by Birgitta Olofsson in consultation with Sven Löfveberg and Ingvar Lundéhn.

On 4 June in early summer I wrote a reminder, which started by saying:

> With my own conscience not 100 % clear and just before summer starts in earnest, I would like to remind you of our agreement that every task group should send me a manuscript of its section as early as possible in the autumn so that we at the Radiation Protection Institute can start editing the document on which we will give a final opinion.
>
> We were hoping that the results of the meetings held during the spring could be circulated within each group so that the groups could agree their respective contributions. Our general workload means that this has not yet taken place except for a few groups, but should hopefully take place before late autumn.

5.5. Information meeting in Misterhult

In February, the County Administrative Board in the county of Kalmar in consultation with the Radiation Protection Institute and the Swedish Environmental Protection Agency called an information meeting concerning the Oskarshamn plant. The meeting was to be held in the municipal hall in Misterhult, 25 km north of Oskarshamn, on Sunday the 21 February. The local population had been invited, primarily fishermen from the region, but also news media and critical groups, primarily the task group against nuclear injuries (AMA) which was represented by engineer Rune Jönsson.*

Before the meeting I received an anxious letter from the nuclear power plant's information manager Staffan Timal, who was worried because *Oskarshamns-Tidningen* had written about Rune Jönsson, calling him an 'expert'.

The meeting attracted many people, approx. 250 people according to one newspaper, while others said there were 40 and 400 respectively. The municipal hall was not big enough. The vicar then kindly offered us Misterhult Church as a place to meet. *Stellan Andersson* of *Göteborgs-Posten* wrote the following about the meeting on 22 February:

> Much has been said about the risks that a nuclear power plant involves but the task group against nuclear injuries has felt the threat to a significantly greater extent than the people in the archipelago around Simpevar[p].

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* The group sometimes also called itself 'the action group against nuclear power'.

> When they left their church this afternoon they were really none the wiser as regards the matter. A Professor from the National Radiation Protection Institute and experts from the County Administrative Board, *Oskarshamns Kraftgrupp* and the State Environmental Protection Agency led the debate and it is extremely difficult to give concrete information about the risks in contexts such as these.
>
> When County Governor [Erik] Westerlind gave everyone the opportunity to speak, none of the residents took the opportunity – not that they get to hear much of what the experts had to say because the loud speaker that had been connected up was not working and the experts' assurances that there was no need to feel seriously threatened by the nuclear power plant drowned beneath the arch of the big church. This led to increasing numbers of residents getting up and leaving after having sat for a few hours for the pleasure of learning nothing.
>
> 'You might as well go home and have a coffee if you still can't hear anything,' said one of the old fishermen as he, equipped with the flyer from the task group against nuclear injuries, left to walk home.

Oskarshamns-Tidningen, which Staffan Timal had been worried about, was not on the warpath:

> Sunday's nuclear power information in Misterhult, which was arranged by the County Administrative Board, the National Radiation Protection Institute and the State Environmental Protection Agency, turned into a fairly quiet and chivalrous battle between experts Professor Bo Lindell of the Radiation Protection Institute and Assistant professor Ulf Grimås of the Swedish Environmental Protection Agency on the one hand and the Task Group against Nuclear Injuries (AMA), which evidently has a number of converts among the population of the Misterhult archipelago, on the other.
>
> There was no compromise on objectivity by either side. On the contrary, Chair of the meeting County Governor Eric Westerlind's original intentions of attempting to limit the discussion to local level did not hold to since the AMA representatives, led by engineer Rune Jönsson from Stockholm, really wanted to generally discuss the overall justification for the existence of nuclear power.
>
> ...
>
> It must then of course be ascertained that the fight between the experts and the AMA was won by the former by a wide margin. All kinds of claims from the AMA representatives about harmful effects from nuclear power plants in America and Canada were all objectively countered and dismissed by Messrs. Lindén [!] and Grimås, who were never nonplussed however harsh their attackers seemed to be.
>
> ...
>
> Professor Lindell pointed out that radiation protectionists were ahead of other environmental protectionists because they always worked with a long-term perspective. There is no reason, thought the Professor, to be afraid of the nuclear power plants because the safety provisions were enormous and stricter than for any other industry. He also said that fish could scarcely become so radioactive that they could not be eaten. The only food that could be was milk.

I do not believe I said 'enormous' - I tend to try and avoid superlatives. However, the task of giving information to a heterogeneous group, in this case experts and local population, is almost impossible. If you talk in a way which satisfies the experts you are talking over the heads of laypeople. If you talk in a way that, in this case, fishermen and farmers will relate to what you are saying, the experts think you have simplified things too far and left things out. No-one is satisfied.

There were plenty of us there from the Radiation Protection Institute and our economists had calculated that the cheapest mode of transport was to hire a limousine with a chauffeur. Our journey caused a sensation when our long, four-door vehicle slipped past other travellers and never seemed to stop. We probably constituted a traffic risk in causing other car drivers to lose concentration. Life is full of risks.

5.6. Rune Jönsson and wind power

The leader of the AMA, Rune Jönsson, was a great advocate of wind power. The following stood in the 'flyer' which was disseminated at the information meeting in Misterhult:

> Nuclear power is to nations as narcotics are to people – initially it works well although it is expensive and seemingly solves some needs, but the longer it is used, the greater the problems become.
>
> WIND POWER – the forgotten source of power – IS AN ALTERNATIVE TO NUCLEAR POWER and is fully competitive in economic terms – non-finite and self-regenerating but, due to the technicians' nuclear power psychosis of being 'in', wind power has been overshadowed. Nuclear power is a child of the war and the delegation of the production of plutonium which is war material.
>
> BENEFITS OF WIND POWER:
> CONVERTED DIRECTLY INTO ELECTRICITY – NO HEAT PROBLEMS.
> DEFINITELY ENVIRONMENTALLY-FRIENDLY – NO INJURIES TO HUMANS!
> EXCELLENT SUPPLEMENT TO WATER POWER.
> SELF-REGENERERATING AND AN INDIRECT FORM OF SOLAR ENERGY!
> CREATES MANY WORK OPPORTUNITIES FOR SWEDISH INDUSTRY.
> FREE - NOT DEPENDENT ON IMPORTATION – DECENTRALISED.
> CAN BE USED DIRECTLY OR COMBINED WITH PUMPED STORAGE POWER PLANTS.
>
> Pumped storage power plant means that water must run from a higher level to a lower level where the power-generating turbines are located, which are then able to use supplied power to pump the water back to the higher level.

5.7. Expertise in the 'radiac centres'

By 1968 I was already concerned that the Civil Defence's radiac centres lacked competent personnel. At the same time, I had found out that many radiation protection experts had been stationed as medical physicists without having sufficient competence for this task. Since then, a number of surveys had been carried out and the Civil Defence Board sent out a circular on 29 January 1971 showing the following:

> In the Civil Defence Board's letter of 25/5/1970, case no. 3300/70, 15/40, the civilian commanders and the County Administrative Boards received the names of proposed people with radiation protection training who were suitable to be stationed in radiac centres.
>
> If it has not been possible to station the named person, the Civil Defence Board intends to do another survey of access to suitable people in consultation with the National Radiation Protection Institute and the FOA.
>
> The Civil Defence Board therefore has to request information before 15/2 as to whether it has been possible to station the people named in the list or whether there was an obstacle to prevent this.
>
> In the light of information received, where there is a vacancy the Civil Defence Board will consult with the Radiation Protection Institute to propose new names of people suitable for stationing in radiac centres.

On 24 February, the Swedish National Board of Health and Welfare stated which of the Radiation Protection Institute's personnel would be placed 'at [their] disposal to be stationed with [them]'. The list included Kaleb Andersson, Hedgran, Helde, Stig David Johansson, Lindell, Lorentzon, Löfveberg, Snihs and Walstam.

On 3 February, I, Kay Edvarson and Gunnar Lindblom from the FOA met to agree a proposal for a radiac preparedness training timetable. A 10-day course for radiac protection personnel was held at Rosersberg in March. It was followed by a 2-day course with emphasis on information regarding radiation protection issues. Roughly 30 people took part in each course.

On 12 March, the Civil Defence Board sent the Radiation Protection Institute a list of expert radiation protection personnel who, owing to the board's circular of 29 January, had been proposed for stationing in the radiac centres. Six of those proposed could not be stationed there because they were stationed elsewhere. The Radiation Protection Institute was asked to come up with proposals for suitable replacements.

On the same day I wrote to Senior Administrative Officer John Ingman of the Civil Defence Board and gave a requested account of conceivable risks in the event of a reactor accident. I am reproducing the letter because it summarises knowledge and views of the accidents at the time.

> Here are some of the promised articles. The subject actually lends itself much better to a discussion and we would welcome a small delegation from the Civil Defence Board for a debate at a suitable time.
>
> I would like to repeat that only one reactor accident has occurred which has affected the surroundings to the extent of necessitating catastrophe measures. No person came to any harm. This was the Windscale accident of 1957 ....
>
> It is also important to remember that a reactor accident does not include a disastrous explosion. If an explosion – a boiler explosion – occurs, the effects are limited to the actual plant. The harmful effects of the reactor accident on the surroundings arise owing to the distribution of the radioactive substances that are released if the reactor overheats and fuel element's capsule is destroyed. This releases the substances which are in gas form and are the most volatile substances. Above all, the iodine isotopes constitute the primary threat.
>
> The immediate risk is in the form of irradiation from the γ-emitting substances in the radioactive gases which could be emitted. Then there is the additional risk of the radioactive substances being inhaled. In the slightly longer term we have the risk of irradiation from radioactive fallout and the risk of foods being contaminated.
>
> The element of risk initially arising (if you imagine increasingly serious accidents) is the risk of high radiation doses to the thyroid gland in infants who drink milk from cows which have grazed on land with radioactive fallout. The other abovementioned risks will occur only with more serious accidents (none of which have occurred so far). The consequences of a very serious hypothetical accident were calculated by a physicist at the Brookhaven Laboratory in 1957 and these calculations are largely still valid. ... Because the risks are radiological rather than mechanical or from heat radiation, the description of consequences and countermeasures are always fairly abstract ....
>
> I would also refer you to the separate letter which we are in the process of sending out and which invites assistance with the formulation of a brochure containing advice and instructions for the County Administrative Boards and an account of the preparedness organisation.

Another course for radiac protection personnel was arranged by the Civil Defence Board at the end of September, also at Rosersberg, again for approximately thirty people.

It should be added that we at the Radiation Protection Institute grinned slightly at the military's and the Civil Defence Board's use of the abbreviation 'radiac' for 'radioactive fallout', but the abbreviation was effective.

5.8. The British Radiological Protection Associations symposium

On 23 March, the British Radiological Protection Association held an important symposium at Imperial College in London. I had been invited by Professor J. H. Martin of the University of Dundee to give a talk on the cost-benefit analysis. Other people giving presentations included Lord Richie-Calder, Robin Mole, H. J. Evans, Donald Gould (science journalist for the *New Statesman*), Craig Sinclair and R. Howells - a small crowd of such significant people that I felt completely out of my element.

I was initially confused by the fact that Martin wrote on stationery marked with 'The Society for Radiological Protection', but this was one of several associations that were part of the Society.

Mole talked about somatic effects and Evans about genetic effects of radiation. Lord Richie Calder's presentation was entitled *Unsafe at any dose* and Donald Gould talked about the public's 'attitude to the atom'. Craig Sinclair talked about the cost-benefit analysis for hazards other than radiation. Finally, Howells talked about legal points of view. The cost-benefit analysis for the optimisation of radiation protection had gained a foothold among those with influence.

During the visit to London I stayed with David Sowby, who now had an extremely modern apartment by Victoria Station and Buckingham Palace.

5.9. **ICRP in London**

The ICRP Committees met at Birkbeck College in London on 15-23 April.

A *Report of the 1971 meeting of ICRP* was published on pp. 615-616 of *Health Physics Journal* number **21**.

So, ICRP Committee 3 met during the same period with me as Chair, Eric Smith as Deputy Chair and Lars-Eric Larsson as Secretary. Dr. E. E. Kovalev from Moscow took part for the first time.

Since the Committee's previous meeting (April 1970), three ICRP documents within the Committee's area had been published, namely:

> Publication 13: Radiation protection in schools for pupils up to the age of 18.
> Publication 15: Protection against ionizing radiation from external sources.
> Publication 16: Protection of the patient in x-ray diagnosis.

Of these, Publication 15 was the most important document, the Committee's main assignment and the paper which Lars-Eric Larsson and I had done the final editing work on one night in Oxford in 1969 with a bottle whisky on the table.

The main thing that was relevant now was a supplement to Publication 15 containing tables and diagrams for use in its application, the document which was to be published as ICRP Publication 21 in 1973. Here, some of the radiation protectionists from the old Radiological Protection Service had produced a first draft. A task group was set up consisting of these experts and with Eric Smith as Chair.

The opinion was that it would be good to supplement Publication 16 with a parallel document on the protection of patients during radiation treatment. Such a document was not to be a radiation treatment textbook and nor was it to give dose planning recommendations. On the other hand, it should give instructions on how to reduce the irradiation outside the treatment area. It should also give critical points of view on inappropriate use of radiation treatment. A group was set up to look at whether drawing up such a document was an important task for the Committee. If so, a task group would be set up with me as Chair. This never happened. Such a document did not come into existence until 1985 (Publication 44).

The Main Commission discussed whether ICRP ought to take up the problems with non-ionising radiation such as microwaves, radars, lasers and ultrasounds. A vote among the members showed 4 in favour, 4 against and 1 abstention. It was known that there were national limits for the intensity of microwaves, e.g., in the USA it was 10 mW/cm^2 (in industry and 5 mW/cm^2 in Federal proposals), and in the Soviet Union 1 mW/cm^2. International organisations such as IAEA and ENEA did not seem interested whereas WHO considered doing something. The Commission agreed to make a statement that it did not intend to take up the matter, but realised how important it was and hoped that another organisation would apply itself.

We stayed at the Imperial Hotel in Russell Square in London. It was not a comfortable experience and afterwards I wrote to the hotel, complaining about how the guests were pushed around in the dining room when they were going to eat breakfast. The hotel director apologised in response, writing 'we are in the process of making changes to improve the situation'. It left me with a bad conscience in case I had helped someone to lose his or her job.

5.10. **The NSfMR's 31st Congress in Reykjavik**

In 1971, the Nordic Society for Medical Radiology held its 31st Congress in Reykjavik with Chief physician *Asmundur Brekkan* as President. Brekkan was also the person who did almost all of the arranging and correspondence. 428 radiologists took part despite the higher travel expenses. Even the Faroe Islands were represented this time.

The Congress was held in Hagaskoli. Iceland's President Dr. *Kristjan Eldjarn* and the university's Vice-Chancellor and the city's Mayor took part in the opening session. The following can be quoted from the 60th yearbook (Unné, 1984):

> The big subject was 'Radiotherapy clinics – Oncological centres'. Following an introduction by L. G. Larsson, E. Poppe gave an account of the way the treatment of cancer was organised in Norway, followed by H. Höst on Norway's *Radiumhospitalet's* expansion plans.
>
> J. Einhorn stated in the discussion that an estimation of the frequency of cancers in Sweden has shown that 25 % of the men and 27 % of the women, i.e., approximately one quarter of the population, will have cancer in the future. The catchment area for an oncology centre ought to have 1-2 million inhabitants and at least 2000 new cases of cancer per year.
>
> R. Walstam thought that the need for radiophysicists in Sweden should be 5 per 1 million inhabitants. In the UK the frequency is 8, in Norway 2.2 and in the USA approx. 2. C. Nyström talked about the need for psychological rehabilitation. K. Vikterlöf (physicist) said that an oncologist should also be a radiotherapist, as well as a good clinician.
>
> L. Feigenberg stated psychological points of view on the organisation of oncological[*] care He said that cancers have far-reaching social and psychological aspects for both the patient and the doctor. Of key significance to the experience of a really serious disease is the anxiety – the fear, which leads the patient to the doctor or prevents him from going to a doctor. The anxiety, the fear, is therefore what needs to be dealt with.

5.11. **UNSCEAR's 21st session**

UNSCEAR's 21st session took place in New York from 14-25 June. At this session I was Chair of the Committee with Franz Sobels as Deputy Chair instead of Vladimir Zeleny, who had been chosen by the Committee but who for unknown reasons did not come to the meeting. Zeleny's absence naturally aroused indignation and anger among delegates. However, this was not taken out on the new Czech delegate, Dr. Klimek, who was quiet but noticeably uneasy. Sobels from the Netherlands represented Belgium as a continuation of the previous arrangement. The Benelux countries cooperated and the Netherlands had several experts in the field. This time, respective Chairmen of the biology and physics sub-groups were Gordon Butler from Canada and Don Stevens from Australia. Sobels was Chair of the genetics sub-sub-group. The Committee had sent greetings to Ralph Bunche who was very ill (he died during the year). Dr. Bunche acknowledged the good wishes with thanks.

Alongside me, the Swedish delegation consisted of Arne Nelson as deputy and Kay Edvarson, K. G. Lüning and Jan Olof Snihs as advisers.

The Committee continued its work with the extensive report which was intended for submission to the General Assembly in 1972. Of particular interest this time was the thorough review of the radiation doses to the population which the peaceful use of atomic energy could be expected to cause.

The Committee also approved the report which had been drawn up on its behalf for the 1972 UN conference on the human environment, and maintained that the principles which were discussed in the report ought also to be of value when applied to problems concerning the identification of and protection

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[*] from the Greek *onko* = tumour

against other forms of environmental contamination. It ought to be possible to base the protection against genotoxic substances and radioactive substances on the same principles.

Marrit and Karin were with me on the trip. We had come via Reykjavik and returned via Paris. We also visited John Hursh and his wife Lydia for an excursion to the Adirondack Mountains where we walked over the hills. This gave us an insight into the local pest, the black flies which, unlike leisurely Swedish horseflies, dive-bomb against the skin causing painful bites before you have time to protect yourself.

5.12. **IAEA consultancy meeting**

On 21-22 June, an initial consultancy meeting was held at IAEA in Vienna regarding an information letter on *Nuclear Power and the Environment*. Another consultancy meeting was held from 10-14 January 1972, but with some other consultants. Karl Morgan and A. W. Kenny were ‘special consultants’ for WHO. The book was published in 1973 by IAEA and WHO jointly. The cover showed a colour picture of the Oskarshamn nuclear power plant.

5.13. **The Berlin Collective**

Our West-German colleagues had established an annual ‘Berlin colloquium’ to which a number of radiation protectionists had been invited to discuss radiation protection issues. Arne Hedgran had taken part the previous year. Presentations and discussions were held in German. Hedgran had now received a new invitation to the 1971 colloquium for 30 June until 2 July. Arne had answered that he was no longer at the Radiation Protection Institute but was now manager of the delegation for Atomic Energy Issues. He advised Professor Stieve, who had sent the invitation, to contact me in order to obtain a deputy. I proposed Bernhard Tribukait, who was both knowledgeable and spoke German.

The list of invited participants included Grande for Denmark, Koren for Norway, Minder and Hunzinger for Switzerland, Zakovsky for Austria, Vic Bond for the USA and Jan Müller for Canada, all of them well-known names.

5.14. **The Nordic Society for Radiation Protection in Copenhagen**

The Nordic Society for Radiation Protection was to meet in Copenhagen on 18-20 August. A preliminary programme was sent out in April. The Chair of the meeting was the Chief physician at the Board of Health, Eigil Juel Henningsen, Per Grande’s boss.[*]

A complication had arisen in that the Society’s board decided to invite Ernest Sternglass to speak at the meeting and was anticipating criticism regarding its decision since Sternglass was not considered to be well-informed. I was asked by Secretary of the Society Ole Berg to propose what Juel Henningsen could say to counter the criticism in advance. Juel Henningsen took up my proposal and wrote the following to those taking part in the meeting:

> As you will be aware, Professor Sternglass has taken part in the debates of recent years regarding radiation risks by providing a series of articles. In these he has maintained that radiation which already exists in various contexts has caused a considerable increase in infant mortality and cancer frequency. Sternglass’ points of view have been heavily criticised and the general opinion is that it is not possible to

[*] Juel Henningsen has already come up several times in my account and was an important man in the Nordic radiation protection work. He had cooperated closely with Rolf Sievert and we were on very good terms with one another. The Danish use of names is worth a comment. If a Danish man has two first names, the surname is often not used on its own but alongside the middle name so that a Swedish person might think the surname was a double-barrelled name. This usage sometimes also comes up in England and the USA and leads to the same uncertainty among Swedes, e.g., regarding the names R. Scott Russell and E. Dale Trout.

> draw the conclusions that he has drawn on the basis of the data he has presented. See also the enclosed photocopy from vol. 68 of Swedish *Läkartidningen*, no. 24, 1971.
>
> Professor Sternglass is to take part in a meeting concerning contamination problems in Trondheim at the end of August. In this connection he has looked at the option of coming to speak in other Nordic countries through engineer Rune Jönsson of Stockholm (member of the Task Group against Nuclear Injuries) and our meeting in Copenhagen has come to his attention.
>
> Given that Sternglass is a controversial person whose points of view have attracted great attention among the public, the board of the N.S.F.S. has assumed that many of the company's members will be interested in having the opportunity to listen to him. From an objective point of view, it should also be interesting to hear Sternglass' claims expressed and discussed in such a way for each of us to be able to form an independent opinion of the extent to which what he is claiming is reasonable.

Ole Berg also sent me a list of the supposed participants in a round table conference on radiation protection for patients:

> Professor Bo Lindell, Sweden (opening speaker and mediator)
> Professor Jerz[y] Einhorn, Sweden.
> Professor Mogens Faber, Denmark
> Head of Department and *cand. real.* Jon Flatby, Norway.
> Chief physician Hans-Henrik Jacobsen, Denmark.
> 1st house officer and Dr. of Medicine Lars Jacobsen, Denmark.
> Physician Gudmundur S. Jónsson, Iceland.
> Assistant professor Bertil Nosslin, Sweden.

The meeting took place in August as planned. It attracted 131 participants, 30 of whom were from other organisations, which meant that 101 members of the Society took part, i.e., 35 % of the total number of members.

Sternglass gave his presentation and, as expected, met with heavy criticism. He showed diagrams of the unanimity of the activity emissions. The whole was a textbook example of how a scientist who is not self-critical chooses the factors which support his hypothesis and turns a blind eye to everything that contradicts it. In the book written by Sven Löfveberg and I, *Nuclear Power, Mankind and Safety* we write about Sternglass' conduct in Copenhagen. I quote how Sternglass viewed infant mortality concerning the Indian Point nuclear power plant on the Hudson River:

> We had the opportunity to discuss this with Professor Sternglass when he visited Copenhagen in August 1971 and put forward his points of view in a presentation before the Nordic Society for Radiation Protection. We asked him how he could consider it to be reasonable to compare a supposed radiation impact in the *direction of the wind* from the reactor with the discharge of radioactive substances in the *river water*. We also asked how he wished to explain that infant mortality in 1968 and 1969 was back to the low values although, according to his diagram, the activity emissions had not fallen.
>
> Sternglass' answer to the latter question was that the emissions certainly had not fallen but that they had changed in composition.
>
> ...
>
> Anyone who has had the slightest training in scientific methodology will realise that Sternglass' method is far from that which is admissible. You cannot 'fabricate' an explanation by selecting a combination of circumstances that suit your objective. There are always many different factors which you can vary *after* an observation to find an explanation. Scientific methodology requires you to *start by setting up* a hypothesis and *then go on to test* whether it is viable. Sternglass consistently works in the opposite way and is thereby always able to find a suitable hypothesis. However, a hypothesis is not proven just because it suits - it has to undergo impartial testing first.
>
> The first question to Sternglass asked whether it would not have been more reasonable to see whether the activity emissions in the *air* looked as though they were

associated with infant mortality in *the direction of the wind*. The discharges to the Hudson River could scarcely harm infants in a community up there inland, least of all because the river water was not used as drinking water. Had Sternglass not also had access to information on emissions to air?

Yes, was Sternglass' response, but the values did not provide such a good link (!).

From the 1971 congress dinner in Copenhagen of the Nordic Society for Radiation Protection. The speaker in the middle is Eigil Juel Henningsen, head of division at the Danish Board of Health, the foremost Nordic leading figure after Rolf Sievert's demise. The Norwegian head of radiological protection, Kristian Koren, is sitting to the right of him. The whitehaired man at Henningsen's left side is the Finnish head of radiological protection, Kauno Salimäki, who regrettably died in the same year. With spectacles, sitting on the other side of the table, the Norwegian head of defence research Thorleif Hvinden, a forceful participant in the Nordic collaboration on radiological protection.

Arne Hedgran and I contributed a presentation entitled 'Points of view on standards for the limitation of activity emissions from nuclear power plants'. We discussed radiation protection optimisation on the basis of a reasonable cost of 200 $ per man-rem. Based on ICRP's expectation that the population dose from all artificial sources of radiation, with the exception of medical sources, would not exceed 5 rem per generation*, we wrote:

> ICRP has clarified that it does not expect the radiation dose to come close to this value this century and that the radioactive environmental contaminations are unlikely to lead to more than 1 rem over a forthcoming 30-year period, i.e., rise to approx. 30 mrem per year. We considered it unlikely that the nuclear power industry, for the whole fuel

* The population dose is actually a collective dose which was stated in the measurement of the time, the man-rem. When we stated it here in rem we were referring to the dose *per caput* of the population, i.e., the average dose to the individual.

> cycle, i.e., reprocessing plants as well, would cause more than 10 mrem per year at the start of the noughties. This means 100,000 man-rem per year for 10 million people. The Swedish electrical energy consumption is not expected to exceed 100,000 MW at the start of the noughties. So, if the nuclear power plants are extended at such a rate that it is possible to calculate a dose commitment which is less than 1 man-rem per MWyear (electricity) on average [actually per MW and year], this protects you against surprises owing to the accumulation of the long-lived substances or an overlay of the effect between many sources of radiation. The average value of the annual radiation dose from the nuclear power industry in the year 2000 will [then] be below 10 mrem.

The others holding presentations included Gun Astri Swedjemark, who talked about non-action levels for contaminated foods, Bengt Pettersson who talked about radioactive ID cards, Anneli Salo who talked about a questionnaire on ways of life, etc. among the population around the nuclear power plant in Lovisa, Tua Rahola and Jorma K. Miettinen who talked about the uptake of radiocaesium in Finnish Saami, *Knud Kristensen* who talked about radioactive medicines, *Klaus Ennow* who talked about patient dosimetry in nuclear medicine, Jon Flatby who talked about patient radiation protection in x-ray diagnostics and Per Oftedal who talked about biological points of view on the location of nuclear power plants.

5.15. **Lars Ehrenberg and the Wallenberg Laboratory**

Radiation biologist Lars Ehrenberg was an important and eccentric scientist, a 'right old Professor'. He may best be remembered for his unconventional idea of stating the risks from chemical mutagens with the assistance of the equivalent dose of ionising radiation which generates an equal risk.

As early as 1959, Lars and the Professor of Botany Åke Gustafsson drew the Medical Board's attention to the risk of cancer and hereditary injuries from mutagenic environmental contaminations, which had already been noted on an international level before the start of big environmental debate introduced by Rachel Carson's book *Silent Spring*.

Lars was in close contact with us radiation protectionists. He realised that the environmental problems had to be discussed on a multidisciplinary basis. He, along with other scientists, therefore took the initiative of proposing a multidisciplinary research laboratory in 1960. Five of his colleagues (Gunnar Ahnström, Mats Harms-Ringdahl, Sören Jensen, Claes Ramel and Carl Axel Wachtmeister) wrote about this in his obituary in summer 2005:

> Lars Ehrenberg maintained that [the environmental issues] required cooperation between several scientific disciplines and in 1960, together with his research colleagues, he proposed that an Institute for Physical Biology should be built up for this purpose with expertise in chemistry, radiation biology, physics, genetics and mathematics.
>
> Following action by King Gustaf VI Adolf and Swedish Marshall of the Realm von Steyern who was Deputy Chair of the Knut and Alice Wallenberg Foundation, the Foundation decided to reserve funds for an Institute of the type outlined by Lars Ehrenberg, also to keep Ehrenberg in Sweden.
>
> Following many rounds of bureaucracy, the new Wallenberg Laboratory was complete by 1971 and ready for Lars Ehrenberg's group of researchers to move into along with groups of researchers within environmental toxicology, environmental chemistry and immunobiology. The Wallenberg Laboratory became a creative and stimulating research environment, particularly tanks to Lars Ehrenberg's achievements.

The Laboratory's first head of department was a chemist, Professor Carl Axel Wachtmeister.

5.16. **The press discusses the 1970 accident at *Radiumhemmet***

In September-October, the press returned to the 1969 radiation accident at *Radiumhemmet* (see Chapter 3). A police report was now finished but the liability issue was open. As is fairly often the case, some newspapers had not been accurate with the details. This was also the case in *Svenska Dagbladet*[*], which caused the chief editor to write a letter of apology to the head of *Radiumhemmet* chef, Jerzy Einhorn:

> On behalf of *Svenska Dagbladet*, I would very much like to apologise that the reference to the police report regarding the 'radiation scandal' at *Radiumhemmet* which we published on 25 September contained direct inaccuracies. At the same time, I am anxious to inform the Professor that the article was not written by the editor Henning Österberg. The freedom of the press prevents me from mentioning the name of the author. Editor Österberg will write a clarification article which he is anxious to submit to the Professor prior to publication.

5.17. **Herbert Parker retires**

There were six old-school American radiation protection pioneers, men who had taken part in the Manhattan Project. There were three on the east coast - Failla in New York and Taylor and Wyckoff in Washington DC. There was Karl Morgan in Oak Ridge in Tennessee. On the west coast there was Stone in San Francisco and Parker in Richland (the Hanford Site). All of them are now dead. Stone died as early as 1966. I have given information about them in 'The Labours of Hercules'.

In 1971, Herbert Parker (1910-1984) retired and his friends around the globe were asked to write a few lines as a book of memories. I wrote that he was one of the first to write his name in Sievert's guest book, on 19 July 1938, and that in my eyes he represented History, and that it was difficult to comprehend how someone who was still so vigorous and active had been involved in so many pioneering achievements. Herb's response was that he was not really retiring - he intended to continue working, but now as a consultant to Batelle. He then wrote:

> You refer to the fact that my name is in your guest book for 19 July 1938. It was when L. H. Gray and Parker spent a month's holiday in Scandinavia, including an extremely fascinating walking trip in the Jotunheimen mountains area in Norway. If the guest book had been continued from the old *Radiumhemmet*, it would have revealed that one of the greatest joys and satisfactions of my earlier professional career was spending six weeks there with Dr. Sievert and his colleagues from January 1933.

5.18. **WHO has no 'ICRP' for non-ionising radiation**

The following can be quoted from the Swedish investigation report on non-ionising radiation[†] (page 36), which unfortunately constitutes one enormous 80-word sentence:

> The problems with protection against harmful effects of non-ionising radiation have been noted by WHO, and in a 1971 report on the subject from its task group it was ascertained that the ICRP formulation of guidelines for definitions and for radiation doses which were acceptable from the health point of view had been of fundamental importance to the development of the protection against ionising radiation, and it was thought that a similar body for non-ionising radiation was most definitely called for.

At the initiative of WHO but with the assistance of IRPA, such a body came into existence in 1977, i.e., initially the INIRC as a Committee under IRPA, which then became the International Commission on Non-Ionising Radiation Protection (ICNIRP) in 1992.

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[*] 'The Swedish Daily', a well-reputed conservative broadsheet newspaper.

[†] See Chapter 6 (1972)

5.19. **WHO course in 'The Hills'**

In August 1971, WHO arranged a radiation protection course in 'The Hills' (Backerne) outside Copenhagen, organised by Per Grande. I was invited to give a presentation. The participants were mainly from exotic countries. I remember that there were plenty of wasps. Kristian Koren, who was also giving a presentation, was stung by a wasp on his skull and became quite befuddled. I advised him to contact a doctor, which he did not want to do. I then gave him antihistamine tablets which I took for hay fever. This helped him and he was very grateful.

An equivalent course was held in 1972 (see Section 7.6). A new Atoms for Peace Conference was held in Geneva in September.

5.20. **Information in *Läkartidningen***

In November 1970 I had been contacted by the chief editor of *Läkartidningen*, Sven Forsse, who wanted an information article about the radiation protection issues surrounding nuclear power. I tackled the work along with Bernhard Tribukait, whom was in charge of the Swedish Radiation Protection Institute's radiation protection medical department at the time. Our other work assignments meant that the work took a long time and when we had finished writing we had created new problems for ourselves. I wrote to Forsse about this on 4 June:

> I have now finally compiled something along with Assistant professor Bernhard Tribukait at our medical radiation protection department, but it has given us a dilemma. We need information for more interested parties than *Läkartidningen* and we do not have time to write new versions on each occasion. We have therefore had to take a brief look at the need to put together something that is generally adequate from the information point of view, and this has meant that there is more material than we would have wanted considering the space available: 35 pages of text is too long for a newspaper article, but we do not want to delete anything because we have taken a great deal of trouble to obtain the balance that we now think the paper has.
>
> I have spoken to Gunnar Birke*, who thinks *Läkartidningen* might want to publish the material in two sections. We have tried to divide it into two but there is no natural dividing point; on the other hand, it can very reasonably be divided into three consecutive sections.

And so three sections it was (Lind, 1971), which we also published in the Swedish Radiation Protection Institute's annual report and could use in the authority's information activities. They contained an early discussion on population doses and dose commitment.

5.21. **Swedish nuclear power**

In June 1971, Krister Wickman was succeeded by the practised Rune ('Bagarn [the Baker]') Johansson as Minister of Industry. In 1971, the situation with the Swedish nuclear reactors was as follows: Ågesta heat and power plant was underway as were the R2 and R2-0 research reactors in Studsvik. Of the power plant reactors, Oskarshamn 1 was commissioned during the year. Four reactors were in the process of being built: Oskarshamn 2, Ringhals 1 and 2 and Barsebäck 1.

* Professor Gunnar Birke was medical editor of *Läkartidningen*.

5.22. **Radiac preparedness in times of peace**

Sievert had made a stalwart effort faced with the threat from the Soviet 'superbomb tests' in 1960 and 1961.* He was worried about the lack of preparedness against continued atmospheric nuclear weapons testing but also against major reactor accidents. In 1960 he had initiated the Commission for Advice in the event of Nuclear Accidents (KRA). When he died in December 1966, he was compiling a preparedness plan which he never managed to finish. In 1971, the major nuclear power plants were becoming a reality. At the Radiation Protection Institute, we felt a responsibility to fulfil Sievert's intentions. When it came to civil preparedness in times of war, I had already taken a number of initiatives by 1968 (see Section 2.15). But the 'radiac' preparedness (the military terms are infectious) had still not been settled, and it was now high time that it was.

We realised that radiation protection preparedness in times of peace involved a number of cooperation problems. We therefore intended to start drawing up a draft of a brochure called 'Radiac preparedness in times of peace'. With that available we would be able to discuss the matter with the many who were involved.

The draft that Sven Löfveberg and I rapidly produced fitted into a 32-page A5 brochure. The table of contents included:

INTRODUCTION
ORGANISATION
AUTHORITIES
The National Radiation Protection Institute
The Commission for Advice in the event of Nuclear Accidents
The Atomic Energy delegation and the Reactor Location Committee
The County Administrative Boards
Police
Fire brigade
The Swedish National Board of Health and Welfare
The National Veterinary Board
LAWS AND REGULATIONS
The Radiation Protection Act
The Atomic Energy Act
The Nuclear Protection Act
The Nuclear Liability Act
RADIOACTIVITY AND RADIATION
POTENTIAL SOURCES OF RADIATION
RADIOACTIVE FALLOUT
RADIATION DOSES AND PROTECTION STANDARDS
IF THE ACCIDENT OCCURS
Alarms and advice
Medical preparedness
The Swedish Radiation Protection Institute's instructions to the County Administrative Boards

However, as we had feared, cooperating was tough. The Radiation Protection Institute did not have a really clear mandate to act and laws and organisations were changing so quickly. The Swedish Nuclear Power Inspectorate appeared in 1974. The Radiation Protection Act was changed in 1976 and the Radiation Protection Institute then gained a stronger position regarding cooperation matters. However, this then meant that the original initiative was inadequate, but the Harrisburg reactor accident which occurred in 1979 brought forth resources for a comprehensive preparedness report which the government requested from the Radiation Protection Institute in the same year.

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* See chapter 16 of 'The Labours of Hercules'.

The development also increased the interest in research surrounding risks. An early example is that RIFO held a seminar about risks on 11 November.

5.23. **Lauriston Taylor writes a piece of history**

In June, I received a letter from Laurie Taylor in which he asked me to review a manuscript of a paper on the history of radiation protection, which I was happy to do since I had considered writing something similar myself. In a letter of 13 December he thanked for my comments and sent me his recently-printed report on radiation protection and standards as a thank you. He apologised that it had not been well checked over and asked me to review the text 'not just for typos but anything [I] thought [was] an error. Since I intend to do much more comprehensive work, any suggestion you might like to give me would be very valuable. I am much more concerned about the accuracy than my own personal feelings, so please do not hesitate to say what you think'.

The 'much more comprehensive work' turned into a book in four volumes, 10 cm thick (!), entitled *Organization for Radiation Protection, Activities of the ICRP and NCRP 1928-1974*. It was published in 1979 and I received a copy from Taylor in 1980. It weighed 5 kilos. I could make a pun about a heavyweight contribution, but it was worth taking seriously. Not only that, to do so would be like throwing stones in a glass house - my own four volumes will weigh just as much[*].

[*] This was actually true for the original Swedish hardcover edition!

6. THE YEAR 1972

6.1. Computed tomography

Doing a tomography, i.e., taking (x-ray) images of specific layers of the body, is an early concept. A Frenchman by the name of *Bocage* had already applied for a patent concerning x-ray images on a moving plate in 1921. He described how, by moving an x-ray camera and x-ray image so that the image becomes just sharp enough for a specific depth in the body, it was possible to obtain a slice image for this particular depth. Unfortunately, the image was disturbed by the overlying, blurred images from other depths. Another disadvantage was that a large part of the body was irradiated in addition to the depicted layer.

Progress was made in 1938 when Hungarian J. Frank introduced the method of *transverse tomography*. This irradiated only the particular layer that was to be depicted, but from the side rather than perpendicular to the layer. The x rays were delimited through a narrow slit so that tissues above and below the layer were not irradiated. The x-ray image of the layer then became just a narrow band. Taking several images while gradually rotating the examined body and simultaneously gradually moving the x-ray plate upwards meant that you obtained an accumulated x-ray image of the layer from different angles, known as a *sinogram*. The sinogram contained enough information for the reconstruction of an x-ray image of the whole of the irradiated layer as if it had been viewed at right angles, but a fair amount of time passed until computers became available to enable the necessary calculations. Optical reconstruction methods were attempted in the absence of sufficiently-advanced computers. The Japanese radiologist *Shinji Takahashi*, who later became a member of ICRP, made important achievements in this regard.

However, calculation formulae ('reconstruction algorithms') were available early on. The first, the *Radon Transform*, had already been introduced by 1917 by the Austrian mathematician *Johann Radon* (1887-1956). However, it was not intended for medical diagnostics. Radon's problem consisted of equations which explained gravitational fields, but his transformation ended up forming the basis for the reconstruction methods of transverse tomography. However, in Radon's time the computer power needed for the calculations was still unavailable.

The next step was taken in 1964 when the South African radiophysicist *Alan McLeod Cormack* (1924-1998) in Cape Town reported an experiment in which he had exposed an inhomogeneous phantom to a series of x-ray beams at different angles. He stated the necessary reconstruction algorithm for transforming the primary results into a cross-sectional x-ray image. Although in doing so he had provided a working computed tomography recipe, the time was still not right – computers were still not powerful enough for the method to be used in diagnostic practice.

Unaware of Cormack's publication, *Godfrey Hounsfield* (1919-2004) took out a patent on a reconstruction method for transverse tomography in 1967. He was employed at British Electrical & Musical Industries Ltd (EMI). In 1968, Hounsfield did an experiment where he exposed a box filled with different objects to extremely delimited gamma radiation from an americium preparation. The strength of the outgoing radiation on the far side of the box was registered using a scintillation detector. After each registration, the source of radiation was moved 3 mm to the side and the procedure was then repeated so as to 'scan' the whole of the object under examination. After 80 exposures where the source of radiation had been moved 25 cm, the procedure was repeated in the opposite direction, but now so that the new exposures took place in between the first, which meant a total of 160 exposures. The drawer was then turned 1 degree at a time for a total of 180 degrees and the procedure was repeated for every angle with 160 exposures distributed over the same slice of the drawer. Because the radioactive source was not very strong, it initially took nine days to complete the irradiation at every angle, which is why it was necessary to strongly increase the strength of the preparation. In the end, the reconstruction into a tomographic image took two and a half hours using the most powerful computer available.

Regarding the computerisation, the examined slice can be seen as being constructed of a large number of small volume elements, *voxels* (cf. the structure of digital images with *pixels*, i.e., picture elements). It is assumed that each voxel weakens the radiation to a given extent, determined by the *attenuation value* of the voxel, which makes it necessary to use monochromatic radiation as far as possible. During the scan, the total weakening of the radiation through the voxels that the beam passes is registered for each beam. The total information on the weakening at the different angles of incidence makes it possible to calculate the attenuation value for each voxel. The final results can be presented as a digital image in which every pixel represents a corresponding voxel.

When the feasibility (but not yet the practical application) had been demonstrated, the next experiment was carried out on a cross section of a brain that was known to have a tumour. This could be discerned, and also calcifications in the tumour. It was now obvious that the method was of clinical value.

The next stage was to examine patients using a prototype of a tomography scanner. For this, Hounsfield cooperated with a radiologist, *James Ambrose*, at the Atkinson Morley Hospital in London. No computer had yet been linked to the scanner. The readings therefore had to be transferred to a magnetic tape which was sent to the EMI factory to be computerised.

In April 1972, 70 patients had been examined and it was possible to publicise the method. This can therefore be seen as the year in which the *transmission computed tomography* (CT) was born, an invention which many see as the most important within diagnostic radiology since Röntgen discovered x rays. Godfrey Hounsfield and Alan Cormack were rewarded for the invention with the Nobel Prize in Medicine in 1979.

EMI marketed its first computer tomograph, the Mark I 'EMI scanner', early on but it was quickly followed by new models. The first model was designed to examine the head. Later models were intended for the whole body. In order to reduce the examination time, they changed from using narrow beams to diverging beams so that scanning became unnecessary. This was made possible by the emergence of new detectors so that the information from the divergent beam could be registered by a gamma camera, i.e., a circular sector-shaped row of a large number of small detectors. It became possible to reduce the measurement time from several minutes to a few seconds.

The first computer tomograph in Sweden, a Mark I EMI, was installed at *Karolinska Sjukhuset* in October 1973. By March 1977, each of the Swedish university hospitals had had an EMI scanner installed, and from November 1977, only computer tomographs for the whole body were installed, starting with *Akademiska Sjukhuset* in Uppsala and *Karolinska Sjukhuset*. The computed tomography (CT) was well established by then.

6.2. Swedish report on non-ionising radiation

The Radiation Protection Institute's, SSI's, letter to the Swedish Government in 1970 proposing a non-ionising radiation report was referred for consideration by the Swedish Board of Occupational Safety and Health and the Swedish National Board of Health and Welfare in 1971. The result was that on 4 February 1972, the Swedish Government asked the Institute to cooperate with the Swedish Board of Occupational Safety and Health, the Swedish National Board of Health and Welfare, the Swedish Defence Research Establishment and the Medical Board of the Defence Forces in investigating the existing problems.

Therefore, on 25 February, the Radiation Protection Institute's board decided to set up a committee with Surgeon General Carl-Johan Clemedson as Chair. The Radiation Protection Institute provided radiation protection inspector Enn Kivisäkk as Secretary with assistance from the recently-employed Monica Carlson. Other members were

Matts Helde, the Swedish Radiation Protection Institute (SSI)
Lennart Hellström, the Medical Board of the Defence Forces
Anders Holmqvist, the Swedish National Board of Health and Welfare
Bengt Kleman, the Swedish Defence Research Establishment
Per Erik Ljung, the Swedish Defence Research Establishment
Gösta Sylwan, the Swedish Board of Occupational Safety and Health

Unfortunately, Gösta Sylwan died during that year and was replaced by *Sven Linnander* from the Swedish Board of Occupational Safety and Health. As proposed by the Committee, *Björn Tengroth*, then temporary Professor at the University of Gothenburg, and *Jan Sverne*, Senior Administrative Officer of the Medical Board of the Defence Forces, were added as experts during the summer. The final person to come, in March 1974, was the Radiation Protection Institute's lawyer, Carl-Gösta Hesser. During the work, the primary contributions noted were those by the dynamic Tengroth, who took part in consultations with other committees, including one regarding the 'Biological effect of electromagnetic fields' set up by the Royal Swedish Academy of Engineering Sciences.

The committee submitted its report on 31 July 1974 (see Chapter 8).

6.3. ICRP in Ottawa

The ICRP Main Commission met on 6-10 March 1972 in Ottawa at the head office of Atomic Energy of Canada Ltd. Conditions in Canada were very wintry. On the postcard home I wrote: 'Ottawa, Saturday 4 March. I made it safely ... It's really cold out here and there's a load of snow', and 'Monday 6 March: I've now had a rest and taken a long walk. It's sunny, cold, there's a lot of snow and very slushy on the roads. I'm now waiting for David [Sowby] to arrive'.

6.4. UNSCEAR's 22nd session

Postcard home:

> New York, Saturday 11 March (Roger Smith Hotel, Lexington Ave on 47th St.): I've now arrived safely at the hotel in New York and the ICRP meeting in Ottawa is over. ... Here at the moment it is +7° out and there is no snow. In Ottawa there was almost a metre of snow and it was between -10° and -20 °C'.

UNSCEAR held its 22nd session in New York from 13-24 March. The Chair this time was Professor L. R. Caldas from Brazil with Professor Sobels as Deputy Chair and Arne Nelson as rapporteur. Gordon Butler and Don Stevens continued as Chair of the biological and the physics sub-group respectively. The Swedish delegation was the same as it was in the previous year: I was the Swedish representative, Arne Nelson was my deputy and Kay Edvarson, K. G. Lüning and Jan Olof Snihs advisers.

This time, the Committee completed its work on the extensive Appendices that were to be published at the same time as the annual report to the General Assembly. Owing to a lack of resources, the Committee had decided to submit the report without Appendices. These were to be published as a separate UN publication and, when it came to the English version, this would be published in conjunction with submitting the report. Our Swedish delegation's report to the Ministry for Foreign Affairs was concluded with the following two paragraphs:

> The western powers proposed that the Committee should not meet again until 1974. However, because the Committee was asked to report on an annual basis in accordance with General Assembly Resolution 913 (X) and the nuclear weapons testing continued and new problems have arisen in connection with the peaceful use of atomic energy, the Soviet Union representative, Professor Kuzin, supported by several other representatives, proposed that the Committee meet in 1973 and that Vienna should be the place for the next session with IAEA as host. The IAEA delegate also confirmed

> that IAEA was willing to act as host. The Committee decided to meet before the end of 1973.
>
> The Committee worked in the same scientific and amicable spirit as always and the significance of its scientific integrity was emphasised in different contexts. However, according to private information, persistent forces appear to be working to incorporate the Committee into either IAEA's work or the UN's disarmament department. This would seriously impair the balance and the relative independence of ulterior motives which have characterised the Committee's activity so far.

It is interesting to know that the head of the UN's disarmament department at this time was former FOA physicist Rolf Björnerstedt, who had close relations with UNSCEAR's Secretary Francesco Sella.

> Postcard:
> Friday 17 March (St. Patrick's Day) Tomorrow morning I'm flying to Washington DC for Saturday-Sunday. - - I'm now going with Nelson and Snihs to *La Paloma* (Mexican restaurant) for dinner.
> Sunday 19 March: I'm now back safely from Washington. This morning I walked from the Cosmos Club past the White House and Lincoln Memorial and across the bridge over the Potomac River to Kennedy's grave. I then took a taxi to the airport. It was warm and the Dogwood and Magnolia flowers were just starting to come out.

6.5. The European Organisation for Nuclear Research (CERN)

The European Organisation for Nuclear Research (CERN) (*Conseil Européen pour la Recherche Nucléaire*), the European research station for particle physics, was formed after the Second World War to try and persuade European scientists not to emigrate to the USA. CERN came about in 1953 at the initiative of prominent physicists like Eduardo Amaldi, Pierre Auger and Isaac Rabi with support from UNESCO. The research station was built in Geneva, close to (and now also over) the border with France. It uses very powerful accelerators for protons, electrons and positrons where the biggest storage ring (the acceleration path) now has a circumference of 27 kilometres! Thousands of scientists from all over the world are working at CERN. The activities are expensive; in 1996, Sweden's contribution was 144 million Swedish kronor.

Lars Persson was the manager's assistant at CERN from 1971-1974 and cooperated with the head of radiation protection, the Norwegian Johan Baarli

6.6. ICRP Committee 3 in Dubna and Moscow

ICRP Committee 3, of which I was now Chair and Lars-Erik Larsson was Secretary, had received an invitation through our Russian member, the nuclear physicist Eugene Kovalev, from the Soviet Union's 'NCRP' (National Committee on Radiation Protection) to hold its next meeting in Russia - in Dubna to be more specific.

Dubna is a research facility 130 km north of Moscow by where the Moscow Canal joins the Volga. The town was the headquarters of the JINR (Joint Institute for Nuclear Research). It was a research organisation that was created in 1956 with participants from the Soviet Union and a number of Eastern states, and its laboratories were placed in Dubna, which does still have a good reputation as a nuclear research centre.

A visit to Russia in 1972, where Leonid Brezhnev was in power and Stalin had been dead for only nineteen years, was no ordinary, everyday occurrence. We knew very little about Russia and had preconceived ideas that did not always correspond with reality.

Anyway, one spring day we arrived in Russia, starting off in Moscow where we were met by Eugene and his sophisticated wife and driven to an enormous hotel where we were ceremoniously checked in. Lars-Eric and I were allocated a shared room, which led Lars-Eric to suspect that we were bugged and that there would not be many Swedish-speaking listeners. As was the case at most Russian hotels, there was always an elderly lady on each floor to ensure that the peace and quiet was not disturbed.

Our first meal at the hotel was hosted by Mr and Mrs Kovalev. The table was laid with various types of *hors-d'oeuvre*. I was next to Mrs Kovaleva, who spoke fluent English (they used to live in London). I hesitated before taking any *hors-d'oeuvres* and asked what I should begin with.

'You're not on Mars,' said Mrs Kovaleva reproachfully. 'We're a civilised society. Eat as you would normally!'

We were transported to Dubna in big, black limousines that travelled at high speed on roads which were deep in mud. The chauffeurs completely ignored the country folk who were standing by the edge of the road being sprayed with mud.

In Dubna, we had the privilege of using a large conference room and were able to devote ourselves to ICRP matters. Pierre Pellerin, the bane of every Chair due to his stubbornness, spoke heatedly about the need to strengthen patient radiation protection. He gave an account of how his authority in Paris had dealt with the problem and, as he had on many previous occasions, declared his gratitude to Rolf Sievert who had inspired him. Pellerin wanted a statement on the patient protection problem, and this was duly granted. In 1973, an ICRP paper in the *British Journal of Radiology* stated that the radiation doses given to patients from diagnostic X-rays were a problem.

However, the most relevant work assignment was to examine the materials that should be included in ICRP Publication 21, which was intended to supplement Publication 15 on protection against external radiation. Those who were mostly involved in this respect were the unlikely pair of big Charlie Meinhold and little Ralph Thomas.

When not in meetings, we walked along the sandy beaches of the River Volga. We asked our Russian hosts which communities we could see the contours of on the other side of the river, but they said they did not know. To begin with I thought they did not dare to say anything about the topography, but I later came to understand that they were completely disinterested in their surroundings, maybe as a consequence of long-term surveillance. I found it easy enough to go into a book shop in Moscow and buy a street map of the whole of the Soviet Union without problems or questions.

So, we had a productive meeting with the Russian NCRP. Several of the members appeared to be very clever and knowledgeable. As was usual in Russia, where age was respected, the Russians were relatively old and understood no English, but did understand German and French. We knew no Russian. Mrs Kovaleva offered to interpret and opened the meeting by describing organisations and authority functions. 'In this country,' she said, 'you should be aware that everything is forbidden.'

At first we were astonished. Was this a bold political statement? After all, it was what many people outside the Soviet Union did actually believe. But it then became clear to us that it was serious and did describe the legal situation without any irony at all. The comparison we were able to make was in the form of the Swedish Hunting Act, Section 3 of which is categorically introduced by 'Game is protected', continuing with the exemption that 'and may be hunted only if done so in accordance with this Act'. You have to know the exemptions to be able to follow the rule.

We were also invited to dinner with the NCRP. We sat at a very long table, maybe thirty people in all. The Chairs of both Committees sat at either end of the table. A while later, a request was heard: 'Prafjessor Lindell, first speech!' And I was obliged to give a speech, whereupon we all toasted each other with vodka. But the requirement did not stop with me. Everyone around the table had to take turns to give a speech and raise a toast. We, the guests, cheated to survival, but several of the Russians took the drinking seriously. When the whole of the table had completed the round of speeches, a new voice spoke: 'Prafjessor Lindell, second speech!!!' And the toasts continued around the table.

You sometimes hear the phrase 'drinking someone under the table', but I had never experienced it literally until the NCRP's dinner. A few Russians were actually under the table. I thought it appropriate to break up the meeting and was supported in this by my committee. Lars-Eric found an excuse that made people take notice:

'It's the ice hockey World Championships and Sweden's playing Russia! We must go back to our rooms and watch the coverage on TV. Anyone who's interested is welcome to join us.'

Back at my room we ended up with three Russians in tow, my room being the largest since I was the Chair (equality evidently didn't stretch to all situations). When we had sat down in front of the TV, Lars-Eric pulled a bottle of vodka out of a cupboard and said:

'Maybe a little vodka wouldn't go amiss while we're watching!!'

This hit the Russians like a bolt of lightning. Their faces took on a green hue - at least that's what I thought - and they mumbled 'Excuse us!' and rushed out, whereupon Lars-Eric put the bottle back, saying 'Now, as it's just you and I, I don't somehow think we need any more vodka!'

The Soviets won 5-3. And that was the end of our first visit to the secretive Soviet Union.

6.7. IRPA in Budapest

Immediately after our visit to Dubna there was time still for a visit to an eastern state; IRPA held its Congress in Budapest. Marrit came with me this time. We stayed at the Royal Hotel on the Lenin ring road. We found that people who were in charge of something, right down to the man behind the hotel reception counter, appeared to be sulky and suspicious whereas the people on the streets and in restaurants appeared to be happy and friendly. What particularly surprised us was the spontaneous happiness which seemed to inspire those taking part in a full-blown May Day parade on Dózsa György. But the buildings still had gunshot damage to the walls and bullet holes in the windows following the Russian intervention against the freedom fighters sixteen years previously, and Soviet soldiers were still on guard on the Buda side of the River Donau.

There is not much to say about the Congress other than the fact that the amicable little László Bozóki acted as proud host, also at the Congress dinner at the Gellért Hotel on Friday 5 May. Following the Congress, the Society's board decided to meet at Lake Balaton where Bozóki, John Horan, Lindell's, Greg Marley, Karl Morgan, Yasushi Nishiwaki, Claire Palmiter, Carlo Polvani and Walter Snyder took part. Courvoisier, Feige, Gopal-Ayengar and Jammet were unable to attend. Karl Morgan, Marrit and I bathed in a warm spring at Keszthely at the western end of the lake. John Horan achieved the tour de force of guiding us around a real Abbey on the Tihany Peninsula.

A Programme Committee meeting for IRPA's 1973 Congress in Washington DC was held in connection with the Congress. I was Chair of the Committee, which met in the 'CLUB' room at the Hungarian Academy of Science. The group otherwise consisted of M. Gras, Julian Liniecki, Brian Lister, Art Marko, Zwanette Nooteboom-Beekman, Claire Palmiter and David Sowby. Secretary of the Committee John Villforth did not attend. The group decided to recommend to the IRPA board that the traditional form of meeting with a large number of presentations and few discussions ought to be abandoned. Instead, we recommended a few presentations but otherwise posters which would be the subject of discussion.

One detail which would lead to conflicting feelings during the Congress concerned the requirement regarding the slides that were shown. The Committee had become tired of people holding presentations and showing images containing text that could not be read. The text on the images to be projected had to be readable at a distance of 30 centimetres.

6.8. Nuclear Power, Mankind and Safety

In my discussions with Sven Löfveberg, it became clear that Swedish radiation protection needed reference literature from which it was possible to obtain answers to the most common questions that the Radiation Protection Institute used to receive. There was little such literature in Swedish. Our board agreed to our using the Institute's resources to create a suitable book. In return we would accept no authorship fee. The board also agreed to promise the publishers a financial guarantee that the publication would not lose them money.

And so we got down to writing. I wrote the first draft since I had the best access to the information that was needed. Sven continued by removing the worst of the blunders and editing the language. We did our best to make the book easy to read. Its title was *Kärnkraften, människan och säkerheten* (Nuclear Power, Mankind and Safety).

We called our foreword the ‘declaration of contents’ and quoted from Paul Valéry: *Everything simple is false. Everything which is complex is unusable.* I quote from the foreword:

> We have ... reserved the right to present our personal views and our personal interpretation of the radiation protection problems.
>
> In this way we hope to have safeguarded our own integrity and that of the Radiation Protection Institute. We have not allowed ourselves to be affected by anyone and we are not presenting anyone’s case, only our personal conviction. The Radiation Protection Institute has no responsibility for what is said here, but does have an interest in having the material published.
>
> However, this does not mean that we are trotting out strange and not very representative views and interpretations. What we are saying is largely typical of the way that those in Sweden who work with radiation protection issues think. We have taken the trouble to ask the advice of others and we have taken advice from most of those in this country who are actively dealing with issues concerning the effects of radiation and radiation protection. We are very grateful to them but prefer not to mention anyone’s name here. We do not wish to deflect any part of the responsibility from ourselves.
>
> Those who advocate nuclear power and those who oppose it may be disappointed with what we write. We have criticisms both ways. We therefore also dissociate ourselves from every out-of-context quotation from what we have written. There are so many different arguments that only the complete issue can provide an acceptable balance.
>
> Many readers may be scared by numbers, calculations and statistics. They should be aware that we have not lost sight of the humanity attached to these numbers. Numbers and calculations can never become inhuman *per se*. They become inhuman only if you forget the purpose for which you are using them.

The book was benevolently received but was not reviewed in the big press. *Dagens Nyheter* mentioned it in a news report but that does not constitute a review. It became reference literature in many important contexts. The nuclear power opponents received it fairly amicably and respectfully but we received a lot of criticism regarding one point where we might have been clumsy in expressing ourselves. It concerned a chapter which we had called ‘ignorance and misunderstanding’.

Our introduction to the chapter was not what you would call controversial. We wrote:

> In our contact with many anxious or critical or annoyed people who are chewing over the radiation risks we have tried to see the matter from both sides. We understand the individual Swede who by inheritance and habit is angry at, or at least mistrustful of, people in authority and who has read or heard that things are not at all the way the experts make it out to be. How is he supposed to be able to weigh up the reliability of a Swedish authority expert against an American Nobel Prize winner?
>
> And we also understand our colleagues – not without a touch of self-pity – --- who, after having done their best under circumstances of great pressure and heavy responsibility, are subjected to questions and criticism which often appears terribly unenlightened. We empathise with those who think it is more important to set about the research or radiation protection work rather than spending a great deal of time, since it does take time, on having discussions with people who either remain stubbornly unconvinced or are not fully capable of comprehending it better.
>
> We still believe that such discussions are worthwhile for all parties. The seed of knowledge brings good harvests in the long term and if, in the adverse wind, any such seeds are blown onto ourselves, it is our job to give them the opportunity to take root.
>
> We have seen how many radiation protection experts and scientists from all over the world react almost mechanically to criticism and we think this a short-sighted reaction. If we are asked silly questions or are criticised by someone who lacks knowledge, it is not a matter of private differences between us and the person criticising, provided we are in a responsible position. Many anxious and interested people hear the question or

> the criticism and listen to the answer in order to try and form a perception for themselves of what is right. If the answer is 'Fool!' it is not a very strong argument and sheds little light for the person who is listening.

Further on in the chapter we may have been clumsy. We attempted to identify the critical groups and stated a list:

- *The anxious* – those who are afraid of the unknown due to ignorance and lack of information.
- *The fanatics* – those who for obscure reasons have an almost religiously fanatical attitude to the radiation as being something which is evil in itself.
- *The calculating* – those who use the fear of radiation as a means to combat something else which is their actual goal.
- *The political* – those who out of concern for the future or for immediate political reasons see the increase in energy consumption to be a bad thing and therefore oppose nuclear power plants.
- *The paranoid* – the pathologically disturbed and distrustful, although these usually concentrate their suspicion on x-ray devices and the radioactive substances in their proximity.
- *The distrustful* – those who draw parallels with society's omissions and incapacity to deal with other environmental contaminations and assume that the authority has never given the radiation protection problems any particular thought.
- *The cautious* – those who have greater knowledge than the anxious but who are afraid of this knowledge because it is incomplete or because they judge the radiation risks without finding out about the risks that they would be running in choosing alternative, radiation-free technical solutions.
- *The indignant* – those who, rightly or wrongly, think that the authorities use erroneous methods.
- *Those affected* – those who are personally affected by something such as a power plant.
- *Those who are hungry for publicity* – those who succumb to the temptation of representing a popular view without being personally committed and thereby gaining publicity or an authorship fee.

We added two paragraphs which our critics do not seem to have read when they accused us of seeing them as paranoid;

> Many more groups can doubtless be formed and several names can often apply at once. As we can see,, the motive expands from the crassest to the most noble. However, in our experience, the majority and the most active of critics and people who ask questions have very respectable motives. And, like everything else in this world, it is not a question of seeing things as black or white.
>
> There are few critics whose criticism is never right in any regard. And what would then be wrong in following Thorild's motto and remembering that nothing is done for the sake of its errors – it is done for the sake of its value. No authority and no expert is superior to the usefulness of self-examination and attempting to see things from different angles. We therefore take a positive view of the criticism, even where we do not subscribe to the views that are put forward.

We added a footnote to the second edition of our book (1975):

> The examples of critical groups were written in 1972 before the Swedish nuclear power debate had begun in earnest. The problems at the time were *fear of radiation*. The nuclear power debate includes a good number of new groups and often concerns the energy society as such. Strangely enough, those who have quoted our group division

have assumed that we have placed them in the paranoid group and have failed to quote the two sections after counting up groups.

Dinner with the Gillberg couple

After our book had just been released, I was invited to dinner with Marianne and Björn Gillberg in Uppsala, which was a little surprising given my biting criticism of Björn in *Dagens Nyheter*. I drove on the new motorway from Stockholm, E4, for the first time. Arthur Tamplin and Dean Abrahamson were also at the Gillbergs'. The two American nuclear power opponents assumed the bitter distrust in the USA between nuclear power critics and authorities, primarily the Atomic Energy Commission (AEC) also existed in Sweden. They assumed that the authorities in Sweden were withholding essential information from the public. I was able to show them our book which gave a clear account of the risks. Tamplin was too tarred by the American debate not to continue to be distrustful, but Dean Abrahamson thought that Sweden was unique.

Marianne and Björn were very friendly and showed honest concern about my journey back to Stockholm. 'Remember that elks can come onto the motorway!' they said. 'Drive carefully - the road is new and they haven't had time to get used to it.'

6.9. **Richard Matz**

In the early 1970s, Sven Löfveberg and I were in close contact with Rune Jönsson and Richard Matz. We respected their diverging views and criticism of authorities and politicians and wanted to assure ourselves that it was unjustified. Many letters were exchanged with Richard Matz in particular.

Matz reviewed our recently-published book, *Kärmkraften, människan och säkerheten* (Nuclear Power, Mankind and Safety), in an article in *Land* (a weekly journal aimed primarily at rural readers). Matz was surprisingly obliging and positive bearing in mind that he represented an organisation that was critical of the authorities.

Matz still thought that we were biased about atomic energy, partly because we did not criticise the nuclear power advocates as heavily as we criticised some of atomic power critics, and partly because he thought we had omitted some information which would be to the detriment of nuclear power. Our response was:

> Now, in fact nuclear power advocates are principally from within the developing industry whose representatives are usually so well trained that they are not guilty of making claims that are completely technically or scientifically incorrect. It must be remembered, and Birgitta Hambraeus* has also said a good number of times, that there is not really any disagreement regarding technical or scientific issues. The disagreement concerns the political conclusions. We are not politicians and should therefore beware of drawing the conclusions when considering the protection. On the other hand, the factual mistakes and ignorance should be criticised so that they do not distort the discussion. People should not draw the conclusion that we are advocates of nuclear power just because the ignorance has mainly been among those who have not been trained in the technical matters. It would of course be overwhelmingly easier from the radiation protection point of view if there were no nuclear power plants. The only thing that binds us to nuclear power is that we cannot assume the responsibility of maintaining that other alternatives are better for society. Our lack of knowledge forbids this, but we also have an inkling that the critics have not seriously reviewed the realistic aspects of alternative solutions.

* Well-known anti-nuclear member of Parliament

On 15 November I received a letter from Matz in which he recommended that we at the Radiation Protection Institute read a West-German book, *Die Wissenschaft und die gefährdete Welt* by Friedrich Wagner. Matz wrote:

> The book contains an historical retrospective view of the way in which the spirit of science has developed over time. There is particular emphasis on Bacon, but even more so on Galilei, the latter as the actual origin of the quantifying mentality within science, which differentiates between primary and secondary qualities, thereby more or less glossing over the human being.

In my response I thanked him for the information on the book, which 'I [was] even more interested in since I [was] in the process of writing a similar book myself'. I continued:

> I am also interested in the reference to Galilei and 'the quantitative mentality' but I think it is a misunderstanding to believe that 'quantifying' glosses over the human being. Unfortunately, anyone who refuses to tackle the quantitative aspects of different problems is instead actually giving human life the value of zero!
>
> This has been criticised by the editor of *Teknisk Tidskrift*, civ. eng. Bertil Håård, using traffic safety planning as an example. In refusing to attribute quantitative values to human life, the planners have taken into account only pure economic losses such as loss of paid income as the costs of a traffic accident. You then have such crazy results like a road traffic death 'costs' less than an accident where someone is disabled and has to be taken care of by society! Not until you start taking into account that a human life as such does also have a value which must be included in the calculations (as was made in 'Road Plan 70') will you realise that it is actually no more reasonable to build roads that kill than it is to build roads that harm without killing. Only when you do not accept that human life must be given a value do you gloss over the human being because the value of human life is then not part of the calculations.
>
> You may well attribute a high value to human life! Then you may realise that much of the development is more than we can afford and that war is something that we should never be able to afford. But you have empty words unless you think in quantitative terms.

I received a long reply in which Matz thought 'they were friendly words to someone who was so hard on you'. He continued with his thoughts, which I thought were agreeable although muddled. They were in line with the ideology of the 1970s, the ideology described by Göran Hägg in his book *Välfärdsåren* [The Welfare Years] (Hägg, 2005):

> In the meantime, the intellectual debate had concentrated increasingly on the environment. People talked about 'the green wave', which involved a move back to the countryside in a return to nature, preferably as a collective, and living in a politically as well as ecologically orthodox way. The thoughts that were first taken up by the cultural left took root in Sweden where the legacy from the end of the last century's dreams of wholesome peasant life and *Sörgården* harmony and consensus has always remained.
>
> ...
>
> Underneath everything, there was also the strong influence of Rousseau and the dreams of nature as a source of kindness and happiness, which had been popular in Sweden ever since the Romantic era…

Matz wrote:

> I may now be tiring you out, which is what I usually do to my addressees - but I have so bloody much to say and still something so bloody simple.

In his next letter he wrote:

> A proper catastrophe may be needed to get people to wake up. It may be that an authority like the Radiation Protection Institute with all its 'standards' is of no use at all in terms of the environment, with standards instead giving people an altogether unjustified sense of security. The result of your work may be expected to lead to the noose being tightened so slowly that people are always within the 'tolerable' limit.

But thus follows the catastrophe! This criticism was very common. The nuclear power critics did not like the fact that the protection was kept at such a level that it became difficult to criticise. Yet at the same time there was a grain of truth in this very criticism. But in his next letter of 15 December, Matz wrote:

> Finally, I would like to vouch for my great satisfaction at being able to stay in contact with the people at the Radiation Protection Institute. Thank you! For although we think differently where the conclusions are concerned, the practical social and production-related ones, we can presumably agree that it is the job of the human race to take good and long-term care of the planet on which he happened to be born. Not without reason, the atom is rather surprised at being able to turn up as a person 'to study itself'.

The reader might think that I am taking up too much space with letters that were exchanged with Matz and Rune Jönsson. However, in the 1970s there was significant opposition to nuclear power in Sweden. It brought the Centre Party to power and subsequently toppled the Fälldin government. It is very relevant to hear the arguments of the nuclear power opponents and our reactions at the Radiation Protection Institute.

6.10. **The Oskarshamn Plant is inaugurated**

The Oskarshamn Plant was opened by the King on Thursday 18 May 1972 following an opening address by the Chair of OKG's board Sune Wetterlundh and a speech by MD Olle Gimstedt.

6.11. **Nordic contact meeting in Oslo**

On 10 June, a Nordic contact meeting was held in Oslo to prepare for the Nordic conference which was to be held in September. Those from Denmark taking part included Juel Henningsen, Schultz-Larsen and Per Grande, from Finland Isola, from Sweden Lindell and from Norway Eker, Hvinden, Oftedal, Stedje and Aamlid who also acted as Secretary.

6.12. **The UN's Environmental Protection Conference**

The UN's first environmental conference was held in Stockholm on 5-16 June with the Minister of Agriculture Ingemund Bengtsson as Chair and the Canadian *Maurice Strong* as Secretary. 113 countries were represented at the conference. The conference would end up being very important to the international environmental policy. One tangible result was that the UN's General Assembly established the UNEP (United Nations Environment Programme) later that same year with its headquarters in Nairobi, Kenya. In summer 1992, the conference was followed by another global environmental conference in Rio de Janeiro, now with 181 countries participating, which led to Agenda 21 with an action programme for the 2000s.

UNSCEAR's contribution was presented at the Stockholm conference (see Section 4:21). Both Dan Beninson and I took part in the conference, which led to our submitting a joint proposal from Argentina and Sweden implying that, when deciding on a location for plants within the nuclear power fuel chain, long transportation distances should be avoided if possible. One African delegate wanted to supplement the proposal by saying that uranium mines should also be located in suitable places with a view to the transportation problems. We tried to explain that people usually had to accept that the mines were located where the uranium ore was situated. Delegates from other African states indignantly said that this was an example of the arrogance of the industrial countries. We realised that, in political contexts, it was not just a matter of discussing things objectively, but also with extreme caution.

Jan Mårtensson sought the assistance of cycling students to transport material and letters between the conference's different premises in the city. This drastically affected my daughter's future life. When in the late summer the Radiation Protection Institute's personnel manager Svea Forss had a shortage of summer temps and found out that Karin worked for the environmental conference, she asked whether Karin might also be willing to enlist as a temp at the Institute's secretariat. So, this is how Karin came to the Swedish Radiation Protection Institute, with no input from me, where she stayed for the rest of her professional life.

6.13. **The alternative conference**

At the same time as the UN's Environmental Protection Conference, an alternative conference was arranged in Stockholm with Hannes Alfvén as key speaker. He talked animatedly about the hazards of nuclear power and said that there were serious waste problems bearing in mind that some radionuclides were very long-lived. In the discussion that followed I said that that certainly was true but that other non-radioactive, environmentally-hazardous substances such as arsenic were even longer-lived – they never decayed.

I pointed out that arsenic was also the most dangerous. It still did not attract any attention or concern that Rönnskärsverken in Skelleftehamn had emitted tonnes of arsenic to air since 1930 through what was once the world's tallest chimney (145 m) and had also discharged incredible quantities of arsenic into the Gulf of Bothnia. Why did that not cause any protests? Arsenic never decays.

Hannes Alfvén was confident that arsenic was converted into non-hazardous forms and thus became inaccessible. Maybe it had only been considered to be dangerous if it were emitted from a nuclear power plant?

6.14. **The units of radiophysics**

The introduction of the International System of Units ('SI') had begun. In a letter to the Swedish Society for Radiation Physics in August 1972 Gunnar Bengtsson, Bo Lindell and Rune Walstam wrote:

> The International System of Units and Measurements (SI) will be gradually introduced in Sweden so that the changeover is essentially completed by 1 January 1976. Schedules and other general information are given in SIS handbook 103, edition 2, May 1972. There have been discussions within clinical physiology and clinical chemistry regarding a coordinated changeover around 1974. There have not yet been any major discussions within the field of radiology. Some points of view have been stated in *Strålskyddsnytt* [Radiation Protection News] year 7, no. 5, pp. 40-41 (1972). The international situation is still uncertain. It ought now to be time for us in Sweden to consider our position regarding a changeover and, following discussions, state our points of view, initially to the ICRU.
>
> It seems likely that the special radiological units rad, R, rem and Ci will be dispensed with on an international basis. For example, there is already a law in Germany stating that this shall take place no later than 1 January 1977. If we in Sweden cannot find substantial grounds for retaining them, we should concentrate our discussion on what we shall have instead.

6.15. **The BEIR reports**

In 1956, at the request of the Atomic Energy Commission (AEC), the American Academy of Science had already set up a Committee which published reports on the Biological Effects of Atomic Radiations ('BEAR'). In 1972, the reports, called BEIR I and BEIR II, were given the more suitable name of the Biological Effects of Ionising Radiation. They contained risk estimates based on the assumption of a no-threshold, linear dose-response relationship. This meant that the number of deaths from cancer from a specific radiation dose to the American population was estimated and gave the highest and lowest values. The lowest value was differentiated from zero, which aroused considerable criticism. The next BEIR report, BEIR III, came in 1980.

6.16. Boat excursion with Richard Matz, Rune Jönsson and Mrs. Westman

Out of the many early opponents of the nuclear power industry, Rune Jönsson and Richard Matz, whom I have already introduced, are the most eccentric people. Sven Löfveberg, in his capacity as the Swedish Radiation Protection Institute's information manager, and I put a great deal of effort into discussions with these opponents who represented the AMA, the action group against nuclear power. This surprised them and was appreciated. One example is the following letter to me from Richard Matz of 13 September.

> Thank you for yesterday! However, in retrospect there is one thing that I would now like to emphasise. Most of our views may clash in that what you and your thinkers perceive to be a catastrophe (i.e., the collapse of industrial production), I see as the escape, or possible escape, namely from the dead end to which the ever-increasing plundering of planet Earth will lead.
>
> However, this was not I was going to talk about, but about the surprising fact that you actually take the time to sit and explain things to, and listen to, people whose views are so different from those that are accepted within the establishment. In relation to the positions in which - as I see it – you have become pretty much locked, you show an openness that is exceedingly unusual among people in your position. Nothing similar would be at all conceivable as regards the Professors of History at Stockholm University, for example, or those in psychology; they adhere so exclusively to their mechanistic way of 'maximising findings' that there never would be any exchange of views; they would never be willing to waste a full day on such puerility as listening to debates on the justification for the activity to which they devote their lives. That is pure 'metaphysics'.
>
> So, on behalf of AMA and FORUM HUMANUM, I would like to convince you of my appreciation of your desire and capacity to debate with us. We are exceedingly anxious to remain on speaking terms with the authorities.

Rune Jönsson was a totally different personality. I have already mentioned that he represented the action group against nuclear power (AMA). The other members of the AMA who made their voices heard were Richard Matz and agriculturist Ann-Marie Westman (1920-2005). Rune Jönsson was a psychological conundrum. His behaviour was normally calm and level-headed, even in nuclear power discussions, provided they were taking place in a small circle. However, when placed before an auditorium, he turned into a vehement speaker who became increasingly enthused by his own voice, nevertheless remaining soft-spoken. As an engineer, Rune's hobbyhorse was wind power which he was happy to talk about for long periods. Time gave him a late redress in the noughties.

One weekend, Sven Löfveberg and I were invited by Rune to accompany him on a trip in the archipelago with his houseboat. I do not remember where it was moored, but we were transported out to the houseboat in a minuscule dinghy. Richard Matz and Ann-Marie Westman also came on the journey.

Ann-Marie Westman is worthy of a more detailed description. She was born in Turku (Åbo). Her parents were Professor of History Per Olov von Törne and Ellan von Born. She was christened Ellan Maria Academica, the latter-mentioned name for her father's joy at being given the first Professorship in History when the Åbo Academy was opened. Understandably enough, she chose another first name, Ann-Marie, and moved to Sweden after the war where she married the book-keeper and later estate manager Anders Westman at *Barsebäck* manor where, in 1970, she had an earth-shattering experience when she found that her section of beach had been blocked off for the construction of the nuclear power plant. She then became a nuclear power opponent, a member of the AMA and an eager debater in nuclear power issues. She was doubtless glad that she was able to experience the closure of the Barsebäck Nuclear Power Plant's last reactor shortly before her death.

In our discussions with Mrs. Westman, she was asked how Sweden could cope without nuclear power in the long run. Her lilting Finland-Swedish response was: 'In Finland we manage on 3/4 of Sweden's energy consumption per inhabitant and we live well.' It's all very well Finnish girls of noble birth having a good standard of living, we thought, but that probably does not solve our problems.

Rune Jönsson's houseboat consisted of what looked like a garden shed positioned on a raft which was driven by an outboard motor. Irritatingly, the exhaust gases blew into the shed where we were sitting, but that was of no concern to the friends of the environment. We had long discussions until we finally came ashore somewhere where Richard Matz explained that there were mushrooms. Indeed, he returned after a while with a big cep mushroom which he passed over to me.

'I should actually give you a poisonous fungus!' he said, 'but you are nice in spite of everything, so enjoy that!'

6.17. **ICRP Committee 4 in Oslo**

After the UN conference in Stockholm, ICRP Committee 4 held a meeting in Oslo. I had been a member of the Committee from 1962-1965 but was going to take part as an observer for the Main Commission of which I was now Deputy Chair. I intended to drive to Oslo and offered to give Dan and his wife and colleague Ambretta a lift.

'We might see some elk,' said I, 'as there are three or four hundred thousand of them in Sweden.' Elk were not an unusual subject of conversation. My ICRP colleagues used to say that I was stubborn as a moose* (as the American expression had it, compared to the British 'stubborn as a mule') and same was said about Jan Olof Snihs.

We stayed overnight at the Högfjäll Hotel in Sälen and took a trip to the Köar river where Dan explained that the mosquitos were the biggest he had ever seen.

When we left Sweden the next day we were given a convincing demonstration of the difference between Swedish and Norwegian tobacco habits. Where we stopped for a cup of coffee, the smoke in the premises was dense. But it was not just the smoke that was interesting - in one cafeteria there was an elk's head on the wall. Dan never ceased to remind me that when we did finally see an elk, it was Norwegian. Not only that, it was taxidermised.

Committee 4 met at Holmenkollen. One of the main points of the discussion was the question of what to call that which is now known as the collective dose. John Dunster was in favour of 'population dose' or 'community dose'. It was obvious that he considered the population dose to be associated with a specific population. I thought it ought to be source-related and be called the 'collective dose', and include all individuals who had been exposed to the radiation.

The difference of opinion was an early example of the difference between the individual-orientated and source-related approaches. The viewing perspectives were different. John saw the irradiation from the point of view of a specific population where the only relevant collective dose was the one received by that particular population. I saw the irradiation from the point of view of the source manager. It was then a matter of investigating the total damage caused by the source and the total collective dose was needed to do this. This conflict regarding the most relevant viewpoint continued for the rest of the century.

Life at the hotel was not without its dramas. Henri Jammet, who could not swim, had got into the deep end of the swimming pool and would probably have drowned if John Dunster had not noticed the situation he was in and saved him. Even the breakfasts had their dramas. We could choose between coffee with no rolls and a bigger breakfast. Émile Wallauschek had agreed to have coffee on its own, but could not resist the temptation of snapping up a bit of roll for himself. This was observed by the strict canteen supervisor who then kept a stern eye on him. The whole thing developed into a battle of

* In America, an 'elk' is a 'moose' and 'elk' means red deer.

prestige where Émile sometimes succeeded in avoiding the supervision and nicking a piece. The battle was followed with interest by the rest of us at the breakfast tables.

6.18. **Sven Benner pitches in**

In the work with the ‘Flag Book’ I was now being assisted by Birgitta Olofsson and also by Sven Benner who conscientiously helped with the editing. This is shown by a letter which I wrote to Benner on 25 August, the beginning of which I quote here:

> I have just returned from my holidays and found your letter in which you ask for a plastic folder of Birgitta Olofsson’s correspondence as regards group B. I enclose it here.
>
> I also enclose a copy of Birgitta’s proposed table of contents. It is in one the folders you already have, but I was thinking of our previous telephone discussions in which you seemed slightly doubtful about which arrangement ought to be followed. I suggest that we follow her ‘New table of contents’ since it reflects what was decided at the meeting in Stockholm when ADS was discussed.
>
> Generally speaking, I do not think you will need to be pessimistic about the lack of decisions in many respects, e.g., when there are different alternatives to choose from. Since the groups have already had such long discussions, it must now be down to the Swedish editors, i.e., you and me, to make comparatively arbitrary proposals for the next meeting.
>
> You mentioned that Koren had spoken about a further drafting meeting before being able to agree on the final the text. I will be happy to do what I can to avoid this. I say this with the experience of our previous meetings. I believe that we now know quite well which are the real wishes in our neighbouring countries and in the majority of the task groups. Attempting to continue ‘writing text’ as a large group will probably end up with it grinding to a slow pace and delaying our timetable. In my opinion, the neighbouring countries are willing to accept a text proposed by us on the basis of the material we have plus that which we can get the task groups to cough up directly. I will speak to Koren in mid-September and think I can probably get him to agree to this.

6.19. **Nordic meeting at Voksenåsen**

A Nordic authority meeting took place at Voksenåsen in Oslo in September 1972 at which the ‘Flag Book’ was discussed, primarily its chapter on the limitation of emissions of radioactive substances from nuclear power plants. The task group which had been set up to write this chapter met in Stockholm in August and December 1972 and then wrote a draft which was discussed in Helsinki in November 1973.

Information was given on the expansion plans for nuclear power in Denmark, Finland, Norway and Sweden (all four countries had expansion plans at this time!). Information was also given on the waste issue, by Ragnar Boge among others. I talked about standards for the limitation of emissions of radioactive substances; the subject was now relevant to the cooperation regarding the ‘Flag Book’. Erik Jansson from the delegation for Atomic Energy Issues (which would become the Nuclear Power Inspectorate in 1974) talked about NARS, the Nordic Task Group for Reactor Safety, of which he was Chair (see Section 23.16). Stig Bergström talked about reactor location (the Urban Siting Commission’s report would come in 1974).

Since the meeting was an authority meeting, which could involve a few delimitation problems, I had given a reminder of the problem in the invitation to Swedish participants as was the case at the previous meeting in 1970:

> The last meeting of this type was held in Stockholm in November 1970, at which the principles for the limitation of […] activity emissions from nuclear power plants was one of the subjects discussed.

> The next meeting will take place on 21-22 September 1972 in Oslo. The subject for discussion this time will be the safety issues of nuclear power in the broadest sense, both emission issues and safeguarding against accidents.
>
> ...
>
> If the same practice as before is to be followed, the participants should be limited to experts who, through affiliation to a responsible authority, are responsible for the safety issues concerned. Independent scientists from university institutions have thus not taken part and nor have industry representatives. However, if a scientist is affiliated to a responsible authority as a consultant or a board member, he has had the possibility of participating through the authority if this was thought desirable. Through its many assignments and reports within the radiation protection field, the atomic energy company has been counted in the same category as the responsible authorities. This has also concerned some officials at the Swedish Defence Research Agency, FOA, perhaps primarily through their affiliation to the Expert Commission for Advice in Atomic Accidents, KRA. It does not appear unreasonable that the power plants' central operational management's environmental group could be seen to be official enough to be able to be represented at this type of meeting, but this matter is slightly sensitive and should be checked with the neighbouring countries so that Sweden is not alone in deviating from previous practice. I hope to be able to provide clearer information about this at the end of June.
>
> We are keen to maintain the same informal feeling as before. I therefore hope that the recipients of this letter comprehend the delineation difficulties.

Reading this now, I get a feeling of mystery-making and cover-up, but we did not see it like that. It was actually a foregone conclusion that the unrestricted academic research would avoid being dragged into something that could be seen as not being independent.

6.20. **IAEA in Mexico City**

In autumn 1972, the IAEA General Conference was to be held in Mexico City. Sigvard Eklund, who had been Director General of IAEA since 1961, had noted the Nordic discussions on collective doses and the limitation of emissions and discharges and invited me to come to the conference and give a brief lecture. At the same time, he approached the Ministry for Foreign Affairs and asked them to pay for my journey. This was in the years when Eklund does not appear to have been too popular at the Ministry for Foreign Affairs [*]. It cannot be reasonable, they said, as might well be expected, to send Lindell to Mexico to speak for only ten minutes. But Eklund was stubborn and I was able to go away – at the Ministry for Foreign Affairs' expense.

In Mexico City I stayed at the Camino Rea Hotel where a letter from the Ministry for Foreign Affairs official and later ambassador, *Per Olof Forshell* (1928-1991) was awaiting me. He wrote:

> Welcome to Mexico - hope you had a good journey. Petri [Ambassador Lennart Petri in Vienna] Alf Larsson, Björn Skala [born in 1940, later ambassador in Vienna] and I are staying at this hotel.
>
> Tomorrow, Sunday, we plan to go to a Charro festival which the Mexican government is arranging for the IAEA people. You are welcome if you have nothing else to do. We are thinking of leaving the hotel at approx. 10.30 and estimate that we will probably be back around 4.
>
> In the evening we are invited to dinner with ambassador Swartz and his wife [Carl and Ulla] – intend to leave the hotel at approx. 19.45. You are very welcome to join us if you have no other plans.

[*] See chapter 14 of 'The Labours of Hercules' and the reference to Lennart Petri's memoirs.

When you receive this letter I will be at dinner with [Nils] Revelius (former Secretary of the Embassy here). I would be grateful if you would call me on xxx-xx-xx and let me know what you would like to do.

Sincerely,
Pelle Forshell

I was embarrassingly aware that my only assignment in Mexico was to speak for ten minutes and that the rest was high-level tourism. I really was not used to such luxury and it gnawed at my conscience somewhat. The bull fighting was bloodless - it concerned capturing small bulls and wrestling them down.

The next day I was to give my ten-minute speech, but this was after lunch. Lunch was enormous, outside with thousands of guests. There was a great deal of food and plenty of wine and the meal probably lasted three hours. I was to give my presentation just after lunch. I found the auditorium was very sleepy after lunch. The head of Argentina's Atomic Energy Commission, Admiral *Oscar Quihillalt*, was one of the listeners. He told Dan Beninson afterwards: 'I did not hear what that Lindell bloke said. I was asleep.'

6.21. **Birgitta Hambraeus starts the nuclear power debate**

On Wednesday 25 October, the Swedish nuclear power debate started in earnest with an interpellation by Birgitta Hambraeus in Swedish Parliament. Mrs Hambraeus, who explained that she based her statement on the book called *Kärnkraften, människan och säkerheten* (Nuclear Power, Mankind and Safety) which Sven Löfveberg and I had just published, said among other things (address no. 59):

> Scientists and authorities have been aware from the word go that the risks associated with nuclear fission are of a different type and magnitude than anything else undertaken by mankind. The safety provisions are also extremely rigorous, and huge efforts and care have been put into environmental protection by the nuclear power plants. However, scientists all over the world are starting to question whether it is possible to master the safety problems to which nuclear power leads. And, as Hannes Alfven has pointed out, it does not matter how much you try if a problem is impossible to solve – it will remain unsolved.
>
> ...
>
> Professor Bo Lindell of the National Radiation Protection Institute says the following in his excellent, explanatory book: 'This long-term storage of the radioactive waste obviously leads to expenses for an indefinite future, but it is easy to calculate the capital that is needed for the interest to cover the annual expenses for the storage and control. These expenses must of course be included in the calculation when discussing the advantages and disadvantages of nuclear power plants. Either that or we push over the expenses to future generations. We must then decide whether the improved technology and a better standard of living which we pass on as inheritance are values that can balance our unpaid debts'.
>
> How would it be possible for us to pay all future generations for their work with our radioactive waste? We are dealing with a concept of time here which we are not used to. No payment system works for ever. No human culture is eternal.
>
> ...
>
> With reference to that which has been stated, permission is requested of the House to ask Minister of Industry the following questions:
>
> 1. Does the Cabinet Minister think the fact that government and the economy have invested a great deal of money in nuclear energy prevents us from objectively discussing advantages and disadvantages of continued expansion of nuclear power plants in Sweden?
> 2. Does the Cabinet Minister think it is morally defensible to produce substances that must be monitored and dealt with by future generations using complicated technical methods for the indefinite future and which would irreparably harm the biosphere were this care to cease?

> 3. Does the Cabinet Minister think that the increasing quantities of radioactive waste from the nuclear power plants' spent fuel elements constitutes enough of a problem to warrant the referral of the matter of the future nuclear power expansion in Sweden to Swedish Parliament for a decision?

Mrs Hambraeus' interpellation was answered by the Minister of Industry, Cabinet Minister Rune Johansson. He started by describing the energy problem in Sweden. Water power had been expanded almost as far as it could be and the other available energy sources, oil and coal, were unattractive. They were expensive and dirty and led to a dependence on foreign suppliers. Despite the many problems of nuclear power it had been found to be the best of the alternatives. There was a substantial and rapidly increasing need for energy.

In response to Mrs. Hambraeus' first question, the Cabinet Minister said that the continued development in the nuclear power field must obviously be closely monitored with regard to the risk factors and to the alternative production methods that were available.

In his response to the second question, the Cabinet Minister explained that he would shortly propose that experts be called in to investigate the matter of treatment and storage of radioactive waste (it became the Radioactive Waste Committee which was set up in December).

As regards Mrs. Hambraeus' third question, the Cabinet Minister's response was that in his opinion, the issue of storing the highly-active waste did not warrant any reconsideration of the Swedish nuclear power programme.

And this was the start of the long-term debate regarding Swedish nuclear power.

6.22. **The letter to Reveman**

On 24 November I wrote to *Helmer Reveman* (1916-1999) who started as Managing Director of the *Ytong* company in 1971. The Radiation Protection Institute was still not authorised to ban the undesirable radioactive gas concrete. Application provisions for the building ordinance were issued by the National Board of Physical Planning and Building*, which had still not realised the scope of the problem. At the Radiation Protection Institute we hoped that industry would voluntarily close down the production of Ytong if we made it clear that future outlooks were dismal. Since I had started by describing the problem and the development of events, I ended the letter with an estimate of the possible extra risk of cancer in typical Ytong houses and then summarised as follows:

> It is unlikely that this will be considered to constitute reasonable grounds to declare an existing residential building to be unsuitable. On the other hand, it is conceivable that these numbers do constitute a reason to assess the building material as unsuitable for continued use if less active material is available.
>
> Equivalent questions have been debated in a number of countries in recent years. The Radiation Protection Institute has recently found out that both the UK and the Soviet Union have drawn up standards for the assessment of the suitability of a building material from the radiation protection point of view. If these standards were applied in Sweden, this slate-based light concrete would be deemed unsuitable in accordance with both the British and the Russian standards. The British standards are still only in the form of recommendations; according to information, the Russian standards are more binding.
>
> In the face of this development, the Radiation Protection Institute has once again taken up the matter of assessing the suitability of different building materials from the radiation protection point of view and intends to submit a proposal to the Swedish Government at the start of 1975 for an opinion. The OECD's atomic energy authority, the NEA, has also taken up the matter of the permissible level of radium in building

* The National Board of Physical Planning and Building was formed in 1967 and merged with the Housing Board to become the Swedish National Board of Housing, Building and Planning in 1988.

material. It is possible that Sweden should wait for the OECD's report, and the Radiation Protection Institute emphasises the great importance of consulting the authorities in the other Nordic countries. However, this consultation can probably be initiated in December.

The Radiation Protection Institute has also started to survey different types of building material and will carry out broader surveys of the level of activity in these materials.

With regard to the fact that restrictions on radioactive building material may initially apply to the slate-based light concrete and [that] any restrictions may have considerable economic consequences for those who manufacture and sell these materials, at this early stage, before any decision has been made, the Radiation Protection Institute has chosen to inform the *Ytong* company of said plans. Information and points of view which may be of significance to the discussion of the matter should be submitted to the Radiation Protection Institute as early as possible in the company's own interests. The Radiation Protection Institute would also like to suggest that the company appoint a technically-competent contact person for forthcoming discussions.

Copies of this letter were also given to some officials within the Ministry of Health and Social Affairs and the Ministry of Industry and the radiation protection institutes in the other Nordic countries for information.

It was still the gamma radiation rather than the radon that was causing the concern.

6.23. **Swedish nuclear power**

In February, the Oskarshamn 1 reactor and thereby Sweden's first commercial nuclear power plant was commissioned. In October, Central Operational Management (CDL) published a forecast according to which Sweden would need 24 nuclear power units.

In 1972, Ringhals was one of Sweden's largest construction sites with a total of 2700 people working there. The construction of Ringhals 3 and Ringhals 4 had begun. Both of these reactors were pressurised water reactors from Westinghouse, each with two turbines from Stal-Laval. The reactor tank for Ringhals 1 was shipped in from Videberg Harbour in April. The tank weighed 650 tonnes and was shipped on a special rail. It took seven days to travel one kilometre!

6.24. **The Radioactive Waste Committee**

In December 1972, *The Radioactive Waste Committee* was set up by Minister of Industry Rune Johansson. A description of the Committee's members, experts, etc. was given in the introduction to the Committee's report:

In December 1972, the Minister of Industry issued directions for a Committee on highly-active waste from nuclear power plants and sent for County Governor Gösta Netzén at the start of 1973 to act as Chair.

Specialists who have been part of the Committee since 1 May 1973 include County Governor Gösta Netzén, Members of Parliament Jan Bergqvist, Einar Larsson, Anders Wijkman and Nils Erik Wååg, Professor Lars-Gunnar Larsson and head of department Arne Westlin. Committee experts from the same period include Ph. Lic Åke Hultgren, civil engineer Alf Larsson, Professor Bo Lindell, Director Erik Svenke and, from 1 July 1973, Director General Gunnar Ekevärn.

On 1 January 1974, Members of Parliament John Takman and Rune Ångström joined the Committee as specialists and Senior Administrative Officer Lennart Lindgren as an expert. Experts from 15 March 1974 also included BSc Leif Hjärne and from 1 July 1974, engineer Bertil Mandahl. Planning Director Philip Moding has been Secretary of the Committee since 1 June 1973 and Senior Administrative Officer Hans Fransson Deputy Secretary since 1 May 1974. The Secretariat is in Malmö.

> On 10 May 1974, the Minister of Industry used a special supplementary directive to expand the Committee's assignment to include also the issues concerning the handling and storage of low-activity and medium-activity waste. Owing to the supplementary directive, the previous name, 'The Committee on highly-active waste from nuclear power plants', has been changed to 'The Committee on radioactive waste', abbreviated to The Radioactive Waste Committee.

The report submitted a situation report on highly-active waste from nuclear power (Ds I 1974:6) and a situation report on the low-activity and medium-activity waste (Ds I 1975:8). The main report consisted of two sections. Section I (SOU 1976:30) contained a summary, considerations and proposals. Section II (SOU 1976:31) contained bedrock documentation. An English summary of the report was published as SOU 1976:32.

The value of the report was the in-depth study of the problems and the account of interesting factual material rather than the actions that were proposed. Where the highly-active waste is concerned, the latter have been superseded by the proposals and measures which came up in the work carried out by *Svensk Kärnbränslehantering AB* (SKB, the Swedish Nuclear Fuel and Waste Management Co). See also Sections 7.18 and 9.15.

6.25. **SKBF, SKB and KBS**

SKBF stands for AB *Svensk Kärnbränsleförsörjning*, which was formed by the power companies in 1972. It was a forerunner of SKB, *Svensk Kärnbränslehantering AB* (the Swedish Nuclear Fuel and Waste Management Co), which is a company that has been owned by the Swedish nuclear power companies since 1984 and whose task has been to deal with radioactive waste. SKB operates a final repository for operational radioactive waste (SFR) and a central interim storage installation for spent nuclear fuel (Clab). However, SKB's major project, begun already at the SKBF time, is the 'KBS' (originally an abbreviation of *KärnBränsleSäkerhet* (Nuclear Fuel Safety) but is now interpreted as *Treatment and Final Disposal of Nuclear Waste.* The KBS project came about owing to the requirement that nuclear reactors should be started only if the owner had either concluded a spent nuclear fuel reprocessing agreement and shown that an 'entirely safe' disposal was possible, or had shown that spent but not reprocessed nuclear fuel could be disposed of 'entirely safely' ('The Stipulation Act' - see 11:04). The KBS work has been accounted for in three reports. SKB's continued programme is based largely on the proposals in 'KBS-3' (see Section 18.11).

6.26. **The IOMP's 3rd Congress in Gothenburg**

'IOMP' means International Organisation for Medical Physics. Its establishment, purpose and activity were described in *Strålskyddsnytt* (Radiation Protection News) no. 4 in 1994 by Rune Walstam, who was Secretary General of the organisation from 1976-1982. The IOMP was initiated at the International Congress of Radiology in Munich in 1959. Following an investigation led by Sven Benner, it was agreed in 1962 that the IOMP should be formed, which it was on 1 January 1963 with four national members: Canada, the UK, Sweden and the USA. A more fixed structure was created at an initial Congress in Harrogate in England in 1965 with Professor Val Mayneord as President. There, the bye-laws were established and the Swede *Berndt Waldeskog* was appointed as Secretary General.

Following a second Congress in the USA in 1969, the third International Congress for IOMP was held in Gothenburg in 1972.

6.27. **The Nordic Congress of Radiology in Bergen**

The Nordic Society for Medical Radiology held its 32nd Congress in Bergen in June 1972. It was attended by 550 participants. 93 presentations were held there, 2/3 of which within a diagnostics section and 1/3 within a therapy section. The emphasis of the Congress was a symposium on urinary bladder and prostate cancer.

The Secretary of the Swedish Society, Curt Lagergren, had written to me the year before the Congress because the board had discussed a proposal that the Nordic Society set up a Radiation Protection Committee. Curt had been requested to ask my advice. My response was:

> Every proposal for new Committees should be viewed with maximum scepticism and caution. Not only has Committee work been stealing more and more useful time, there is greater confusion if many Committees submit changing proposals regarding similar matters, so this means you scarcely suggest that yet another Committee is appropriate until you know which need (other than that of the initiators) it is intended to fulfil and what its proposed objective is. Radiation protection measures are proposed at an international level by ICRP. Any competition there would create major confusion. ICRP is also the Radiology Congresses' own Committee. Radiation risks are being investigated by the ICRP Committees and by the UN's Radiation Committee [UNSCEAR]. The application of [the ICRP] recommendations will be discussed by the ISO and IEC and by national authorities. We have Swedish associations for radiology, radiophysics, nuclear medicine and radiation protection, which are in turn affiliated to international conferences and societies.

6.28. **ICRP at Great Fosters**

The ICRP Main Commission met from 11-13 November 1972 at Great Fosters in Egham. We discussed two task group reports and a proposal from the NEA. John Dunster had obtained a portable computer, the first I had ever seen. John had it on the table in front of him. The departure from normal behaviour irritated Bill Pochin, whose facial colour alternated between normal and violet. In the big park there was a tiger which they explained was tame but which hungrily eyed up Henri Jammet who was the one who discovered the exotic pet. He had difficulty convincing the rest of us that there really had been a tiger.

Bill's angry outburst and changes of facial colour have been described by David Sowby in his memoirs, *Man ages*. I quote:

> Whether because of early potty training, lengthy incarceration in English private schools or what, he had developed a quick temper. This tendency not to suffer fools gladly was at odds with his training as an English gentleman, which had taught him to be patient and polite to others. His education told him that anyone who had come, for whatever reason, to a gathering at which he was present must be as intelligent as himself; but his heart informed him that this particular person was a fool who needed to be put down.
>
> ...
>
> He could usually get his own way at a meeting by cowing most of the participants with a display of his temper. A dramatic change would occur in the colour of his face, which first went scarlet and then changed to purple, then green and finally white, and was accompanied by a noisy display of him breaking pencils. He kept a supply of rather old, fairly short pencils, which could be brought into use during these histrionic displays.

6.29. **Nuclear explosions for peaceful purposes**

At the end of November, a conference on the peaceful use of nuclear explosions was held at IAEA in Vienna. I took part along with FOA experts Ulf Ericsson (then at the Ministry of Foreign Affairs) and Kay Edvarson, who was temporary head of department at the FOA at the time since Torsten Magnusson had been promoted to Director General in 1968. Otherwise, a bit surprisingly, there were no names that we knew on the list of participants. We got the impression that it concerned a collection of clueless enthusiasts and we were horrified by some of the presentations. For example, there were plans to use nuclear charges to join the Orinoco and Río Negro rivers in Venezuela. Bearing in mind that the Orinoco is the third largest river in South America and the Río Negro is one of the River Amazon's main sources, it is little wonder that people had doubts about the project. Luckily it never came to pass.

7. THE YEAR 1973

7.1. SKBF: Svensk Kärnbränsleförsörjning AB

Svensk Kärnbränsleförsörjning AB (SKBF, Swedish Nuclear Fuel Supply Ltd) was formed in January by the power companies *Vattenfall*, *Oskarshamnsverkets Kraftgrupp AB (OKG)* and *Sydkraft AB* to procure nuclear fuel on behalf of the members.

7.2. Visiting the Norwegian Atomic Energy Association

On 30-31 January, Sven Löfveberg and I were in Norway at the invitation of the Norwegian Atomic Energy Association. We visited Kjeller, where Sven talked about the information problems in connection with the nuclear power expansion and we both answered questions in connection with our book, 'Nuclear Power, Mankind and Safety'. Our host was Chief Engineer *Rolf Lingjærde*.

7.3. ICRP in Brighton

In April 1973, ICRP and its Committees met at the Bedford Hotel in Brighton. At this meeting the Commission was voting on the new composition of members and on the Chairs of the Committees. Owing to an unfortunate choice of voting procedure, Karl Morgan was voted out of ICRP. This led to a serious crisis which could have severely damaged the Commission. I later had cause to compile a summary of the letters that were exchanged following the meeting (Sowby was Secretary of ICRP, the Canadian Gordon Stewart Chair and I Deputy Chair). The letters are so illuminating as regards ICRP's problems and policy at the start of the 1970s that I have decided to show most them.

On 24 April 1973, the following letter, marked ACTION was sent to the members of the Commission together with a ballot paper ('I do/do not confirm the selection of the following eight members: C. G. Stewart, D. J. Beninson, J. Liniecki, A. S. McLean, Y. I. Moskalev, H. B. Newcombe, E. E. Pochin, E. Windeyer'):

> The Commission's Officers have discussed the voting procedure that was used when electing the new the Commission in Brighton. The Commission first decided to choose the four Committee Chairmen (A. C. Upton, J. Vennart, B. Lindell, H. Jammet). Before the election of the remaining nine members began, the Commission confirmed its tradition of that votes from seven of the members present would be required for a decision. In the two first series of votes, this decision resulted in two members (O. Hug and R. H. Morgan) losing their places. The Commission then continued to elect a diagnostic radiologist (Professor Takahashi).
>
> The next step was to elect two new candidates (J. Liniecki and L. Rogers). When these had been elected, the Commission continued to eliminate two names from a list containing the two new candidates along with the eight remaining members of the current Commission. At that stage, the Commission agreed that upon each round of voting, the candidate who received the highest number of no votes, provided that this number was at least three, would be eliminated.
>
> Looking back, we realise that this procedure was not the equivalent of the procedure that was applied in the first two rounds of voting since a member could be excluded on the basis of as few as three votes.

Under these circumstances, the Commission's Officers believe that a confirmation of the decision on the last eight members would be reasonable. The members are therefore asked to fill in the enclosed ballot paper.

C. G. STEWART
B. LINDELL
F. D. SOWBY

From ICRP in Brighton 1973.
'Bill' Pochin and the head of NRPB, Andrew McLean.

What had happened was that the controversial Karl Morgan had been voted out, which was scarcely what the majority of members would have wanted. The requirement of three no votes was an unreasonably low one for exclusion, particularly since only the British had more than three members. The final vote had concerned eight places because Jammet and Lindell had already been elected as Committee Chairs, Hug and Russel Morgan had been voted out, and Loutit had not wanted to be re-elected, and there should be a total of thirteen members.

After having received this letter, Bill Pochin wrote to David Sowby on 2 May with copies to Gordon Stewart and me. Bill was angry:

Dear David,

I have received the ballot paper dated 24 April and see that it says that the Commission's Officers believe that 'a confirmation would be reasonable'. Since every step of the procedure that was used for this voting at the meeting had been approved by the Commission before the voting, and since I believe that the Commission was in a position to make its own decisions as to how it would vote at each stage, I would like clarification of what is meant by the word 'reasonable'. If this word means 'necessary' in the sense that the previous procedure was invalid, I would contest the interpretation.

If it simply means that the Officers would feel reassured if the result of the voting were to coincide with the result of the previously-agreed procedure, I would like to ask what the Officers' view would be if the Commission had approved another procedure (using this ballot paper) had it conflicted with the result of the previously-agreed and, as I see it, valid procedure. To me, this voting indicates repudiation of the previous procedure and I would need to be convinced on this point.

Yours sincerely
E. Eric Pochin

On 3 May, Pochin sent yet another letter to Gordon Stewart:

Dear Gordon,

I ought perhaps to explain the position I adopted as regards the ballot paper for membership of the Commission in my letter to David yesterday which I copied to you. In my view, the voting procedure was formally correct (as regards necessary majorities) and the ballot paper which asks about this is therefore incorrect as well as unnecessary. I took a particular look at the voting against one candidate among 14 names as being the exact equivalent of a vote for each and every one of the remaining 13 candidates and think that this point was agreed in the discussion in any case. If so, all candidates who received fewer than 4 no votes were proposed for membership with the necessary quorum of 7 or more votes. The nomination of each and every one of such candidates for membership of the Commission should therefore be formally correct in accordance with rules and agreed procedure. However, limiting the number of the members of the Commission to 13 adds the necessary limitation that not all such nominations can be accepted and that the agreed procedure of accepting the nominations which have the strongest support appears to me to be both appropriate and completely permissible within the Commission's authorisation to determine its procedure.

My acceptance of the procedure that we used does of course mean that I concur with and would if necessary confirm the election of the eight members mentioned on the ballot paper. What I disagree with is the need for, and therefore the appropriacy of, holding a vote about this point.

Yours sincerely
E. Eric Pochin

David Sowby's response to Pochin on 7 May 1973 was as follows:

Dear Bill,

This is the response to your letter of 2 May which you addressed to me; my response also takes account of your letter to Gordon of 3 May.

The purpose of the letter and the ballot paper of 24 April was to obtain confirmation of the choice of members, which was not received at the meeting; what was received at the meeting was an indication that a few members did not wish to re-elect a specific person, but also that many more had the opposite view. In that position, the Commission could have set about obtaining a majority decision, either through an additional vote (as was done in the previous vote which resulted in the rejection of Hug and R. H. Morgan) or (hopefully) through a final vote or show of hands to confirm everything. This was not done and the purpose of the letter and the ballot paper of 24 April was quite simply to ask for this confirmation now.

I hope that the last paragraph of your letter of 3 May means that you are prepared to support this confirmation.

Yours sincerely
F. D. Sowby

On 15 May 1973 I wrote to Sowby with copies to Pochin and Stewart:

Dear David,

I have received copies of Bill's letter to you, Bill's letter to Gordon and your letter to Bill.

I admire the way in which you all use English in a way that it presents facts but does not show your inner feelings. An ill-mannered and tactless Swede like me would have used more volcanic language, which may be why Swedes should not write letters.

I would like to support what you wrote to Bill on 7 May 1973. My only change would have been to say 'in that position, the Commission ought to have set about'. I cannot blame anyone for our failure to do it since I did not suggest it myself, although I ought to have done. My only excuse is that I was tired and believe that we were all tired. At least that is how we looked afterwards.

This was therefore my last time of going to meet up at different times or days from those we agreed on from the start, or to work more quickly to save tine. I reproach myself for not having expressed the view on plenty of occasions at ICRP and in other organisations when programme changes were proposed in order to be able to leave a day or two earlier. When I think about it more carefully as I have now had cause to do, I am convinced it is a mistake not to fully utilise the presence of a number of qualified people after a timetable has been agreed.

Best wishes and kind regards,
Yours sincerely
Bo Lindell

On 21 May 1973, Sowby wrote the following to Stewart with a copy to me:

Dear Gordon,

Bill Pochin submitted his ballot paper last Friday with confirmation of the selection of the eight members of the Commission. That makes a total of nine members of the Commission in favour of the confirmation and one (K. Z. Morgan) against.

Yours affectionately
F. D. Sowby

On 28 May 1973 I wrote to Karl Morgan and here quote the introduction to a long letter:

Dear Karl,

As you may have realised from the ballot paper that was sent out by the Commission's Officers, I do not think that the voting procedure in Brighton was acceptable and I think that only a majority confirmation of the result would turn it into an acceptable decision.

I am sorry that I was slow to understand the implication of the voting procedure that we all agreed to follow in the last round of voting. Had we used the same procedure that we used when we voted out Otto Hug and Russel Morgan, namely to require that voting continue until we had at least seven votes against one name, we may have achieved another result. I am sure that it came as a surprise to most of those who were present when we suddenly found that you had been voted out, and I am also sure that most of us had no idea of how the votes might have been distributed.

I have done a lot of thinking about the most suitable approach because I was unable to accept the procedure that we had used. One possibility could have been to re-do all the votes; another possibility was to confirm the result with the help of an acceptable procedure, i.e., with a majority decision. I came to the conclusion that it would have put an end to ICRP if I had insisted on a re-vote. Several members would have objected so strongly to this that they would probably have left the Commission. In order to save ICRP I have not dared to make the decision. On the other hand, I could not allow the result to stand as it was without making it clear that the voting procedure we used was far from acceptable.

[…]

Therefore, Karl, I ask you forgive me for not reacting immediately when we accepted the unfair voting procedure in Brighton and also for preferring the ballot paper to requesting a re-vote. I am ashamed about the completely unnecessary humiliation you were exposed to when we had a long technical discussion about the absence of a procedure to elect an Emeritus Member. That, in my opinion, should have been done long before the meeting or after it, not while you were waiting.

[…]

With best wishes and kind regards,

Yours sincerely

Bo Lindell

Morgan answered this letter on 1 June 1973 on *Health Physics Journal* headed paper:

Dear Bo,

Many thanks for your letter of 28 May 1973. I am very grateful for your kind words and I much appreciate the thoughts that are expressed in your letter. When I hesitated to accept the Emeritus membership of ICRP, I did not intend to fish for compliments from my friends, but we are all human and I deeply appreciate the kind words in your letter and in those that I have received from Dave Sowby, Howard Newcombe, Gordon Stewart, John Loutit and Laurie Taylor. You have all been most kind in the thoughts you have expressed and move me deeply to reconsider what action I should take regarding the matter. Before I make a final decision, I would like to talk to some of my very good friends at the forthcoming annual meeting of the Health Physics Society in Miami Beach in a few weeks' time and make a final decision at that time.

I must have been inattentive in Brighton when I did not realize that our voting procedure should permit a decision with just three votes and that with four votes from the UK it was a pretty unfair arrangement when candidates from the States were pitted against those from the UK. I very much appreciate your reflections when you put this issue to Dr. Sowby for further action, but I am sure you realize that when we had left Brighton there was almost no adequate action to take. Under no circumstances would I like to shuffle the current membership so that one of those who were elected in Brighton is forced out and I get in. On the other hand, I am sure you realize that the ballot paper which has now been sent out for approval only looks at the final choices in Brighton and the procedure would not be considered legal were ICRP legally incorporated under a statute in one of the States in our country. I know nothing about the laws in Europe and ICRP is not incorporated so there is no legality involved, but it is completely clear that no other candidate would have a chance of being elected with such a procedure (and, of course, in this case, those who were voted out would not agree to be elected).

From ICRP in Brighton 1973.
Dan Beninson and Julian Liniecki, Poland.

Despite what I have just said, I very much appreciate your consideration and trouble taken to voice some kind of rectification, but I am afraid that there are sometimes certain mistakes we make which cannot easily be rectified as far as the procedure is concerned. As regards our relations, I hope we can always be the best of friends and, irrespective of whether or not I accept the Emeritus Membership of ICRP, I hope our paths will cross many times in the future under enjoyable circumstances. With regard to what I have said above, I should hasten to clarify that I like all current members of ICRP, and the feelings I have expressed against the imbalance of the membership are not intended to reflect any personal feelings in any way when it comes to the members from the UK. My biggest regret is that we have to some extent unintentionally tarnished the image of ICRP by overburdening it with administrative officials from one country and that this does not reflect the high standard and objective that was established by our common friend and long-term colleague, Rolf Sievert.

Best personal wishes
Sincerely
Karl Z. Morgan
Chief Editor

Extract from a letter from me to Sowby of 19 June 1973:

[…] I have written a kind letter to Karl Morgan and have received an equally kind response and an indication that Karl is still wondering about the best way to act, to accept or not to accept the honorary membership.

How did Bill react to my letter of 15 May? I may soon need to consult him about various matters and it would be helpful to know whether I was a friend or an enemy. […]

Extract from Sowby's letter to me of 25 June:

[…] I have not had any contact with Bill for several weeks and I am therefore not aware of his current temperature or blood pressure. If I succeed in getting a reading I will let you know. […]

On 17 July 1973, Karl Morgan accepted Emeritus Membership in a letter to Sowby:

Dear Dave,
Following many weeks of soul searching and after having consulted many of the leading radiation protection figures in our country, and after having received a letter from most of the members of the ICRP Main Commission (only one of the four members in the UK), I would like to make a decision on this matter once and for all.

First of all, I would like to say that I am very sad that I became involved in this matter. For me, the question is not a matter of membership for Karl Morgan of ICRP, for there are many others who could fulfil the function adequately. The question is, quite clearly, about the politics where the row of leadership in radiation positions in the UK is clearly represented and where they dominate to such an extent as regards voting procedures that they can get whichever person they want into the Main Commission and its Committees (the new Chairmanship for Committee 2, for example). I am very interested in what ICRP can do to retrieve itself from this terrible situation and to guarantee a strong future. I am not just interested in ICRP as such, but want to offer it my strong support because of my great fondness for Rolf Sievert who devoted much of his life to the success and preservation of this organisation as a vital and necessary part of our society. If it were not for Rolf Sievert, I would already have put together another organisation to make a greater impact and take the place of ICRP, free from politics, in a position to request appropriate economic support, and an organisation responsible for all forms of ionising radiation with greater representation of workers within the area from an extensive selection of the world's experts.

After having listed my points of view like this, and bearing in mind all the strong encouragement from my friends in the Commission, and recognising that the matter of my Emeritus Membership could have been left open, I would now like to accept this on the understanding that I will not be able to take part in all of the ICRP meetings but would like to be in touch every other year for economic support to be able to take part in such meetings. I would of course also like to receive all of the ICRP publications and pre-releases and be entitled to criticise or praise these while they are being prepared as has previously been the case. I would never be able to accept the position if it were simply a mark of respect or an empty gesture, and I hope that you and others in the Commission who have written to me and asked me to reconsider my decision would also want me to be an active member (with the exception of the right to vote) and not simply remain just to give the impression that ICRP has a more satisfactory representation from the United States and other parts of the world.

[...]
Warmest regards,
Sincerely
Karl Z. Morgan
Chief Editor

On 23 July I wrote following letter to Sowby (with a copy to Gordon Stewart). It is of interest because it deals with policy matters.

Dear David,

I have just received a copy of Karl Morgan's letter to you of 17 July. I am glad that Karl is now accepting the Emeritus Membership. I believe it was necessary to have a new Chairman of Committee 2 but that it was an unnecessary mistake to vote him out of the Commission. But once this mistake had occurred it was irreversible. Having someone like Karl at our meetings will keep us on the alert. It is good for ICRP that he has now agreed to work with us.

I do not really know what to say about Karl's primary complaint. It is indisputable that there is a very high density of competence in the UK and that there are many obvious candidates for most of the ICRP assignments, so it is not by means of conspiracy that there are so many British members in the Commission, and I disagree with Karl that Jack Vennart was elected as Chair of Committee 2 because of the British dominance. For all I know it may actually have taken place against some of the British votes.

Nevertheless, there unfortunately is a British dominance. It is a pity that we do not have a rule which limits the number of Commission members to a maximum of three from one and the same country. But it is not just a question of numbers – it is also a question of policy. Up until 1965 there were four US members and there was certainly a heavy US influence on the Commission's recommendations. The only good equilibrium was during 1965-1969, although those whose mother tongue was not English had reason to complain (and did so) about the British, Canadian and American dominance with eight members.

Part of the problem is that the British members strongly represent a national policy, which was not the case to the same extent with the four American members (Taylor, Morgan, Stone and Muller) from 1962-1965, for example. They actually more or less represent the policy within a single national organisation and I think that is a considerably greater danger to ICRP than anything else. The members of the Commission should not forget that they have been elected because of their personal ability without reference to nationality. If we have been given the privilege – and the responsibility – of being members of the Commission, it is important that we do not abuse our position to arrange good results for our own countries. I believe the members of the Commission should act as individuals who are expected to contribute to the international understanding of the radiation protection problems, and I think this is an obligation that we must not forget, even if it were in temporary conflict with our national interests. If we were expected to act in our national interests, the ICRP election ought to have followed the same procedures as the election to other international organisations where nations rather than individuals are represented. If that were the case, it would obviously not be acceptable to have four members out of thirteen from one and the same country.

At present we have four British members as a result of a vote, a result which nearly all of us have approved. I think the British members ought to realise that this is a sign of trust in their professional capacity and that they must now be very careful not to belie this trust. What bothers me is that this problem has not been looked at by the British themselves. If this means that they either do not see the problem or they are happy with the situation, we can anticipate problems. If they are not happy with the situation and realise what the problem is, they themselves proposing a solution would minimise the embarrassment.

Another part of the problem is the fall in the number of representatives from the USA. This is also very unfortunate, but partially unintentional. Had Russell Morgan not withdrawn, he would doubtless have still been in the Commission. His uncertainty and absence invited votes against him. If Laurie Taylor had not actually opposed Lester Rogers, Rogers would probably have been voted in. We could very well have ended up with four Americans if we had voted on another day with a slightly different discussion.

If we do not look at individuals (as we should) but stubbornly persist in looking at countries, this means that the Brighton voting leads to no drastic changes - one Brit out and another in, i.e., no change in the total number. Two Americans out but just one in. Another one could have got in and one less could have been voted out. The second was now replaced by a Japanese, which shouldn't be too much of a shock from international point of view.

The German who was voted out was replaced by a Pole. That does not shock me either, but may have serious consequences for ICRP on the European Continent since the German-speaking countries have long been complaining about under-representation in ICRP. Some people, Henri Jammet for example, seem to see it as wrong that Liniecki does not 'represent' a national authority. This looks to me like an attempt to turn ICRP into an official, pseudo-governmental organisation, something that I would be opposed tog. The link with national authorities ought to be arranged either through suitable representation on Committee 4 (with the risk of leakage into the Commission) or through appropriate cooperation with organisations such as WHO, IAEA, the ILO and the OECD/NEA.

Best wishes,
Sincerely
Bo Lindell

On 25 July 1973, Sowby wrote the following letter to Morgan:

Dear Karl,

Many thanks for your letter of 17 July. I am very glad to hear that you are now prepared to accept Emeritus Membership of ICRP.

Regarding the position of the Emeritus Members, I require them, with the exception of the right to vote, to be viewed in exactly the same way as members of the Commission and to thus receive all of the Commission's papers and publications. I assume that Gordon Stewart will write to you on a formal basis as regards your acceptance of this position.

Yours sincerely
F. D. Sowby

On the same day, Sowby also wrote to Gordon Stewart:

You have now received Karl Morgan's letter of 17 July. I do not know why he wrote to me since this is actually a matter that he ought to have written to the Chairman about. However, you have received a copy and are therefore equally involved in the correspondence.

As far as I can see, all that remains for you, as Chairman, to do is to write to him and confirm that the Emeritus position involves full and active participation from the member (except for the voting), and therefore means that the Emeritus Member is treated in exactly the same way as all other members and will receive all of the Commission's papers and documents and is expected to take part in all the meetings. I see he says something about needing to approach the Commission for economic support for approximately half of his expenses. Although the Commission has generally decided that it should not be responsible for travel expenses for Emeritus Members, I actually believe that if Karl is not in a position to receive remuneration for these from his own organisation, the Commission should ensure that he is not forced to miss a meeting just because he could not obtain travel expenses.

Since the Commission was in agreement in wanting to have Karl as an Emeritus Member, I cannot see why the matter should need to go to the Commission again; we should just inform them of Karl's acceptance.

From ICRP in Brighton 1973.
Secretary and Chair: David Sowby and Gordon Stewart, Canada.

On 27 July, Sowby wrote me the following letter as a response to my letter of 23 July:

> Dear Bo,
>
> This is a response to your letter of 23 July as regards the membership of the Main Commission. As Failla would say, I agree with you 100 % on practically everything you say in your letter but, as you know, I am already rescued. The problem now is to rescue some other members of the Commission. I see that you have sent a copy to Gordon Stewart so he will be aware of your views. I assume there is a possibility that copies of your letter will be sent to some other British members of the Commission. As far as I am concerned, I cannot see that I can do much other than accidentally drop a copy of your letter right outside Andrew McLean's office!
>
> But I assume that this whole thing will have to come out into the open, possibly at the Commission's next meeting. I have recently been in contact with the Director of an organisation called the Electoral Reform Society, one of whose main assignments is to advocate the use of the Single Transferrable Vote at elections in this country. The system is used by a number of specialist organisations and the Society actually handles the counting of votes for these. It recently also played a very significant role in the election in Northern Ireland where the STV was used. I have asked the Society's Director to propose a method for the Commission's election and he appears to think it is possible, although interestingly enough he says that the various constraints that come from the Commission's by-laws present him with a significant technical challenge. One of the things he will probably discuss is that he will need advice on the maximum number of members from each country since he needs to enter the information into his system of constraints. Like you, I think such a number is definitely needed, and I am

sure that the maximum number should be three. This should have the further advantage of preventing Americans and Britons coming together to form a majority. A maximum of two would be even better of course, although maybe too restrictive.

In any case, this question definitely needs to be discussed next March if the Commission shall be able to set up a new voting system. It will then be possible for you to discuss many of the questions in your letter.

I should be able to tell you more about this when I meet you in Oxford.

Yours sincerely,

F. D. Sowby

In Brighton, the Commission had decided that the Emeritusship would not be for a lifetime but for four-year periods. Lauriston Taylor had been re-elected on that basis. He responded in a letter to Sowby on 31 August 1973:

Dear David,

It was helpful of you to let me know that I have been re-elected as Emeritus Member of ICRP for the next four years. As I am sure you understand, it means a great deal to me to be in a position to remain in contact with so many of my friends and activities that I have had dealings with over the years. I was pleased to hear that K. Z. had changed his mind. I think he will be glad he made that decision in the long run.

When this matter is behind us and I can have no personal interests to consider, I would like to comment on the special mechanism and procedure which was determined at the last ICRP meeting as regards Emeritus Members. But since I was not present at these particular discussions, I am not sure what lay behind the special arrangement that was finally determined.

I guess my main interest concerns the four-year election of Emeritus Members. I thought that the title 'Emeritus' was generally used for the person's lifetime. I have never heard of any Professor who has been Emeritus for a limited period but I am not sure whether the definition really prevents it. I believe it is mainly a question of the application.

It just so happens that we have studied the same question for the NCRP where we currently have only a few 'honorary members'. It was proposed that anyone who has been a member for one or two periods should automatically become an Emeritus Member, but it seemed a bit too much of a routine. The matter is still being considered and no special recommendations have been formulated.

With best wishes,

Yours sincerely

Lauriston S. Taylor

After having sent all these reproduced copies of letters to Sowby, I wrote the following to him:

I have not had time to continue my research into the follow-up of the questions which were asked, but we know that your proposal for the Single Transferable Vote was adopted by the Commission, and this was also what happened with my proposal to limit the membership (no more than three from one and the same country). Quite by chance I found a letter from me to Laurie Taylor in which I promised that, were I to become Chairman, I would get the Commission to withdraw its decision regarding the 'four-year election' of Emeritus Members.

7.4. **ICRP Publication 22**

At its meeting in Brighton, ICRP approved a report from a task group within Committee 4 which had been tasked with clarifying what was intended by paragraph 52 of ICRP Publication 9 in which the Commission had recommended that any unnecessary irradiation should be avoided and that all radiation doses should be kept as low as is readily achievable, economic and social considerations being taken into account..

The task group consisted of members of Committee 4 or, more specifically, the American Lester Rogers (Chair), John Dunster, Carlo Polvani and Don Stevens.

The group thought that the requirement in paragraph 52 could best be fulfilled through cost-benefit considerations. At the same time, the word ‘readily’ was replaced with ‘reasonably’. The cost-benefit analysis was illustrated with a simplified example. The quantities they assumed would be included in the calculation were the total detriment (D) and the protection cost (S).* The radiation protection was optimised when the sum of D and S had a minimum. You could draw a diagram where the independent variable (called ‘E’) determined the size of D and S. The group proposed that E could be the collective radiation dose†. The condition for optimal protection then became

$$\frac{dS}{dE} = -\frac{dD}{dE}$$

In the diagram, this was true for the minimum point on the curve for S+D. A common mistake is to think that the optimum point is where the curves S(E) and D(E) intersect one another.

In order to be able to form the curve S+D, the quantities S and D must be stated in the same units. The protection cost unit S is of course a monetary quantity expressed in dollars, for example. This means that it is then also necessary to express the detriment in monetary units. This was something which aroused criticism. The collective dose was expressed in dollars, which was interpreted as ‘putting a price on human life’. This aroused the displeasure of the Vatican, although the latter came to understand after a meeting there in 1983 (see Section 17.6).

I was subject to the same sort of criticism myself on a number of occasions. I countered this with the following example: Imagine I am Director General of ‘the National Protection Authority’ and have funding of 100 million Swedish kronor to protect against a certain risk. I have high ambitions and succeed in saving two human lives, but the money has then been used. Next year I have the same budget. Learning from the mistake, I then decide to use only ten Swedish kronor to save one life, but instead of saving ten million lives I do not save anyone at all for that small sum. You therefore have to set an acceptable cost for saving lives, which is ten and fifty million Swedish kronor. If I choose a policy which means that I work on the basis of that sum, I save the maximum number of lives. Choosing such a policy has nothing to do with ‘putting a price on human life’. The Vatican’s ethical experts also realised this in 1983.

7.5. IAEA on the capacity of the environment

From 30 April until 4 May IAEA arranged a panel of experts which was given the title *The Capacity of the Environment to Accept Radioactive Materials*. I had been appointed Swedish representative. Other participants included Dan Beninson, Henri Jammet, *Arrigo Cigna*, and Francesco Sella. Seven observers had been invited, including Stig Bergström from Sweden and *Neal Mitchell* from the UK.

The meeting was important. It meant a certain paradigm shift. As Chair I could not accept the title. Talking about ‘the capacity of the environment’ went against ICRP’s policy. I received support from Dan Beninson. What we ought to be discussing was principles for limiting the release of radioactive materials into the environment, which did also eventually become the title of the final report.

The title that was first proposed was based on the old idea that the recommended dose limits were sufficient to deduce the protection requirements since the belief was that exposures below the limits were completely non-hazardous. The new view was that this concerned only deterministic injuries while

* The choice of letters was unfortunate. ‘D’ could be misunderstood to mean radiation dose and ‘S’ could lead you to think of the collective radiation dose for which the name became normal.

† People talked about two types of collective dose. ‘Population dose’ meant the total collective dose, while the fraction of this which concerned a delimited population was called ‘collective dose’, i.e., contrary to what is now customary. This was the result of having demanded of Committee 4 that the total collective dose be used in calculations, and of John Dunster having originally used ‘population dose’ with reference to a limited population. In that conflict I got my own way but the price was confusion when it came to the name.

the risk of stochastic injuries such as cancer and hereditary injuries still remained, albeit to a lesser extent, below whichever limits you might choose to set.

In the same year, ICRP Publication 22 would come out with a description of the principle to optimise the protection so that requirements could be set even though the limit values had not been exceeded. The meaning of the ICRP dose limits changed from being directly operative to stating a risk which was unacceptable under any normal circumstances, while that which really determined the protection requirements was the protection optimisation supplemented by the special, source-related limits that were initially called source-related upper bounds and later dose constraints.

For us in Sweden, the IAEA initiative made a very timely appearance since we were in the process of drawing up provisions for the limitation of emissions and discharges when it came to the nuclear power plants (they were published in 1977, see Chapter 11). I had had introductory discussions with primarily Jan Olof Snihs and I was now arguing in the expert group for the same angle of attack.

The work required yet another expert group meeting, which took place in 1976. A consultancy group consisting of Dan Beninson, Henri Jammet, Bo Lindell and A. Preston was set up to edit the text that was to be discussed at the meeting. The final report, IAEA Safety Series No. 45, was published in 1978. It was updated at the end of the 1980s (see Section 19.19).

7.6. **The 2nd WHO course in Denmark**

A new radiation protection course was arranged in 'Bakkerne' by WHO, again with Per Grande as organiser and I was again invited to give a presentation. Marrit came with me this time and we drove to Denmark. We used the car over the weekend to take a trip to the Northern Zealand coast along with Bill Spiers and his wife. In the evenings I played table tennis with Bill and was punished despite his being fifteen years my senior.

7.7. **IRPA in Washington DC**

IRPA's third international Congress was held at the Washington Hilton Hotel in Washington DC from 9-14 September 1973. The Health Physics Society hosted the Congress. I was Chair of the Programme Committee which had had to give its opinion on 266 submitted abstracts. 57 of these were judged to be excellent and worthy of verbal communication.

The Programme Committee had promised not to release slides which showed unreadable text. We kept to what we had promised and happily confiscated a number of images that would have been of no use to the audience. However, some of the main people, including Dick Chamberlain and Walter Snyder, refused to surrender their inadequate images and insisted on showing them. OK, we said, you may show the unreadable image, but not until we have stuck a (transparent) red cross over it, so that everyone sees that the Programme Committee has rejected the picture. Tough measures.

I had been given the honour of delivering IRPA's Sievert lecture, which was a great privilege. The lecture was entitled *Radiation and Man*. I referred to ICRP's achievements with dose limits which guaranteed that no-one would be affected by acute injuries, something that was still a problem in many conventional types of worker and environmental protection. I continued:

> With the conventional standards of thinking, small radiation doses would be considered not only safe but also often non-existent. Let us not forget that laws on food additives in many countries until recently have completely forbidden any presence of carcinogenic substances, but that the definition of a 'zero quantity' has been a 'non-detectable quantity'. Had radioactive substances been chemically toxic instead of radioactive, many of them would, in the terms of the law, not have existed until new scientific detection methods had revealed their existence and complicated life for the health authorities.

I showed examples of how naturally-occurring radioactive substances can emit surprisingly high radiation doses and attempted to explain why natural radiation and radiation doses to patients were to be exempted from the ICRP dose limits. If the dose-response relationship is linear and has no threshold (which later went on to be called the LNT relationship'), each small additional dose leads to the same small additional risk, irrespective of previous or subsequent radiation doses. This means that each source of radiation can be judged separately if preferred. However, if the dose-response relationship has a threshold value or is not linear, all sources of radiation and additional doses must be included for a total assessment, a complicated undertaking. I then wrote:

> I maintain that in the risk-benefit evaluation of any given practice, the only relevant factors to be compared are the total harm and the total benefit from the practice. If the benefit does not outweigh the possible harm we should be concerned. The degree of our concern should of course increase in proportion to the harm actually expected. If human lives are at stake, I think we are morally and ethically obliged to be worried long before the harm exceeds the threshold that makes it obvious.

From the IRPA Congress at the Hilton Washington Hotel in Washington DC, 1973.
Bo Lindell in the lectern, Karl Z. Morgan at the table.

I then used the 'PQR cost' (see Section 4.12), with PQR = 100 $ per man-rad to show how it is possible to make the significance of small radiation doses comprehensible. I illustrated this using the PQR cost of a number of x-ray examinations, where it varied from 1 cent (dental x ray) to tens of dollars per examination. I also showed how the exposure of Swedish miners to radon had fallen drastically from 1970 to 1973 thanks to simple protection measures (and a commendable effort by Jan Olof Snihs which I unfortunately had not mentioned in the paper).

then discussed the collective dose commitment (then called the population dose commitment) and proposed that the concept of harm commitment ought to be generally introduced.

Finally, I estimated the PQR cost of the nuclear weapons tests carried out thus far and got it to 50 billion dollars. Irrespective of whether this corresponded to a large or small actual risk, it was still competing with other activities. The collective dose to the world's population from the nuclear weapons testing, I wrote, corresponded to 1000 years' (accident-free) operation of 150 nuclear power plants of 1000 MW electric power each. I wrote: 'We should therefore be grateful to those who succeeded in reaching agreement on the cessation of the heavy atmospheric testing 10 years ago'. How true.

The Congress' dinner offered an embarrassing intermezzo. A special table had been set for the IRPA board. Henri Jammet's collaborator Gilbert Bresson checked the place settings and found that Jammet did not have a place at the table. Appalled, he went to find Jammet and told him about what he had found. Jammet was equally appalled and both of them left the banquet hall, gesticulating furiously and red of face.

7.8. **Supersonic flight**

Bo Lundberg (1907-1991) was a well-known aircraft engineer and aircraft designer who had been a test pilot in the 1930s and later head of the Aeronautical Research Institute right from 1944 until 1967. His knowledge, ability and experience lent him credibility when he started criticising the planned supersonic transportation (SST) in 1961.

Bo Lundberg's criticism raised many questions which were fully within his area of expertise. He criticised the technology, and wrote in an article in *Search* (Lund, 1973):

> An SST has to fly in two aerodynamic environments, subsonic and supersonic, which are widely different as regards optimum wing configuration, stability, etc. Every SST must therefore be a compromise solution, inevitably more complex than a subsonic jet plane.

According to Lundberg, this led to unavoidable risks. The sonic boom was also a big disadvantage. And particularly important: Lundberg showed that the supersonic aircraft could never be profitable. Supersonic aircraft like Concorde and the Russian Tu-144* were built in any case as a matter of prestige.

In his eagerness to find arguments against the supersonic aircraft, Lundberg also found that the radiation risks from solar flares were not negligible, particularly not for foetuses in pregnant women. If a solar flare were expected, the pilot would need to allow the aircraft to descend to a lower altitude. But it was uncertain whether he would want to take that risk in reality. Lundberg thoroughly investigated the problem and consulted ICRP and other experts. In 1972 as a consequence of Lundberg's warnings, the Council of Europe invited ICRP to study the problem. ICRP responded with the following statement:

> The Commission recognises that the latter (solar flare) radiation may on rare occasions increase in intensity so rapidly that early planning will not suffice as a measure of keeping exposures to an appropriately low level. The only way of avoiding high exposures would then be to descend to lower altitudes. In the exceptional situations when this is necessary, radiation risks would have to be weighed against any hazards related to the remedial action.

This may not have been particularly helpful. However, Lundberg had another big card to play:

> Not much imagination is required to predict that the first one or two SST accidents will put an end to the attraction of the supersonic aircraft. Most passengers will then conclude that the moderate amount of time gained will not outweigh an increase in the

* After the Soviet aircraft designer Andrei Tupolev (1888-1972)

> risk. The resulting extensive boycott would lead to the elimination of, if not all, a large share of the SST flights.

The Concorde project was undeniably an unprofitable prestige project. The aircraft, which was built in cooperation between the British Aircraft Corporation and French *Aérospatiale*, was a four-engine jet aircraft for 100 passengers. At high altitude, it could fly at twice the speed of sound. A total of just twenty aircraft were built. The first journey took place on 2 March 1969, but regular traffic from London Heathrow and Paris' Charles de Gaulle to New York's JFK and Washington's Dulles did not start until 1976. The aircraft were owned by Air France and British Airways. An accident year in the year 2000, financial problems and other factors led to Concorde being decommissioned in 2003. Bo Lundberg was vindicated, but not until after his death.

7.9. The Congress of Radiology in Madrid

The 13th International Congress of Radiology was held in Madrid in 1973 with 5000 participants. On 15 September at 20.35 King Gustaf VI Adolf passes away and is succeeded by his grandson, whose name becomes Carl XVI Gustaf.

7.10. Radioactive pacemakers

In June, the Radiation Protection Institute had asked the Swedish National Board of Health and Welfare to give its opinion on the use of radioactive pacemakers in Sweden.* The Institute, which followed the international development, guessed that this was an example of how technical innovators are behind the marketing of a product for which there may be no actual need.

The Swedish National Board of Health and Welfare responded in a letter of 6 September, which read:

> ... the board must state that the board currently does not believe that we should have a positive attitude to the use of radioactive energy sources in pacemakers.
>
> In the board's opinion, there is also currently no reason to initiate a trial of such pacemakers in Sweden. However, foreign experiences of the same should be followed attentively to provide a basis for any change of attitude if such is considered to be appropriate.

The Swedish National Board of Health and Welfare had consulted some medical experts. Professor *Gunnar Biörck* at the Serafimer General Hospital's medical clinic, which had the greatest collective experience in Sweden of the aftercare of pacemaker patients, wrote:

> When we jointly examined the Radiation Protection Institute's letter I felt convinced that it was currently wise to observe an apprehensive approach to trials with radioactive pacemakers.

Professor *Leif Hallberg* at the Swedish National Board of Health and Welfare department for acute healthcare, etc. wrote:

> With regard to the risks with radioactive pacemakers and the rapid development of solutions that are already implied to be better in order to reduce the frequency of battery replacements, maintaining an apprehensive attitude to radioactive pacemakers appears to be the most reasonable.

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* The history of the pacemaker is told in Chapter 9 of 'The Labours of Hercules'.

Professor *Lars Werkö* at *Sahlgrenska* hospital's medical clinic thought 'that there were no circumstances in which it was medically justified to permit the use of radioactive energy sources, even in individual cases'.

The users were thus apprehensive or negative; as we had believed, it was the innovators who thought they had found a use. At the time of writing, this is the fiftieth year since Rune Elmqvist designed the world's first insertable pacemaker and in 1958, *Åke Senning* inserted it into a patient called Arne Larsson who was interviewed by *Dagens Nyheter* in the year 2000 because it was his 85th birthday. The conventional technology had won.

7.11. **The WHO symposium in Warsaw**

In October 1973, WHO arranged a symposium in Warsaw on the health risks and biological effects of non-ionising radiation. Björn Tengroth from Sweden took part. After this symposium, WHO arranged a discussion in Copenhagen in which the Chair of the Swedish Committee Carl-Johan Clemedson took part.

7.12. **Israel's nuclear weapons and the Yom Kippur War (the October War)**

During the 'Six-Day War' of 1967, Egypt had unsuccessfully tried to obtain nuclear weapons from the Soviet Union, which had reduced the geniality of the communication between both countries. Seymour Hersh's book *The Samson Option* says that early in 1968, Israel's Defence Minister *Moshe Dayan* gave the go-ahead for the continued production of plutonium and nuclear weapons, and that Israel started producing 3-5 bombs per year. On 28 September 1970, President Nasser died of a heart attack and was succeed by *Anwar al-Sadat*. Sadat abandoned Nasser's socialist-orientated politics and expelled all Soviet military advisers in July 1972. However, a proposed peace agreement with Israel was not implemented since Golda Meir was opposed to Egyptian troops on the Sinai Peninsula. Sadat then began planning to recapture at least part of the Sinai Peninsula and prepared an attack on Israel in league with Syria. In the afternoon of 6 October 1973, the holy Yom Kippur day, Israel was surprisingly attacked by Egypt and Syria and 'the October War' or 'the Yom Kippur War' broke out.[*]

The Israelites were ill-prepared on this occasion and had difficulties countering the attack. They are said to have had about a dozen nuclear weapons at the time, and the possibility that they would be used was seen by the surrounding world as a serious threat. However, Israel's government continued its policy of neither confirming nor denying that they had access to nuclear weapons.

On 8-9 October, the situation stabilised when Israel was able to bring in reserve forces. On 11 October the Syrian offensive at the Golan Heights was stopped. On 14 October, the Egyptian army which had crossed the Suez Canal and travelled 10 km eastwards on 6 October prepared a further advance eastwards. But the Israeli forces succeeded with a surprise manoeuvre by crossing the Suez Canal themselves. The road to Cairo was now open and the 3rd Egyptian army was surrounded on the eastern side of the Suez Canal. Under pressure from the major powers and the UN, the parties then agreed a ceasefire.

The aftermath lasted until 1979. Golda Meir and her government resigned in 1974 following criticism that the country had allowed itself to be surprised. When the peace negotiations between Egypt and Israel progressed poorly, the American President Jimmy Carter invited Sadat and Israel's new Prime Minister Menachem Begin to Camp David in 1978 for talks, which were productive and which also led to Sadat and Begin sharing the 1979 Nobel Peace Prize.

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[*] Yom Kippur is the Jewish holy day which is called the Day of Atonement.

7.13. **The Environmental Advisory Council**

The Environmental Advisory Council had been set up as a Committee under the Ministry of Agriculture in 1968 with the task of developing the environmental work by bringing together politicians and scientists. It held an important meeting on 23 October 1973 with approx. 70 participants and Ingemund Bengtsson as Chair. The subject was the safety aspects of nuclear power. The meeting was to start with a presentation by me, Arne Hedgran and Stig Bergström. The hundred or so pages of minutes contain so much that I am quoting extensively from them here.

I talked about the national and international structure of radiation protection and then concentrated on radioactive waste. I ended by saying (the minutes record what we all said in long sentences with didactic repetitions, not how we would have worded things had we been writing):

> I shall finish by saying that we at the Radiation Protection Institute think the safest method from the radiation protection point of view is to store the highly-active waste under supervision. However, this is not a satisfactory method from an economic or technological point of view. Various more final solutions have therefore been discussed, which will doubtless appear later. These solutions can be expected to involve economic and technical improvements, and it may even be possible to 'forget about' the waste by somehow rendering it harmless for the future. However, this potentially leads to disadvantages from the radiation protection point of view since you might then have done something that is irreversible. Provided you store the waste under supervision, you have chosen a good solution from the radiation protection point of view, and it may therefore be misleading to say that there is currently no solution to the waste problem. No decision has been made on what to do with the waste in the long term. You can do things and you can discuss whether these things are beneficial or disadvantageous from the radiation protection point of view, but secure supervised deposition of the waste – when the heat has worn off and when it can be handled better and solidified in different ways – that is what we can currently count on as being adequately safe if we do not have too much waste.

Arne Hedgran spoke on behalf of the Delegation for Atomic Energy Issues and talked about the safety issues. He started by saying:

> To put it very simply, you can say that the key safety problem at the nuclear power reactors is the <u>simultaneous</u> presence of high radioactivity in the fuel and the risk of this melting down and thereby emit the products. ... This circumstance was in principle known 20-25 years ago when the development of the peaceful use of reactors began in the USA. The rapid conclusion was that nuclear energy can be accepted only on condition that an adequate technique is produced to prevent activity distribution if an accident occurred.

He also said:

> An important safety aspect is the location of the power plants. All over the world, and perhaps slightly more in Sweden than elsewhere, we have endeavoured to position the nuclear power plants so that they are not in the immediate vicinity of population centres. The determining view is that you must be able to carry out an evacuation if radioactivity were to be distributed in spite of everything. The biggest accidents that have been analysed as being technically reasonable do not lead to any effects which would require such measures. But again: the technique may not function as well as expected, and you can see siting in sparsely-populated areas as part of the 'defence-in-depth' principle.

The third introductory speaker, Studsvik's radiation protectionist Stig O. W. Bergström, spoke in his capacity as Secretary in The Urban Siting Investigation (see Section 4.22). He said the following about reactor accidents:

> As regards accidents, you find that, according to the design principles, very big accidents, those that have catastrophic effects inside the plant, do not have environmental effects which lead to any classification between nearby and remotely situated. We have been working on the basis that the protection devices will allow very substantial damage to essential components and pipelines without the radiation dose in the surroundings causing any acute effects. Classifying the locations is thus only possible if you assume that rarer accidents occur than these big ones that as yet have never happened. The differences in the risk profile between nearby and remotely situated thereby refer only to consequences of major and unlikely accidents which also have an unfavourable outcome as regards the atmospheric distribution.*

In conclusion, Bergström said:

> ... this report has heavily emphasised our need for a uniform risk thinking within society. At the moment we have no comparison templates. When we have produced our result there is nothing to compare the result with. When evaluating alternatives, be it location or power source, you find that failure on the part of a society to openly declare a risk philosophy leads primarily to potential misunderstandings.

The following discussion occupies a good 90 pages of in the minutes. The main participants were Bo Aler, Stig Bergström, *Nils Dahlbeck* ('Captain Bäckdahl'), Kay Edvarson, Arne Hedgran, *Lennart af Klintberg* (water court judge at Södertörn City Court), Börje Larsson, Bo Lehnert, Bo Lindell, Sven Löfveberg, *Bryan McHugh,* Arne Nelson, Lars Nordström, Hans Palmstierna, Jan Rydberg, Erik Svenke and Gunnar Walinder.

We began by discussing the risk from radon in uranium mines and ordinary ore mines. Bo Lehnert wanted more research in general, and Hans Palmstierna intervened, confirming that this was something that was seriously wanted, not one of the scientists' usual ways of requesting funding. Lehnert reminded us that there was an alternative nuclear fuel – thorium instead of uranium. Reactor safety was a recurring subject and we also discussed gas-cooled reactors. The risks of plutonium were discussed and Kurt Lidén summarised by saying:

> As regards the radioecological behaviour of plutonium, we have talked plutonium-239 in the first instance. Were we actually to approach the hygienic limit value for all air on the globe simultaneously, the quantity that would have to have been distributed throughout the atmosphere would be something like 100,000 kilogrammes rather than 200 kilogrammes – a number which comes up in the debate.
>
> Another circumstance of interest as regards plutonium is that nuclear weapons testing means that we already have a coating on the globe corresponding to 4 500 kilogrammes. I would like to claim that it is relatively evenly distributed. However, the quantity is so small that we have some difficulties actually identifying it, but it is possible.

'Janne' Rydberg talked about the handling of waste and the possibility that some of the radioactive waste could be put to use. He referred to the lighthouse in the Stockholm archipelago which was run on energy from strontium-90. I objected:

> Attempts to utilise the waste products have often begun. This has been going on for a long time and has led to a number of fairly crazy projects such as radioactive wristwatches and other such things that people might not necessarily need.

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* The idea that reactor disasters like the Chernobyl one are so unlikely that they can be precluded in practice has proven to be a mistake. It is based on the incorrect but common-among-technicians belief that the probability is an objective magnitude which can be calculated. They forget that all probability estimates need the assumptions made to be correct. The only probability for this is an amount of trust. The assumptions often do not hold water.

What you may gain through this is additional overall product value, but I doubt you gain anything as regards safety. What you are doing is distributing these substances to a number of different small places so that they are more difficult to monitor and the risk of something getting lost increases. On the other hand, there is less of a risk of everything getting lost all at once, but the risk of that happening must be seen as being very small.

Therefore, I do not think there is any particular pressure from the radiation protection point of view to attempt to remove and spread these sources of radiation when they can be stored in one place under better supervision.

Rydberg answered:

Only a brief comment. One advantage is that you obtain a material where you have a much better idea of what happens to it. You might say that this increases the safety. I agree with Lindell that there may be certain problems if the waste is being distributed in many different places. However, there is nothing to prevent you storing the three said fission products [krypton, caesium and strontium] in one place.

Rydberg had a question about plutonium:

Can I further detoxify plutonium by chemically changing it? It is obvious that making it so chemically complex that anyone who steals plutonium has no chance, using reasonable resources, to convert it for nuclear weapons will prevent theft thereof. The technicians and national reprocessing plants, etc. can then of course use their resources to very easily convert this plutonium into a useable form. How do things stand with nuclear weapons and the chemical form of plutonium?

Kay Edvarson's reply to this was:

The FOA has not looked more closely at the options of using plutonium other than in metallic form for nuclear weapons. However, generally speaking, we have concluded that other plutonium compounds are not particularly suitable. The debate has now shifted so that there is a tendency to portray the production of nuclear weapons as something that is very easy. That is not actually the case. I have difficulty believing it would be relevant for a non-sophisticated nuclear weapons producer to attempt to use anything other than metallic plutonium.

We also talked about possible acts of terrorism - what happens if someone distributes the radioactive substances using conventional explosives? Edvarson replied:

We at the FOA have previously looked at what is called radioactive weapons which would involve detonating radioactive products using conventional means. It was shown that if you really do want to obtain a proper effect and to give people fatal doses, this is an exceedingly disadvantageous method. It would be a method to cause a terrible nuisance locally, within some tens of metres, when it came to clearing up afterwards, but that is all.

Börje Larsson said:

I believe [...] that the public has fairly considerable faith in the expertise that is in the technology and the radiation protection. ... I also have no concerns about the development of nuclear power provided everything works as normal. ... I have a feeling that our discussion today has served to support our faith in the technology and radiation protection to some degree. So far I have not heard much to convince me that we would be able to handle the situation should something extremely serious really happen, let's say political or military misuse or a major accident. I believe that, whether you are for

> or against this issue, you have to understand that this is the point that the general debate will eventually focus on.

I too had a contribution to the issue:

> It is also an eye-opener for the nuclear power industry that if and when a serious reactor accident occurs, it will definitely be very important to the general opinion [the Three Mile Island and Chernobyl accidents had not yet occurred]. In this context, despite everything, it is probably not that unlikely that this may happen somewhere among all these reactors that are being built all over the world and which at least we believe are less safe than those we build in Sweden. If such an accident happens, it will of course have very serious consequences for the general opinion. ... A smaller accident is more likely, but even then it is difficult to clarify the difference one way or the other. It is therefore not that unrealistic to prepare for some such smaller accident to occur somewhere in the world within the not too distant future, and that we must then be prepared for the repercussions.

Six years would pass before Three Mile Island and the repercussions in Sweden became a nuclear power referendum.

The future did not look too bright. No-one wanted to continue with fossil fuels like oil and coal in the long term, and many did not want nuclear power. The latter talked about new, alternative energy sources such as wind power and solar energy. Lars Nordström had a more realistic view of the case and wanted to express his opinion as a Professor rather than as a member of the delegation for Atomic Energy Issues:

> ... I would appeal to people to devote more attention and give more resources to long-term research. However, it must not be done in the belief that this is the way to solve any current problems – it must be done understanding that these are long-term issues. We have an oil crisis right now with the war going on in the Middle East. We have become dependent on oil and frightened by nuclear power. You then ask if there are alternatives. My answer to that is that there are no alternatives other than the conventional. The only things that Jungnell can incorporate into *Vattenfall's* planning are conventional methods. There are marginal things to do there, with wind and with solar energy – we must not take them out of the equation. However, the big input must be coal and natural gas.

Nils Dahlbeck wondered whether a heavy increase in energy use would end up leading to a harmful global temperature increase. Bo Lehnert's answer to this was:

> If my calculation is correct, 1 Q per year ($3 \cdot 10^{14}$ kilowatt hours) spread out over the Earth's surface would lead to an average temperature increase of two hundredths of a degree. This will be our approximate level of energy consumption at the end of the century. If we go up by a factor of ten, the temperature increase will exceed one tenth of a degree and this can have serious consequences since the climate depends heavily on the temperature.[*]

Hans Palmstierna said that he had gained the impression that the waste issue was what constituted the biggest problem with nuclear power. Bo Lehnert on the other hand thought the possibility of a catastrophic reactor accident was what constituted the biggest problem and that the waste problem was 'of a secondary nature, even though the waste issues are of course very important'. I shared this view and thought that the waste problem was primarily an economic one.

The text in the minutes was completed by:

[*] We should remember that today, we talk about temperature increases of full degrees because of the greenhouse effect.

> The chairman concluded the meeting by emphasising that the number of concentrated contributions leading to the incredibly interesting discussion made the meeting a very energetic preparation. The minutes from the meeting were predicted to be of great value in the continued discussion regarding the nuclear power issues. It was perhaps no surprise that the agenda had a point for alternatives. It was ascertained that the thoughts of the invited specialists were way ahead of the thoughts of laypeople. The chairman finished by emphasising the value of being able to include in the minutes that there *are* views on the energy sources of the future, even if the opinions are divided.

This big meeting of the Environmental Advisory Council must have been important. As well as the Chair, two other Cabinet Ministers were present, i.e., Rune Johansson and *Camilla Odhnoff.* Observers were MPs Kerstin Anér, *Staffan Burenstam-Linder*, Birgitta Hambraeus and *Åke Wictorsson*. There were influential Director Generals and ministry officials. There were representatives of industry and a County Governor – Gösta Netzén. The meeting should have made its mark.

7.14. **The oil crisis**

The 1973–74 oil crisis was connected with the Arab–Israeli October War of 1973. Oil had increased its share of the world's energy use over a twenty-year period from 37 to 55 %. Western Europe had developed so that it was dependent on imported oil. The USA had become the biggest importer despite its own oil assets. Most of the oil was extracted in the Arab world and trade had long been controlled by American, British and Dutch oil companies. As a counterbalance, the Arab States formed the OPEC, the cooperation organisation of the petroleum-producing countries, which in 1973 became a power broker and was able to determine production volume and prices. The Arab countries introduced an oil blockade against the Netherlands and the USA and the oil prices rose steeply. In 1974, the price stabilised at a new level: 11 dollars per barrel compared with 3 dollars per barrel previously. At the time of writing this, the price has exceeded 80 dollars a barrel!

7.15. **IAEA in Warsaw**

A meeting of a panel of experts in Warsaw was introduced on Monday 29 October. The panel was set up by IAEA and was to discuss estimates of population doses, both individual doses of radiation and what we now call collective doses. I was asked to be Chair of the panel, assisted by IAEA's *G. E. Swindell* and his Secretary, a striking woman called Dagmar. Swindell was head of IAEA's radiation protection department at the time.

The panel consisted of twenty experts from twelve countries. As was usual at this type of panel of experts, the work was dominated by a few people. Among them were Dan Beninson from Argentina, Stig Bergström from Sweden and *Geoff Webb* and *Pamela Bryant* from the UK.

The meeting took place in the Palace of Culture, designed by Russian architects and a gift from the Soviet Union, a dominant and pompous building in the middle of the city. You were not free to do what you liked there. When we wanted to have proposed texts copied it was not just a matter of putting the original in a copier and pressing a button. Photocopiers were obviously thought to be devices that were dangerous to society and that could produce revolutionary pamphlets. Each time, Dagmar had to go a couple of flights higher up holding a special pass to where a strictly monitored copier was stored and take her copies under supervision.

At the time, Geoff Webb was a young man with a Beatles haircut and this was the first time Dan and I met him. He had recently returned from the USA to the NRPB which, in 1972, had decided to take an inventory of all radiation doses to the population and had given the assignment to Webb. At the time, Geoff had no great understanding of the collective dose calculations that Dan and I wanted to have done. Pamela Bryant, who probably shared his reluctance, still had a calming influence on his bent towards opposition.

The draft report shows an ambitious list of all conceivable sources of radiation, natural and man-made, with one exception: radon. It is interesting to see that the problem with radon had still not been observed.

Dan arrived from a meeting in Belgium with one arm in a sling. He had slipped on a bottle top on a street in Brussels. But his smoking habits had not suffered. We were driven each morning from our hotel to the Palace of Culture. On the first day, Dan asked the chauffeur to stop the bus in front of a tobacco shop. Twenty or so of us sat there waiting while Dan got himself some cigars.

No IAEA report was ever published, but Bengt Pettersson, then from the Swedish Radiation Protection Institute, temporarily employed at IAEA, edited our conclusions, so there is a manuscript. But we had worked in vain, although not completely unnecessarily. We had made a valuable contact: Geoff Webb.

7.16. The NEA discusses the matter of building materials

The OECD/NEA's Radiation Protection Committee (CRPPH) finally began to tackle the issue of radiation in homes, which was a precondition for the Radiation Protection Institute to have its warnings heard. Preparations were made to set up an expert group which started meeting in 1973. It had the following members:

L. Berteig	Norway
O. Castrén	Finland
H. Goenvec	France
W. A. Kolb	Germany (Chair)
M. O'Riordan	England
B. Rüegger	NEA (Secretary)
H. Schmier	Germany
A. Susanna	Italy
G. A. Swedjemark	Sweden
D. Vos	The Netherlands

The group created a report which the NEA published in May 1979, the same year in which the public's concern regarding radiation in our homes culminated.

7.17. The development of nuclear power

In January, Swedish Parliament had decided that for the time being, the expansion of nuclear power should be limited to the eleven units on which decisions had been made by then. This number was less than half the number that the CDL had thought would be needed in 1972. The Swedish Parliament's decision followed a motion by Birgitta Hambraeus of the Centre Party.

It was now the election year. The energy matters featured in the election campaigns for the first time. The Centre Party led the opposition to nuclear power, inspired by a speech by Hannes Alfvén at the Centre Party meeting in June. The election resulted in a 'hung parliament', with 175 Social Democratic and 175 non-Socialists. The Social Democratic government remained but the Centre Party surged forward.

7.18. The Radioactive Waste Committee (AKA)

The Radioactive Waste Committee, referred to in jest by the Secretary Philip Moding as the 'Aka'demy, began its work. See also Sections 6.24 and 9.14.

7.19. **Nordic meeting in Helsinki regarding the 'Flag Book'**

In November (13-15) 1973, representatives of the Nordic radiation protection authorities met in Helsinki and in principle approved the 'Flag Book' once the proposed changes that had been sent to the Secretariat in Stockholm had been considered. The thick work report for which the changes had been proposed had been sent out on 30 August. The proposals received had been edited by *Sten Grapengiesser* and filled a 30-page report. In it, the proposals were divided into three groups: 'general issues', 'main issues' and 'side issues'. It was suggested that the discussions at the meeting should begin with the general issues.

Thirty-eight people from Denmark, Finland, Norway and Sweden took part in the meeting. From Sweden, Benner, Boge, Grapengiesser, Helde, Hesser, Lindell, Löfveberg, Lorentzon, Bengt Pettersson, Snihs and Tribukait took part.

7.20. **Extraordinary UNSCEAR meeting**

UNSCEAR held an extraordinary meeting on 26-27 November. I do not have details about the meeting place but would take a guess at New York. Since I was busy with the Nordic Authority meeting in Helsinki, Sweden was represented by Kay Edvarson who reported to the Ministry for Foreign Affairs on 7 January 1974. They had heard the rumour that the Secretariat was being relocated. Kay wrote:

> As regards the future location of the Secretariat, the general opinion expressed was that being located in Geneva would be largely the same as being in the current location, and would also be advantageous for the Secretariat in some ways in its continuing cooperation with other UN bodies with environmental protection interests, while Vienna and Nairobi on the other hand would be worse than the current location.

Nairobi was mentioned because the UN's new environmental protection organisation, the United Nations Environmental Programme (UNEP) was domiciled there. Vienna was mentioned because the UN's new Secretary General, *Kurt Waldheim*, was Austrian and was happy to see more international activity in Vienna.

7.21. **IAEA consultancy meeting**

On 10-14 December, the consultants whom IAEA had appointed to draw up a working document met in Vienna for the next expert meeting regarding what was still, despite our protests, called 'Methods to determine the capacity of the environment to receive radioactive materials'. At the previous expert meeting, it had been agreed that the title ought instead to be 'Principles t for establishing limits for the release of radioactive materials into the environment'. This was also the title in the final document, IAEA Safety Series No. 45, when it was finished in 1978.

8. THE YEAR 1974

8.1. Task group in Argentina

On 24 February I sent a postcard home:

> I am now safely in Buenos Aires with the others. Here, it is 22-24 ^{o} C, a nice, warm summer. This card cannot be posted until Monday because no stamps are sold over the weekend! We are now going out to look at the city before flying on to Bariloche in the afternoon.

This was the first time I had been to Argentina. The reason for my visit was that the ICRU had set up a task group for the subject of 'Conceptual grounds for determining the dose equivalent', the quantity that is now called the equivalent dose. The group was led by Harald Rossi and had a further two ICRU members, Harold Wyckoff and John Dunster. ICRP had been asked to appoint a further two participants from among its members. They were Dan Beninson and me. Since John was a member of both ICRP and ICRU, the two Commissions had equal weighting.

We were to meet in San Carlos de Bariloche in Patagonia at the foot of the Andes close to the border to Chile, by the beach of the big lake Nahuel Huapi. Here, on the small island of Huemul, was where the German physicist Ronald Richter experimented from 1949-1952 with what he maintained was a fusion reactor, with President Perón's support. In 1952 an investigation commission, whose Secretary was Dan Beninson's father Eduard,[*], revealed that he was an impostor

Richter's fraud was not exclusively an embarrassment, it had led to Argentina forming the Atomic Energy Commission CNEA (*Comisión Nacional de Energía Atómica*) in May 1950, certainly on false premises but with plenty of vitality. On the outskirts of Bariloche a plant was created for research and teaching in nuclear physics similar to Risø in Denmark. The CNEA then dominated its life in Bariloche.

Dunster, Rossi, Wyckoff and I stepped off the plane at the airport outside Bariloche with great expectations. What struck us first was how fresh the air felt to breathe and how beautiful the view was. We were driven to the research station where we were to stay in a small guesthouse close to the approach where we would be working, eating and sleeping with the exception of the occasions when Dan drove around with us in the beautiful natural surrounding area with high mountains and beautiful lakes. The small town of Bariloche where we sometimes went in the evenings resembles a Swiss or an Austrian winter sports town and the tourism was said to be continuously increasing.

One of our trips was to a winter sports centre with a cable car system and a separate chairlift system. We had intended to travel up the mountain by cable car, but it was so windy that the trips had been suspended. We ate lunch in the plant's restaurant instead. While the others stayed at the table, I walked up the mountain, reaching the nearest summit where the cable cars stopped. Mesmerised by seeing twinflower and wild strawberries a long way up I asked a couple of Indians to take a photo of me up on the mountain. I then surprised the functionaries by using the downwards chairlift for the trip back down. My anxious friends were standing down there. My trip had taken too long and Harald Rossi was on the verge of walking up the mountain to look for me.

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[*] I have written about this in more detail in 'The Sword of Damocles'.

The trips out into the gorgeous surroundings have of course remained in my memory more than the work with our assignment. But despite everything, the work was dominant and eventually led to ICRU report 25, published in 1976. Paragraph 24 of the report describes the problem:

> Since, as a rule, it is impossible to measure directly the dose equivalent received by the tissues of irradiated persons, it is necessary to derive its magnitude from other quantities. There are several quantities that may be employed in the various steps of the process linking the emission of ionizing radiation by one or more sources to the dose equivalent at the point of interest.

The connection between these quantities was described using a diagram in an appendix. Anyone who wants to get a quick idea of what the report is about can start by studying the diagram.

8.2. ICRP at WHO in Geneva

The ICRP Main Commission met on 11-17 in March at WHO's head office in Geneva.

8.3. New editorial group for ICRP

Things had progressed far enough for ICRP to see there was an evident need for a new document to replace Publication 9. An editorial committee was set up under 'Bill' Pochin for this purpose with Dan Beninson, Henri Jammet, Bo Lindell and David Sowby as members. Five years had now passed since Pochin had stepped down as Chair of the Commission and been succeeded by Gordon Stewart. I was Deputy Chair, Sowby Secretary and Jammet Chair of Committee 4. Dan had a mainly international track record as an UNSCEAR delegate and member of Committee 4.

8.4. The CRPPH in Paris

The OECD/NEA's Radiation Protection Committee (the Committee on Radiation Protection and Public Health, CRPPH) met in Paris on 21-22 March 1974 under the Chairmanship of David Richings from the British NRPB. The meeting had been preceded by a meeting of the Committee's 'bureau' in January, i.e., Richings, I and the Secretary Emile Wallauschek, when we also discussed the cooperation with NEA's new safety issues committee.

The Committee finally gave its support for a report containing recommendations for radioactive pacemakers. The recommendations were now completely different from what they had originally been. They were no longer based on an extensive use of radioactive pacemakers but concentrated on a study in the anticipation of evidence that non-radioactive pacemakers were preferable. I criticised the conflict between the CRPPH's principal rejection of radioactive consumer products and the technical experts' enthusiasm for developing and finding a market for new methods and products.

The Secretariat had been given the task of drawing up an NEA report for the OECD's leadership on the impact of the radiation protection requirements on the expansion rate of nuclear power. The report was firstly to be approved by the NEA's board, but points of view were to have been obtained from the CRPPH before that.

The discussion about this document became very heated and difficult for the Chair to control. On the first day of the meeting, a large number of delegates declared that they did not think the document was acceptable, even though the Secretariat had done a good amount of work during the short time available. The Chair asked for concrete examples of inadequacies but had difficulty obtaining any exact answers. He then set up a task group to formulate the criticism. He asked me to be Chair of the group.

It turned out that the task group was able to provide concrete proposals for changes to the text on all points apart from four. These had been put forward by me and were thought to apply to such vital questions that the group would prefer comments before changes were proposed. I was asked to write these comments. My comments were supported by the delegates from Denmark, Italy, the Netherlands, the UK and Austria. The Chair then drew up a proposal for a statement from the Committee to the NEA's board.

The delegates from Belgium and France and the representative of the CEC objected to this proposal. They did not think the Committee had had enough time to give any opinion on the Secretariat's document other than that it was a valuable and useful report. I along with most of the delegates objected to this. When the Chair was unsuccessful in finding a compromise, the Secretariat formulated a statement that the French-speaking countries could accept. But it was not accepted by me, who thought it withheld information to the board that the document had serious inadequacies. I demanded that two of my original proposals be appended to the statement. This was accepted since many delegates supported me.

My first point concerned the treatment of 'public understanding' and 'the public's opposition' to nuclear power. I did not think the presentation was adequate. I thought that 'opposition' and 'lack of understanding' often reflected real inadequacies. I wrote:

> Nor would it be fair to suggest that the opposition to nuclear power were always the result of ignorance, misinformation or hostility and believe that better 'comprehension' would eliminate the problems. As with every other substantial industrial effort, the production of nuclear power leads to some degree of risk. Much of the public's concern can be linked to the fact that this risk is a complicated one and difficult for even the experts to quantify, and that the need for nuclear power has not always been convincingly demonstrated to the members of the public for whom the increase in energy consumption is generally speaking a cause for concern.

My second point concerned radiation protection and the handling of waste. I wrote:

> It is possible to criticise the current text on radiation protection and waste handling, not owing to that which is said but owing to that which is *not* said. This causes a certain imbalance. For example, the storage of separated plutonium constitutes one of the greatest potential risks in the overall fuel cycle. The risk is linked not only to theft or misuse of plutonium as fissile material, but also to the high radiotoxicity of primarily plutonium-238 which could be distributed in the event of a fire. We ought also to realise that the stores of plutonium will continue to grow until the material is actually recycled as fuel. However, the consequences of such a recycling from radiation protection point of view (transportation, fuel production, etc.) have been discussed very little so far. With breeder reactors, the accumulation of stored plutonium will accelerate and create problems that ought to be closely studied.

The fact that Sweden had assisted with the NEA's involvement in the dumping of low-level activity waste in the Atlantic had attracted attention and led to questions. In my report from the meeting I wrote:

> Although Sweden is in principle against any dumping in the world's oceans, it should be seen as positive that countries which continue dumping radioactive substances with reference to the London Convention are doing so under the supervision of the NEA rather than of their own accord without any insight.

8.5. **Ringhals 2 and the Oskarshamn plant's second unit**

Following a few problems with jellyfish in the cooling water and faults with pumps, Ringhals 2 supplied the mains with electricity for the first time on 17 August and Ringhals 1 on 14 October, but there was still the question of a trial run. The jellyfish from the filter housing of the cooling water intake ended up rotting on the tarmac, which was described by the mass media as 'nature's own opposition movement against nuclear power'.

Unit no. 2 in Oskarshamn's nuclear power plant was commissioned in December.

8.6. **Nordic authority meeting in Copenhagen**

The Nordic radiation protection authorities met in Copenhagen on 29-30 April 1974. Owing to the substantial interest in the matter, a decision was made to publish a preliminary version of Chapter 19 of the ‘Flag Book’ in advance. The offprint was published in April 1974 as a 24-page pamphlet in English jointly from radiation protection institutes in Copenhagen, Helsinki, Oslo, Reykjavik and Stockholm under the heading *Basic principles for the limitation of releases of radioactive substances from nuclear power plants*. In a presentation I summarised the reasons for stating radiation doses for large populations (the italics are my own):

> The expression ‘population dose’ has not been clearly defined. However, in autumn 1973, a number of panels and task groups under IAEA and ICRP started to agree on uniform terminology.
>
> Radiation dose in the sense of absorbed dose is not an addable quantity when different tissues or bodies have been irradiated. We have therefore introduced the quantity ‘collective dose’ with the unit man-rad.* A person who has received a radiation dose of D rad can be said to have received a collective dose of D man-rad. The collective doses are addable.
>
> The total collective dose from a given source of radiation is the sum of collective doses from the source of radiation to all individuals†. If you add them up with no geographical limitation, you can talk about the collective dose to the whole of the Earth’s population, which was previously often referred to by the term ‘population - dose’. You can also talk about the collective dose to a limited population or within a limited area.
>
> The concept ‘dose commitment’ is the full time integral of the average dose rate in a given population.
>
> If you multiply the dose commitment in a given population by the number of people, you obtain the collective dose commitment. If you divide the collective dose by the number of people, you obtain the average radiation dose in the given population.
>
> A dose commitment should always be related to an event that will cause future radiation doses. You can talk about the dose commitment per MW and years of nuclear power production.
>
> One useful connection is that the *future annual radiation dose due to an operation which generates one and the same dose commitment every year is numerically the same as the dose commitment from one year of the operation*. Applying annual dose limits to the dose commitment instead of to the temporary actual annual dose guarantees you that the future annual dose, despite the accumulation of the radioactive substances in the biosphere, will be below the dose limit.
>
> *If we introduce a secondary limit for the dose commitment per unit of an operation whose future development can be forecast, e.g., a limit for the number of man-rad per MW and year, you can also gain control over the development of the future radiation dose.*

The work with Chapter 19 influenced the wording of IAEA Safety Series No. 45 on *Principles for Establishing Limits for the release of Radioactive Materials into the Environment*, which had begun with an expert meeting in Vienna in 1973 and would be concluded with a new meeting in 1976. The final IAEA report came out in 1978. This harmonised the IAEA recommendations and the Nordic ‘Flag Book’ which was published in 1976. This was so much easier because I was Chair of the two IAEA meetings and was able to push the Nordic points of view which had been expressed during the work with the ‘Flag Book’ but were originally based on the Nordic expert meetings in Stockholm in 1970 and in Oslo in

* The collective dose now refers to the quantity *effective dose* for which the unit is *man-sievert* (man-Sv).

† The current definition of a collective dose is the product of the number of irradiated people and their average radiation dose.

1972. The fact that the work with ICRP Publication 26, the new fundamental recommendations, was ongoing at the same time (to be completed in 1977) also facilitated the Nordic work.

8.7. IRPA task group for non-ionising radiation

From 1974, IRPA had a task group for non-ionising radiation. In 1977, the group became an International Non-Ionising Radiation Committee (the INIRC).

8.8. The Nordic Congress of Radiology in Uppsala

The 33rd Nordic Congress of Radiology was held in Uppsala with Professor H. Lodin as President. Monday 10 June started with the opening meeting in the University's assembly hall where the University's Vice-Chancellor, Professor Torgny Segerstedt, held a welcome address.

At the meeting, Professor *Rolf Wideröe* held a controversial presentation in which he criticised the use of Ellis' formula. The tolerance and value of different fractionation patterns of tumours and healthy tissues were discussed at a clinical radiobiology symposium with Börje Larsson as moderator.

Computed tomography of the skull was considered to be revolutionary.

8.9. Non-ionising radiation – report finished

Carl-Johan Clemedson's Non-ionising Radiation Committee with *Enn Kivisäkk* as Secretary submitted its report to the Radiation Protection Institute on 31 July. The report contains a detailed account of non-ionising radiation with reference to concepts, physics capacities, the sources of radiation, the biological effects of radiation and the possibility of stating limit values. The summary said:

> The report has dealt with the issue of whether the Radiation Protection Act with its implementation decree can also be applied to non-ionising radiation, but has found no reason to propose any change to the law or the decree. ...
>
> Owing to the above risk factors that are associated with non-ionising radiation, the Committee thinks it is exceedingly important for the Swedish Government to utilise the authorisation in accordance with Section 1 of the Products that are Hazardous to Health and the Environment Act and now provide that the Act shall apply also to devices or objects which, whether or not in use, emit non-ionising radiation and which may lead to a risk of causing injury to people or damage to the environment. ...
>
> ...
>
> The work assignments of several central authorities ... also includes the supervision of non-ionising radiation. These supervisory tasks may include particularly complicated assessments and opinions which, in order to be correct, indisputably require the input of expertise within the fields of radiation physics and radiation biology. It is unreasonable to conceive that every central authority with supervisory tasks will be able to provide such expertise from within itself. According to the report, several reasons, including the complexity of determining the existence and magnitude of the risk factors, dictate that this expertise should be collated through a body. For reasons stated in greater detail in the report, the National Radiation Protection Institute should be this body of experts.

The report thus proposed a major task for the Radiation Protection Institute. The task became greater still in 1976 when the Radiation Protection Act was changed to also cover non-ionising radiation.

8.10. Non-ionising radiation – the concept

In this context, it may be appropriate to explain the problems that were dealt with in the report.

Ionising radiation is radiation that consists of electromagnetic radiation or particle radiation with particle or quantum energy which enables the radiation to dislodge electrons from atoms in irradiated materials. The atoms are then ionised, i.e., are no longer electrically neutral. *Non-ionising radiation* is consequently radiation that has insufficient quantum energy to release electrons. The latter type includes low-energy *electromagnetic waves* and *acoustic waves*.

A wave transports energy. The acoustic waves (infrasound, audible sound and ultrasound) are mechanical pressure waves through materials; they therefore cannot transport energy through vacuum. The electromagnetic waves consist of changes in electric and magnetic fields, changes that propagate at the speed of light. Maxwell's equations show that changes in electric fields create magnetic fields and *vice versa*. The source of the electromagnetic wave is electric charges in motion, e.g., in a transmission aerial, in vibrating molecules, braked electrons in an x-ray tube anode or quantum leaps in atoms or atomic nuclei. The result is a transverse wave of field changes involving changes in both the electric field and, in line with this, also in the resulting magnetic field, an electromagnetic wave.

In 1905, Einstein was able to explain the photoelectric power by assuming that light could also be described as a particle flow where the particles, the photons, have a quantified energy which, according to that which Max Planck showed in 1900, is proportional to the frequency of the field change (υ). What we call *electromagnetic radiation* can therefore be attributed to both wave properties and particle properties.

An electromagnetic wave propagates itself at the speed of light ($c = 3 \cdot 10^8$ m/s). The wavelength (λ) then becomes $\lambda = c/\upsilon$. The frequency υ is stated in hertz (Hz) with the dimension of 1/s. With the alternative approach, the quantum energy becomes $E = h\upsilon$, where h is Planck's constant ($h = 6.626 \cdot 10^{-34}$ kg m^2/s).

8.11. **Electromagnetic radiation**

Electromagnetic radiation, counted from the highest frequencies and photon energies, covers gamma radiation and x rays, ultraviolet radiation, visible light, infrared radiation ('heat radiation'), and radiofrequency radiation. The gamma radiation and the x rays have high enough photon energies to be able to ionise atoms. The others are counted as non-ionising radiation. If you list the electromagnetic radiation layers in the order of decreasing photon energy or frequency, i.e., according to increasing wavelength, you get the following picture:

Gamma radiation X rays	Ultraviolet radiation	Visible light	Infrared radiation	Radiofrequency radiation

The photon energy (E) and the frequency (υ) increase to the left

←————————————————————————

The wavelength (λ) increases to the right

————————————————————————→

x

E > 12.4 eV $\qquad$ λ > 100 nanometres

The border between x rays and ultraviolet radiation (UV radiation) is marked by 'x'. It lies at a wavelength of 100 nanometres or, if you prefer, at a photon energy, stated in electron volts (eV)[*], which is $1240/\lambda$ if the wavelength λ is stated in nanometres, i.e., 12.4 eV. This means that the wavelength for

[*] See 'Pandora's Box'.

ionising radiation is so short that it is preferable to state the photon energy. For non-ionising radiation on the other hand, the quantum energy is so small that it is preferable to state the wavelength which stretches from the most energy-rich, 100-nanometre UV radiation to radiofrequency radiation with wavelengths of between one millimetre and a good number of kilometres. For the radiofrequency radiation, you often alternatively state the frequency which then stretches from 300 gigahertz (GHz) down to 10 kilohertz. At very low frequencies, such as 50 Hz, the wavelength is so long that the radiation can be considered to be quasi-static, i.e., the field strength is the same over very long distances at all times.

8.12. **Electric and magnetic fields, the weber and the tesla***

Direct current generates both electric and magnetic fields but no radiation since there are no field changes to propagate. The Earth has a magnetic field that we demonstrate using compasses. The unit *weber* gives a measure (1 Wb = 1 volt-second) of the *magnetic flux* (Φ). The unit *tesla* (1 T = 1 Wb/m^2) is a measure of the *magnetic flux density* (B) which is popularly known as the 'strength' of the magnetic field. The size of the tesla is such that reference is often made to millionths of a tesla, the microtesla (μT). The Earth's magnetic field is approx. 30 μT at the equator and 60 μT at the poles. Another measure of the field 'strength' is the time derivative of the magnetic flux density, the electromagnetic *induction*, $-\,dB/dt$, which is stated in T/s. If instead the induction is considered to be derivative of the flux, $E = -d\Phi/dt$, it is stated in volt. Finally there is the 'magnetic field strength' ('the magnetising field') $H = B/\mu_o$, where $\mu_o = 4\pi\cdot10^{-7}$ Vs/Am is called *permeability for vacuum*. The unit for H is ampere per metre. H is actually the primary field size and $B = \mu_o\cdot H$ the resulting flux density in vacuum. These sizes have been given different definitions over the years and also succeed in confusing a physicist.

Alternating current generates field waves when the change in the field through a voltage change propagates along the conductor. At high frequencies, we describe the field waves as electromagnetic radiation (see previous section) and are then less interested in the field strengths than the radiant energy. However, at low frequencies we perceive no radiation but see the field changes in phase over long distances since the wavelength of the radiation is so long. Magnetic fields with frequencies lower than 300 Hz (corresponding to wavelengths of more than 1000 km!) are usually called *power-frequency.* These include the fields that are generated by common 50-periodic alternating current.

At a distance of one metre, common household items such as TVs, radios, ovens, vacuum cleaners, shavers and hairdryers emit field strengths between 0.05 and 0.5 μT with 50-periodic frequency. Mobile telephones and cordless telephones differ from such articles in that the device is held so close to the head and have a high-frequency microwave electromagnetic field; for example, for a GSM 900 telephone, the frequency is 900 MHz and the wavelength 3 dm. Natural, significant, high-frequency magnetic fields occur only in thunderstorms where, at a distance of a few kilometres from a flash of lightning, you get an induction of 10-100 mT/s, corresponding to that which the field around a hand drill can cause close to the machine.

8.13. **Ultraviolet radiation**

Ultraviolet radiation has wavelengths between 100 and 400 nanometres but delineation varies. It is usually grouped into three components, called UVA, UVB and UVC where UVC is the one with the shortest wavelength, i.e., the most energy-rich component. Although UV radiation is classed as non-ionising, UVC radiation, which has wavelengths between 100 and 280 nanometres (corresponding to photon energies between 12.4 and 4.4 eV) can actually cause ionisation. Owing to its higher energy it is the most biologically active component, but UVC radiation from the sun does not reach the Earth's

* weber after Wilhelm Weber (1804-1891), a German physicist active in Göttingen, tesla after Nikola Tesla (1856-1943), a Serbian-American scientist, active in the USA after 1884.

surface – it is absorbed by the atmosphere. On the other hand, the dangerous UVC radiation can be emitted from poor sun lamps.

UVB radiation, with wavelengths between 280 and 315 nanometres, also has harmful effects and can penetrate the atmosphere to some extent, particularly if the stratosphere's ozone layer is depleted. Finally, UVA radiation, with wavelengths between 315 and 400 nanometres easily penetrate the ozone layer but is not really more harmful than visible light.

An overdose of UV radiation from the sun causes redness of the skin (erythema) which, as regards UVB radiation, can turn into a tan through an increase in skin pigmentation. However, high doses of UVB radiation can also damage the skin through blistering and sunburn. UVA radiation is not as effective in causing either erythema or a tan, but it does help to darken the formed pigment. Long-term UV irradiation of the skin leads to chronic skin changes, rough and crinkly skin and a greater risk of skin cancer.[*] The absorption in the atmosphere means that UV radiation is at its most effective when the sun is at its highest in the sky, i.e., the 12 o'clock period. Good solariums emit mainly UVA radiation but also a little UVB.

The eyes can also be damaged by UV radiation. UVA radiation can be absorbed by the eye lenses and cause cataracts. UVB and UVC radiation are absorbed superficially and can harm only the cornea and conjunctiva. A moderate UV dose does not cause any immediate problem for the eyes, but cells are killed and when after a few hours these have been dislodged, an irritation is noticed which can become very painful ('sand in your eyes') at higher doses. The pain lasts for a day but the damage does not lead to any permanent affliction.

8.14. **The Swedish Nuclear Power Inspectorate (SKi)**

The Swedish Nuclear Power Inspectorate came into being in 1974 through the reformation of the Delegation for Atomic Energy Issues but Arne Hedgran was still in charge.

8.15. **IAEA in Seattle**

An IAEA meeting in Seattle in July has faded from my memory, but I do remember an episode outside the meeting, an event which is interesting from the risk philosophy point of view. Marrit had, at cost to ourselves of course, come with me and we were to spend a few days of holiday with Helen Margoni, our hostess when we lived in White Plains from 1957-1958 while I was working at UNSCEAR's Secretariat in Manhattan. Helen now lived in the small town of Victoria on the southern tip of the 460 km long Vancouver Island in Canada. We hired a Dodge in Seattle and drove to Victoria. Over the weekend, our sense of adventure led us to take a round trip to the north of Vancouver Island to then take a ferry over to the mainland and travel back to Seattle. Helen came with us.

Vancouver Island is covered with green forest. There are many roads, but most of them are closed to anyone other than timber transporters. However, over the weekend they were open to tourists. We followed one of these roads northwards. After several hours of driving, we came to a bridge over a deep ravine. The bridge consisted of planks over steel cables. We stopped before the bridge. Was it intended for vehicles? It did not look as though it would take a load of timber. Would it take our car? We were now forced to make a decision without having full information. The fact that the road was a timber road and was therefore highly likely part of the system told us that it was OK to drive over the bridge. It would also be difficult to turn around. Its frailty and the life-threatening consequence were we to crash down into the ravine advised against it. Our decision was not made on scientific grounds. We wanted to get over. Marrit and Helen walked over the bridge. I then followed with the car. The bridge held of

[*] WHO has recently estimated that up to 90 % of all malignant skin cancers are caused by the sun and solariums.

course. Bearing in mind the major consequence component of the risk involved, this example was undeniably of interest in risk assessment terms.

8.16. **Francesco Sella leaves UNSCEAR**

In a letter dated 11 September 1974, Francesco Sella wrote to me in the formal tone that was used by the Secretary of a Committee when writing to a national representative:

> Dear Professor Lindell,
>
> I would like to inform you that the Committee is now in the process of moving its offices from New York to Vienna and that the new office is expected to be opened at the start of October in provisional premises in the main building of the UN's Organisation for Industrial Development (UNIDO). However, for the time being, all post must be sent to New York.
>
> I would also like to take this opportunity to inform you that I have left the organisation and that, from 12 September, I am no longer Secretary of the Scientific Committee. The name of my successor will be announced as soon as he has been appointed.
>
> Yours sincerely
> Francesco Sella
> Secretary
> The Scientific Committee on
> the Effects of Atomic Radiation

8.17. **UNSCEAR's 23rd session, now in Vienna**

Contrary to its custom, UNSCEAR held its 23rd session in Vienna where the Secretariat had now been moved. The meeting took place on 14-18 October 1974. The Chair was Professor L. R. Caldas from Brazil with Professor Sobel's as Deputy Chair and Dr. C. B. Guzmán Acevedo from Peru as rapporteur. In the Swedish delegation, Arne Nelson had asked to be able to leave as my deputy and had been succeeded by Gunnar Walinder. As before, advisers were Kay Edvarson, K. G. Lüning and Jan Olof Snihs but, bearing in mind that the radiation doses to the population from the operation of nuclear power plants were now a relevant issue, the delegation had expanded through the addition of civil engineer Stig Bergström from *AB Atomenergi*.

When I wrote to the Ministry for Foreign Affairs in August about the composition of the Swedish delegation, I had expressed concern about the development. I wrote:

> The forthcoming UNSCEAR meeting was anticipated with a degree of unease on the part of the Member States' representatives, seven of whom had the opportunity of informally discussing the future of the Committee with the Chairman of the Committee at a Congress in Seattle this summer. The unease was due to the fact that several factors conspired to impair the functionality of the Committee. According to the General Assembly's decision, the Secretariat will be moving to Vienna, which the delegates think is unsuitable from the efficiency point of view. The Principal Secretary of the Committee, Dr. Francesco Sella, has left the Secretariat because of this and there is uncertainty as to whom his successor will be. The Committee has been enlarged by five new Member States* and has been given additional functions, which means that there is a danger of it sliding towards political rather than scientific standpoints unless the delegations are careful to preserve the scientific integrity of the Committee.

* Indonesia, Peru, Poland, Sudan and West Germany.

I thought I would need to defend the very substantial Swedish contribution to UNSCEAR's work:

> There has been a comparatively high level of ambition on the part of the Swedes in the international cooperation as regards these problems [the scientific work]. In return, Sweden occupies a relatively prominent position in this work, which has enabled us to influence its direction and has facilitated the assimilation of the international experiences.

As could be expected, before 1974, UNSCEAR, as a Committee under the UN General Assembly, had its Secretariat in the UN headquarters in New York, the room on the 34th floor where I had worked as one of the consultants for the Secretariat in the 1950s. The Committee also met in the UN building in those days, but alternately also in the UN Office in Geneva. But the winds had changed now.

As a consequence of the UN Environmental Protection Conference in Stockholm in 1972, a new organisation, UNEP (the United Nations Environment Programme), had come into being with its headquarters in Nairobi in Kenya. The UN Secretary General, Kurt Waldheim, who had aspirations of becoming President of Austria (and did so in 1988) wanted to see as many international organisations as possible in Vienna. At the same time, UNSCEAR Secretary, Italian Francesco Sella was positive towards moving the Secretariat from New York to Europe where his children could hope for, as the aristocratic Sella saw it, a better education.

At the same time as Waldheim began pulling the strings that tied the UNSCEAR Secretariat to New York, UNEP noticed that UNSCEAR was dealing with environmental issues. But UNSCEAR was the General Assembly's Committee and could not be incorporated into UNEP, although UNEP in Nairobi could be made responsible for running UNSCEAR's Secretariat in Vienna – a strange arrangement.

The delegates from UNSCEAR's Member States wanted the Secretariat to remain in New York since increasing the distance to the Assembly could reduce interest in the Assembly and thereby affect the budget. Some Member States, among them Sweden, acted forcefully through diplomatic channels, particularly because it was thought that Waldheim's attempt to move the Secretariat to Vienna reflected self-interest rather than looking after the interests of UNSCEAR's efficiency. The disagreement between Sweden and Austria (who supported Waldheim) became embarrassingly dramatic.

However, Waldheim won and bureaucracy triumphed. After a while, UNEP was made responsible for the personnel administration for UNSCEAR's Secretariat while the expenses for the Committee were still determined in New York. Sella, who had perhaps hoped for Geneva, did not want to move to German-speaking Vienna and left the Secretariat. It took time to appoint a successor because of the bureaucracy in Nairobi and the Committee could not meet again until October 1974, but then in Vienna. The first meeting premises provided by Austria was in Hofburg, the old Imperial Palace whose origins went back to the 1200s. But the first meeting in Vienna, in 1974, was held in IAEA's premises.

The languid rigidity of Vienna, apart from its music, made an impression. We observed that at the time there were no young people among those out strolling on the central Kärntnerstrasse. A wicked jest spreading among the visitors was the exchange 'What's new in Vienna? Oh yes, Franz Joseph has died.' The Secretariat's move had not appealed to our good nature. But there was also a tension and sense of mystery over Vienna. When we were walking into Hofburg we saw façades and gates that we had recently seen when the repeat of Orson Welles' *The Third Man* was broadcast on the TV. You could imagine the Harry Lime theme emanating from among the old buildings.

When the Committee met at IAEA's premises in October, Dan Beninson had been asked to be its scientific Secretary. The Secretariat had been referred to some rooms in UNIDO's premises in a building on Wasagasse, not far from Annagasse where Sigmund Freud had worked, outside Ringen in the north-west section of the city. There were no longer large numbers of long-term employees. The office work was taken care of by *Waltraud Holzer*, 'Frau Holzer', a slim, dark-haired, extremely efficient Austrian lady of indeterminable age. The only scientific colleagues on a long-term contract were New Zealander *Bernie O'Brien* and Russian *V. Lyscov*. We were not sure whether O'Brien's first name really was Bernie, but it felt easy to call him Bernie since he strongly resembled Barney from *The Flintstones* on the TV. But our Bernie was a wise and knowledgeable man who was worthy of every respect. Lyscov often made trips to the Soviet Embassy and everyone took it for granted, without tangible proof, that he was a KGB officer. The further assistance that was needed to draw up parts of UNSCEAR's next report was provided by consultants who worked at home and were not in Vienna for long periods, but who were pushed hard by the exacting Dan for the short periods they were there.

8.18. **The oil crisis**

'The Yom Kippur War' of 6 October 1973 (see Sections 7.12 and 7.14) led to an oil crisis. In turn, it led to advice on how it would be possible to save energy in homes and at workplaces. The newspapers used instructive images to show how you could seal cracks and cover valves to reduce the ventilation and thereby energy consumption. It caused concern at the Radiation Protection Institute. Indoor air would have higher radon levels and an increase in the risk of lung cancer could be anticipated. The Radiation Protection Institute consequently issued a warning in newspapers, radio and on TV. It was not taken seriously in Palme's energy seminars. Kerstin Anér, who sat next to me, said 'So, this is just a ploy then?' Olof Palme, who was Chairman, asked whether we really were serious. When I assured him that unfortunately it was serious he looked mistrustful.

8.19. **The nuclear power issue**

The Swedish nuclear power debate continued during the autumn. The Energy Forecast Report (EPU) had put forward a consideration which presented different alternatives for the increase in energy consumption. In a speech in Gothenburg in September, Minister of Industry Rune Johansson said that the referral bodies which were to give their opinions on the report were also to give their opinions on a saving alternative and that the energy problems had been studied in a large number of study groups throughout the country. Then, in spring 1975, a bill was expected for an energy minimisation programme policy and a ten-year period during which no new decision would be made on the nuclear power expansion.

The press thought the speech was surprising and that it involved a change to the government's previous view of the nuclear power issue. The Minister of Industry had said as late as at the OK meeting in August that nuclear power was the only alternative for the energy supply of the future. According to *Dagens Nyheter*, the negative sentiments within its own ranks now seemed to have surprised the government.

The debate intensified and the book written by Sven Löfveberg and me, *Nuclear Power, Mankind and Safety*, was referred to by both parties. In mid-October, an article by John Takman with the heading 'Nuclear power – what is the alternative?' was published in the left-wing papers *Ny Dag* ['New Day'] and *Norrskensflamman* ['The Flame of the Aurora Borealis']. Takman wrote the following about our book:

> As you are aware, there is a huge 'information campaign' in progress; several thousands of study groups on the energy issues will be held around the country this autumn. Bo Lindell and Sven Löfveberg's book is the only reliable source I know of in Swedish and it would be an historic scandal if the original edition were sold out and it was not available as a pocket edition when the market was drowning in 'study books' written by the most fantastic chiropractors in the field.

Following a touch of polemic against the nuclear power opponents, Takman in his articles gave a level-headed, insightful summary of the energy problems:

> <u>No alternative energy sources before the turn of the century</u>
>
> As far as I am aware, no realistic assessors are counting on major energy sources other than oil, coal, hydroelectric power and nuclear power for the next 25 years. Oil will obviously be much more expensive than it is now, even before it really becomes a finite resource, and it is short-sighted in any case to burn up a finite raw material. Expanding hydroelectric power would give a modest power and energy increase only,

and would in some cases be a barbaric act. Expansion on Kalixälven would mean having to obliterate the existence of two Saami communities, and in one of these cases, the gorgeous Jockfall, the pastureland of fifteen farmers would disappear below water.

Soviet scientists are clearly setting their hearts on solar energy and reports say they have promising research projects underway, but it will be a considerably more expensive energy than what we are used to now, at least in a country like Sweden. In the USA, the Soviet Union and even in Sweden, advanced research has been ongoing for a couple of decades into extracting energy by fusing light atomic nuclei. When it becomes a reality, this will not be a 'clean' form of energy either. As with the fission of uranium, it will lead to radioactive waste problems.

No-one can obviously know if and when there will be a breakthrough for the research as regards these and other alternative energy sources. What we do know for certain is that it will be a long time before the research results gain practical significance for a modern society where the aim is to maintain a high level of employment and an acceptable standard of living for everyone, or the many developing countries where the populations are fighting to escape their misery.

In December, the artist *Kerstin Abram-Nilsson* (1931-1998) sent a Christmas card to a number of people, me included. The thing that captured the attention of the mass media was that one of the recipients was Olof Palme and that the message concerned nuclear power. She wished us a 'sensible year', which is what we all wanted to look forward to. The greeting she sent us was an illustrated list of grim captions such as:

Classified is the danger
that nuclear power plants can harbour.

The Earth, our only home,
is threatened by the millirem.

The coldness of immorality
in counting cases of cancer fatality.

The axe is quick to kill,
nuclear power has a much slower skill.

A huge blow is ours to shoulder
if CDL is what we go for.

I wrote to Kerstin and told her what I thought were mistakes and exaggerations. I also wrote: 'I believe that your concern and your indignation are open and honest and I might have acted as you did had I not had another knowledge basis'. I also enclosed a couple of poems that I had written in the 1940s after having been depressed by the atomic bombs.

8.20. **The Urban Siting Investigation**

The Urban Siting Investigation, which was set up on 15 April 1970, submitted its report (SOU 1974:56) in June 1974. The following had been called in as experts: the active member of the National Swedish Board for Space Activities *Hans Håkansson* (Chair), Chief Engineer at *AB Atomenergi* Lars Carlbom, Head of Department at the delegation for Atomic Energy Issues Arne Hedgran, Director of *Sydsvenska Kraftaktiebolaget* Yngve Larsson, Director of *Stockholms Energiverk* Jan-Erik Ryman, Deputy Assistant at the Ministry of Housing and Physical Planning *Kjell Svensson*, and technical Director of *the Swedish State Water Power Board* Ingvar Wivstad. On 8 June, a number of experts were appointed to the Investigation, as well as civil engineer Stig O. W. Bergström of *AB Atomenergi* as Secretary of the Investigation. The Investigation was thus run by very well-qualified and highly-esteemed technicians, but there was no radiation protection expert apart from Hedgran and Bergström and there was no biological expertise at all. The investigators certainly endeavoured to be impartial, but it cannot be denied that they looked at the problems through the eyes of interested technicians.

The Urban Siting Investigation was the first major Swedish overview of the health and risk problems of nuclear power unless you include Lindell and Löfveberg's 'Nuclear Power, Mankind and Safety' from 1972. In order to get a general idea of the problems, reference was also made to ICRP's and UNSCEAR's reports and the 'Rasmussen report' (WASH-1400) from America which had recently become available. The report was followed in that same year by the first section of the Radioactive Waste Investigation (AKA), which was also very informative. It was then some time until the Energy, Health, Environment investigation (1977) and the Energy Commission's report (1978) on equally extensive studies. The main person who should be commended for his substantial work with the Urban Siting Investigation is the Secretary, Stig Bergström. Most of the work took place in Studsvik. The Investigation's report was a significant document.

But there were also inadequacies, which were criticised in the referral responses from the FOA and the Radiation Protection Institute among others. Some of these inadequacies can be explained with reference to the knowledge situation at the start of the 1970s. The criticism from the FOA and the Radiation Protection Institute took into account the lack of discussion of the consequences of a radioactive ground covering, particularly with a view to the economic consequences of evacuation and interference in the food supply. The overall consequences in the investigation had not covered collective doses at great distances since the late injuries owing to radiation doses under 1 rad (from beta and gamma radiation) had been assumed to be non-existent so that radiation doses under 1 rad (corresponding 10 mSv) had not been included in the calculation.

The concept of risk was handled on a par with the knowledge at the time but is at variance with today's perception. 'Risk' was defined as the product of the scope and probability of an injury, i.e., as an expectation of the consequence. This conflicts with the current view of 'risk' as a compound concept which covers both probability and consequence. The disadvantage of the expectation is that it is useful only when it is a measurement of the probable outcome over a relevant planning period. This is the case, for example, when the annual probability of individuals having a certain illness is 1/1000 and the healthcare area covers 100,000 individuals. The expectation of the annual outcome is then 100 instances of illness per year, i.e., around 2 cases per week. This is valuable information for those who are responsible for healthcare because what will happen in a given week will be roughly what is expected for a week's work. However, if a certain catastrophe claims 100,000 lives and has an annual probability of 1/10,000, the expectation of the annual outcome is 10 cases. That number is not exactly of interest to a planner – there will not be 10 deaths in a few years; the important thing to know is that if the catastrophe occurs, it will be a very big one. The expectation of the consequence of unlikely catastrophes is only of interest to those who are planning for millions of years, but who does that?

The likelihood of an accident was represented in the report by the supposed frequency, i.e., instead of saying that the annual likelihood was 0.001, it was preferable to say that the frequency of the accident was probably 1 in 1000 years. However, the meaning of 'probably' was not discussed. Behind every probability value lies an assumption that the estimate is correct.

One detail, but not unimportant, was the incorrect definition of 'population dose', i.e., collective dose, as the sum of the doses to all individuals. Doses to different people are not addable and talking about collective doses of millions of rad, which is what the result with that definition will be, is physically unreasonable. The correct definition is the product of the number of irradiated people and their average dose. If you then talk about man-rad or man-sievert, you are introducing the extra dimension of 'man' and making the collective doses addable; you can also talk about the collective dose for one single person. In calculating the average dose, you must calculate the sum of the individual doses, but that sum is only one calculation component of the collective dose and must not be confused with the same.

8.21. **The first Asiatic regional Radiation Protection Congress**

The first Asiatic regional Radiation Protection Congress was held in Bombay in December, arranged by the Indian Association for Radiation Protection with the support of IRPA.

9. THE YEAR 1975

9.1. The energy policy

Following the oil crises of recent years, the government in January proposed a bill for a new energy policy. At the time it had had access to the reports from the Urban Siting Investigation, the Energy Forecast Report and the Energy Programme Committee and an energy saving survey carried out by the Ministry of Industry in cooperation with 25 governmental authorities. The bill led to the 1975 energy policy decision that same spring. When it came to hydroelectric power, Swedish Parliament decided that the last large rivers (the Kalix, Pite, Torne and Vindel rivers) should be spared further development.

9.2. ‘Hearing’ regarding restrictions to radioactive emissions and discharges

A hearing regarding the limitation of emissions and discharges was arranged by the Radiation Protection Institute in *Karolinska sjukhuset’s* assembly hall on 20 February once a proposal for new regulations had been published by the Radiation Protection Institute on 1 January. The proposal was based on the offprint of the preliminary version of Chapter 19 of the Nordic ‘Flag Book’ which had been published separately in April 1974. The Radiation Protection Institute welcomed points of view before 10 May 1975. A proposal for regulations was drawn up on the basis of these points of view and was presented to the government in November 1975 in accordance with the regulation which said that governmental authorities could not, without consideration by the government, issue regulations which might have extensive economic consequences. According to the Radiation Protection Act, scrutiny by the government was also needed if the regulation ‘may considerably affect the design or operation of the plant’. The government’s approval was given in March 1977.

9.3. The Non-Proliferation Treaty

An NPT Review Conference was held in Geneva on 5 May 1975 with Inga Thorsson as Chair. The Secretary General of the UN Kurt Waldheim and Director General of IAEA Sigvard Eklund took part in the meeting. The agreement had been signed in 1968 (see Section 2.21).

9.4. *Dagens Nyheter’s* debate regarding the nuclear power issue

On 12 May, a discussion meeting was held at the *Anglais* hotel on Humlegårdsgatan at the invitation of *Dagens Nyheter’s* culture section in which thirteen ‘scientists’ and five members of the section took part. Ingemar Wizelius, who was now working his last year at *DN* before he retired, had contacted me. I had always had good relations with the lovely Ingemar, who had worked at *DN* for more than 30 years, mainly in the cultural department but also as foreign correspondent in the 1950s. His primary contributions were as an esteemed literature critic but, since 1958, he had continued to show great interest in my work, always friendly and helpful.

Those who had been invited included:

Gunnar Ahnström	Björn Källström
Hannes Alfvén	Lars Kristofferson
Lars Ehrenberg	Bo Lindell
Ulf Grimås	Jan Rydberg
Arne Hedgran	Gunnar Walinder
Bengt-Owe Jansson	Torbjörn Westermark
Klas Jirlow	

The following took part from *DN*:

Olle Alsén	Karl Erik Lagerlöf
Jörgen Eriksson	Ingemar Wizelius
Björn Berglund	

I do not remember the discussion, which probably went as many other nuclear power discussions went at the time. On the other hand, I do remember asking myself afterwards about the ethics behind a major daily newspaper searching for the 'truth'. *DN* was, and is, a big power broker. Was there any awareness of the power that was available and the ease with which it could be abused? When the employees of the big press think they are safeguarding democracy and justice, do they realise the power they have and that it is not necessarily a manifestation of democracy? Matters are in the hands of a few.

9.5. New nuclear power plants start up: Barsebäck and Ringhals

On 1 May, the first unit in Ringhals nuclear power plant was put to commercial use. It happened to be Ringhals 2, the only pressurised water reactor, the Westinghouse reactor. The first boiling water reactor in Ringhals, Ringhals 1, was commissioned on 1 January 1976. Göran Ekberg (1919-1993), MD of *Sydkraft*, pressed the start button for Barsebäck 1 on 15 May; the unit was commissioned in July.

9.6. ICRP in Brighton

ICRP and Committees met on 7-16 April at the Bedford Hotel in Brighton

9.7. Consultants for UNSCEAR in Vienna

In April, Dan Beninson called me asking me to come to Vienna as a consultant for UNSCEAR. Dan, who was attempting to coordinate the work among a number of consultants who were working at home drafting Annexes to the 1977 UNSCEAR report, was short of ideas for the composition of the Annex which would present the radiation doses to those who worked with radiation sources, primarily in healthcare but also within the nuclear power industry. Some sort of policy ought to be formulated. Which quantities would UNSCEAR want details of?

And so I ended up in a small room on Wasagasse and met Frau Holzer for the first time, Dan's exceedingly efficient Secretary. Dan was a demanding employer. He looked in on me at pretty regular intervals and asked if I had any bright ideas. The problem was how to define the details that would be reported on radiation doses. The difficulty was that the available details were primarily readings from personal dosimeters. In addition to the measurement problem of determining the extent to which the read-off value represented a relevant radiation dose to the person wearing the dosimeter, it concerned how the measurement values for a group of workers should be reported. Stating an average dose was misleading since the average value depended on how many were included in the group. The majority had not received any extra radiation dose at all. Stating the collective dose was less sensitive in terms of the group choice but gave no clue as to whether it was a matter of small doses to many or large doses to a few.

We solved the problem by introducing a *reference distribution* with log-normal distribution* and an annual average value of 1/10 of the ICRP dose limit for workers. The fraction of the number of workers who exceeded the dose limit was the 0.1 per cent. We then aimed the interest at the collective dose ($S_{1.5}$) which was formed from individual doses in excess of 1.5 rad, a dose value which was often used in reports. For the reference distribution, this collective dose was 31% of the total collective dose (S). We then defined a quantity Ω which, for the relevant group, was the quota $S_{1.5}/S$ standardised against the reference distribution, i.e.

$$\Omega = \frac{\frac{S_{1.5}}{S}}{0.31} = 3.23\frac{S_{1.5}}{s}$$

That was the quantity that we wanted to present.

I was in the company of Marrit and Karin. Dan and Ambretta, who had an apartment at no. 7 Modena Park, 4th floor, drove us around the regions around Vienna.

9.8. Atlanta, Claire Nader and Walter Snyder

On 23-27 June, a conference (called ‘course’) on the subject ‘Energy and environment – cost-benefit analysis’ was held in Atlanta in Georgia. The course was arranged by Karl Morgan who was now Professor at the Georgia Institute of Technology and Dr. *Ratib Karam*, Professor of Nuclear Technology at the same university. Morgan invited me to give a presentation on the cost-benefit analysis of energy sources, which was a current subject for ICRP of which I was Deputy Chair at the time. I wrote a postcard home from New York:

> Had a good journey. I booked into the Commodore Hotel in Grand Central. I then went and ate ‘smorgåsbord’ at a restaurant in Stockholm. I then slept from 9 until 9. I am now at the La Guardia airport on the way to Atlanta.

From Atlanta I wrote that the hotel was ‘among weeds and petrol stations north of the city around 20 minutes’ walk from the meeting place’.

According to the preliminary programme there would be a good number of known speakers such as Dean Abrahamson who had taken part in the Swedish nuclear power debates, and Saul Levine and Roger Mattson from the NRC and Bill Rowe from the EPA. I also noticed that Ralph Nader’s sister Claire was part of the programme. She was almost as controversial as her brother, the pugnacious consumer spokesman who became world famous in 1965 when he published the book *Unsafe at any speed* in which he criticised General Motors’ cars. One of my colleagues talked about her ‘fanatical eyes’. After the course in Atlanta I was to travel to Oak Ridge at the invitation of Walter Snyder to give a presentation on ICRP’s plans.

My presentation was entitled *Quantifying the Cost and Benefits of Energy*. It was also published as a Swedish Radiation Protection Institute report (SSI:1975-022). It offered a fairly in-depth examination of the fundamental principles, but I did not attempt or give quantitative advice, instead writing:

> The reader should be warned already at the beginning that he will find very little quantification in the following presentation, should he be looking for actual results of cost-benefit assessments of various sources of energy. The author has no expert knowledge of the costs of energy or its benefits.

* The physical measurement values such as length or weight are often in an interval whose distribution is usually stated using a Gauss curve and is now called normal distribution. A log-normal distribution is a spread of values in which the logarithm for the measurement values is normally distributed.

I now note that I was assuming that the reader was a 'he'. My review of the value assigned to human life may be worth quoting since it summarises the views on the problems at the time.

> We wish to feel that human lives are sacred, irrespective of cost implications, and that economic considerations are futile and improper. 'Life' is often referred to as a unique quantity which can either be 'saved' or sacrificed. On the other hand, we know that death cannot be outwitted. All we do in our efforts to save lives is not really to save but to prolong lives, to save days, to add days to life.
>
> ...
>
> If saving lives can be described as adding days to life, the question also arises whether all days are of equal value. If not, an equivalent to adding days to life would be adding life to days, i.e., to improve the quality of life. And when we speak about the value of one day of life, the question also arises: to whom? To the individual himself, to his [!] friends and relatives, to society, or to mankind?
>
> There is little reason to believe that the subjective value of life to the individual himself is a function of age. On the other hand, a constant value of life over age implies that the individual will value each remaining day more and more the older he gets. This does not seem unlikely for a healthy individual with a strong interest in life.
>
> However, there may be periods of life which seem very difficult to live. Other periods, of happiness and achievement, may seem invaluable. If the individual's health is good, each day may seem precious, if he is ill he may be praying for a merciful end. Therefore, the value of a day of life may vary from day to day, not as a function of age but reflecting the health, interests and social functioning of the individual. There may be instances where he might be willing, literally, to exchange years for a precious minute.
>
> The individual's value to society, however, varies with age and function. A child might even be considered to have a negative value, as such, to society, causing expenses for infant care and schools, but it gradually becomes a valuable investment. Few old people are of value to society (even though they could well be) and the majority of people have a value which is measured by their present and potential productivity (of children, ideas, or man-hours of labour).
>
> 'Society', in this sense, however, is a bureaucratic structure rather than a living organism and would only reflect a collective, impersonal interest. But it could also be seen as the sum of its individuals. The individual's value to his fellow members of society and to his friends and relatives would not be measured by productivity alone. A child, while being a nuisance to the bureaucratic machinery of society, is valued and loved by its parents, relatives and friends. The ties of friendship multiply and strengthen as the individual grows older, but may fade at old age when perhaps only few friends and relatives remain.
>
> In developing crude general principles, it is impossible to take into account all the intangible qualities that should properly come into the assessment of the value of one day of life. We are forced to consider an average day to an average individual.
>
> We know that society does not and cannot put an infinite value on the human life. Of the people who die in any given country, some could have been saved for more days of life at a surprisingly low cost, some could not have had any more days at any cost. The distribution of the dying population over life-saving costs is different in a highly developed industrialised country as compared with a developing country and there is no consistent approach to health and safety planning as regards the amount of money that society is willing to pay in order to 'save a human life'.
>
> ...
>
> In a developing country, where starvation and low living standards take a frightening toll of lives, it is usually possible to save lives at a very low cost, both statistically and individually, but we have continuous evidence that these lives are not considered sacred enough to justify additional efforts. One reason may be that a definite solution to the problems would mean quite considerable efforts, because even if a life is saved it must be saved over and over again. The cost of saving a day of life is perhaps small, but the

> number of days waiting for being saved is very high, at a level which makes life-saving a difficult international political problem.
>
> Authors who have made explicit assumptions on the value of a human life for cost-benefit assessments have often worked on the basis of insurance practices. This usually gives quite low values. However, one must assume that the value of a human life should at least be higher than the cost society is willing to accept for hospitalization and sick pension if an accident victim survivals. If this assumption is not made, the logical but appalling consequences would be, for example, to build roads and cars that make sure that people are killed rather than injured at an accident. This is an indication that the value of life must be higher than just the productivity assessment.

Important discussions on this matter took place later at a meeting at the Vatican (1983) and at a conference arranged by the Swedish National Audit Office (1991) (see later Section).

One evening, Karl Morgan invited me home for dinner. The other guests were Professor *Melvin Carter* and his wife Ann, Professors Ratib Karam and *G. G. Eichholz*, *Claire Nader* and *James* and *Helen Mills*. The latter were introduced as 'local Georgian citizens who are very active in opposing nuclear power'. Helen Mills was very strident and spoke in a broad southern dialect.

When Claire Nader heard that I intended to hire a car to drive from Atlanta to Oak Ridge she asked if she could come along. Claire proved to be an enjoyable travelling companion. She definitely had firm opinions and was perhaps, as many said, pushing her brother, but she showed no fanatical characteristics while in my company. We stopped at the Watts Bar Dam, a hydroelectric dam on the Tennessee River in between Chattanooga and Knoxville. The dam structure is 900 metres long and 35 metres high and impounds a lake that is more than 100 km long and up to 2 km wide. The dam has the double task of protecting Chattanooga against floods (if it does not break!) and accommodating a power plant which, with five units, can generate 150 MW of electric power. Claire shook her head sadly at this manifestation of power technology.

In Oak Ridge I accompanied Claire when she visited some friends. We sat drinking soft drinks in a very large garden. The group of environmental friends were remonstrating against a motorised scarecrow which was making enough noise to disturb them. After a while, I was able to tell them that the scarecrow had gone quiet without their noticing. An interesting observation. I told the group about the Swedish right of public access and what was for them the exotic sport that we call orienteering, and they were more interested than I had expected.

The visit to the lovely Walter Snyder was of course interesting. It was now almost twenty years since my first visit and much had changed, but Snyder was his old self. Walter had a doctorate in mathematics from Ohio State University and initially taught mathematics at the University of Tennessee. Becoming a consultant to the Oak Ridge National Laboratory had aroused his interest in radiation protection and he was employed by the Laboratory's Health Physics Division of which Karl Morgan was head. As a colleague of Morgan he was given assignments for ICRP and the American NCRP. He became involved in the work with calculating MPC values (highest permissible concentrations) for both of these organisations. He became Secretary of ICRP Committee II (later called Committee 2) of which Morgan was Chair. Karl Morgan would not have coped without Walter Snyder.

In 1967, Snyder became Chair of the American Health Physics Society for a year and became director of publications for IRPA. In 1975 he would receive the HPS' Distinguished Achievement Award. The following was written in that context:

> Besides all of this, Walter is an accomplished trumpet player, an historian with enormous breadth of historical knowledge, and a storehouse of good stories, many with a strong mathematical component.
>
> Health physicist, mathematician, musician, historian, connoisseur of good food and beverage, Walter Snyder has made distinguished contributions to the field of internal dose calculation, the setting of national and international standards for radioisotope use and exposure, and to both fundamental and applied research in several health physics disciplines. [Health Physics 29:371 (1975)]

Walter Snyder had a sharp intellect which put even Dan Beninson to shame. Dan has said that once when he was in London he had a bet with Walter regarding a mathematical claim. The loser would pay for dinner. Dan lost and he never forgot that Walter made off to Simpson's-in-the-Strand, the well-known, four-star – and expensive – restaurant.

9.9. The Nordic Congress of Radiology in Aarhus

The 34th Nordic Congress of Radiology was held in Aarhus with Professor Sigvard Kaae as President. The Congress was divided into two sections, one for diagnostics and one for therapy, biology and physics. There were 104 presentations in all, 25 of which concerned therapy and 5 radiophysics. Kurt Lidén gave 'an excellent account' of the current situation of the new radiological SI units.

9.10. UNSCEAR's 24th session in New York

Despite the Secretariat having moved to Vienna by then, UNSCEAR held its 24th session in New York on 15-19 September, mainly because the meeting resources (simultaneous interpreters, copying options, etc.) were still lacking in Vienna. The Chair of the Committee was now Professor Sobels with the Czech representative Dr. Klimek as Deputy Chair and the Polish representative, Professor Jaworowski, as rapporteur. As it did at the previous session, the Swedish delegation consisted of me as Chair, Gunnar Walinder as deputy and Stig Bergström, Kay Edvarson, K. G. Lüning, and Jan Olof Snihs as advisers.

The report now being prepared and which was published in 1977 was intended to cover all the fields of radiation and the risks of both cancer and hereditary injuries. Particular attention was paid to the nuclear power problems.

9.11. KVA conference on energy in Lerum

On 27-31 October 1975, the Royal Swedish Academy of Sciences (KVA) and the research councils arranged an energy research conference in Lerum, 20 km outside Gothenburg. The conference was held at *Aspenäsgården*, an attractive conference facility. Both Gunnar Bengtsson and I were invited to take part in leading assignments. The conference was divided into four task groups. Gunnar would be Secretary of one of these and I Chair of another. This surprised us since we were not experts in energy research, but perhaps they had looked at other qualities. Each group included 6-8 scientists. Professor Per Brinck from the Zoological Institution in Lund was Chair of the conference.

Gunnar's group was to discuss *Side Effects of Energy Production and Energy Use* and had Assistant professor Erik Arrhenius from the Wallenberg Laboratory as Chair. My group's task was simply to write something about *Energy Use*, a formidable task. My Secretary was Jan Rydberg, Professor of Nuclear Chemistry from Chalmers. Both Gunnar and I beavered away at our tasks, which for me meant producing working documents until late into the nights.

The two remaining groups dealt with *Energy Production and Energy Storage* and *Energy Production and Energy Use in Relation to Developing Countries*

9.12. Inger Ragnhult

I must remember to mention Inger Ragnhult (1925-2006)* again. Inger had been appointed as medical physicist at the central radiophysics laboratory at the *Sahlgrenska* hospital in Gothenburg on 1 January 1964. In the 1950s, Rolf Sievert had refused to allow her to become a radiation protection inspector on

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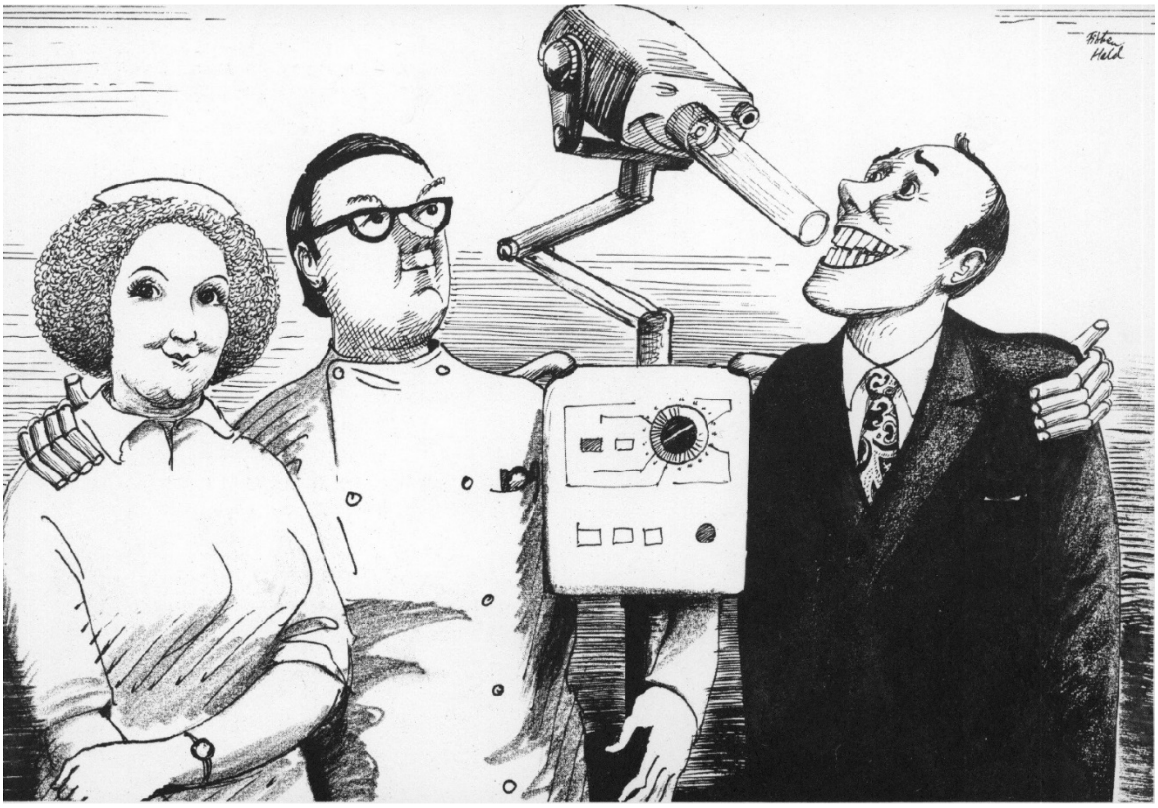
* See also 'The Labours of Hercules'.

the grounds that it was not morally appropriate for women to travel around the country with male colleagues. So she became medical physicists instead – and a brilliant one at that.

In the Swedish Medical Physics Society's member leaflet *Sjukhusfysikern* [Medical physicist] (July 2006), Lars Gunnar Månsson has dedicated an article to Inger and written:

> Inger fought resolutely and successfully throughout her professional life in her mild-mannered way for the ideas she believed in – often against current trends. She was always friendly and helpful – unpretentious in everything – yet always instilled great respect through her expertise and experience. Her thoroughness and quality awareness lives on within medical physics at Gothenburg and she is still a role model for all of us as her fellow workers and colleagues through her safety awareness and clear patient perspective in all radiation physics work.

Good deeds are done in silence. Inger made considerable achievements within medical physics and could also enjoy international renown, although she was not conspicuous in her greatness; her modesty meant it was less discernible than it deserved to be.



Drawing by Fibben Hald for the information campaign on dental x rays
run by the Swedish Radiation Protection Institute.

9.13. **Dental x-ray information**

In 1975, the Radiation Protection Institute carried out an information campaign in which 14,000 dentists and dental nurses (approximately equal numbers in both categories) received a series of four postcards. The cards showed cartoon drawings of Fibben Hald[*] and simple radiation protection

[*] Niels Christian ('Fibben') Hald, born in 1933, is a skilled drawer who had since the 1950s illustrated *Kajenn's* daily poetry in *Svenska Dagbladet* and cooperated with Lennart Hellsing in a number of picture books.

information. The campaign was followed up by information articles in the scientific press and an information folder. It was completed with a questionnaire and a competition.

The Institute received 2 700 responses, just 34 of which were wrong. With the responses was an opportunity to express points of view. 37 of these were negative (32 dentists and 5 nurses) while 1,006 contained praise and thanks for the initiative (476 dentists, 530 nurses). In addition, 166 dentists and 48 nurses gave valuable advice and points of view on the continued radiation protection work. This experience showed that this type of action was a cheap and effective way for the authority to simultaneously chart the problems and disseminate information. The person in charge of the campaign was Sven Löfveberg, assisted by the x-ray checking department.

Examples of the points of view received include:

> ‘An instructive and straightforward campaign. Nice to receive information from a government body in the form of postcards - refreshingly devoid of bureaucratic language!!’
>
> ‘Drop the hint to other government bodies that it is permitted to be humorous in Sweden. Congratulations!!’
>
> ‘Extremely disheartening for a governmental institution to act in such childish ways. The target groups are highly-qualified professionals and are entitled to be treated as such’.

9.14. **Letter from Olof Lagercrantz in September**

‘I apologise for answering your letter so late. There was a considerable delay in my receiving it and the article. We were also slightly concerned that the article might be too difficult for our readers, but we have now decided to publish it in any case with thanks, since it is undeniably very important’.

9.15. **The Radioactive Waste Investigation in Moscow and Novovoronezh**

The Radioactive Waste Investigation made a study visit to the Soviet Union. We began in Moscow where, among other things, we got to meet the Supreme Soviet Committee for the Protection of the Environment and Rational Use of Natural Resources and the Soviet Atomic Energy Commission. It was something of a culture shock, partly because we met in the Kremlin and partly because of the generational difference. The Soviet Commissioners consisted of only old men while the presentation of the Swedish investigation was not made by our Chair, Gösta Netzén, but by our Secretary, Philip Moding, at an age where he would never have been able to take the floor for any Soviet Committee.

We were also to visit a low-activity waste station some km outside Moscow and were taken by bus. I suddenly recognised where I was from my visit to ICRP Committee 3 three years previously. We were on the way to Dubna, which was not what we were expecting. The bus driver also started to look lost. But I had the road atlas with me which I had bought on my previous visit so I went up to him and told him where we were and how we could get back on the right road. There was no secrecy with the roads – they were just not interesting.

We took a longer trip, by train to Novovoronezh, a nuclear power plant which had big pressurised water reactors. What I remember about the visit is a dubious ‘safety culture’ and quantities of cockroaches on the floor of the turbine hall.

9.16. **The WHO panel in Brussels**

At the request of the Belgian government and in cooperation with the latter, WHO’s European office arranged a meeting of a task group in Brussels on 1-5 December 1975. The reason for the meeting was the public’s concern about the safety of the nuclear power industry. The group’s assignment was to discuss the industry’s impact on human life and the environment. I took part in the meeting and was appointed Chair. Dr. E. Komarov, Deputy Director of the Soviet Research Institute for Roentgenology and Radiology in Leningrad, was Deputy Chair. Particularly noteworthy participants included P. Tanguy, head of the nuclear safety department at the French research centre in Saclay, south of Paris, Bill Pochin representing the British NRPB, head of the Danish Finsen Laboratory, Mogens Faber, and geneticist Per Oftedal from the University of Oslo. Apart from WHO as the organiser, international organisations represented included the CEC, IAEA, ICRP, IRPA and the OECD/NEA. The Secretary from WHO was Dr. M. J. Suess.

The group worked on the basis of a working document that had been written by Professor Jack Schubert from Hope College in Holland, Michigan. An editorial committee consisting of J. M. Døderlein (from Kjeller), B. A. J. Lister (from Harwell) and Schubert, drew up a final version of a text based on the task group's proposal. It was published as a WHO Regional Publication entitled *Health Implications of Nuclear Power Production*, but not until 1978.

The group recommended that the health effects of the nuclear power industry be compared with corresponding harmful effects of other energy sources, but these harmful effects then had to be added up throughout the activity chains and expressed per unit of energy supplied.

Table 9 of the report is of particular interest. It shows estimates of collective doses (per MW and year) and the number of accidents (also per MW and year) for the different stages of the nuclear power fuel cycle. The collective dose to the public, per MW of electric power and year, was estimated as 0.7 man-rem and to the personnel 2.2 man-rem. The number of acute deaths among the personnel from causes other than radiation was estimated at 0.55 per 1000 MW and year, which was approximately the same as what could be calculated from the radiation doses.

10. THE YEAR 1976

10.1. **Ringhals 1 is commissioned**

Ringhals boiling water reactor, Ringhals 1, was commissioned on 1 January. Later on there was an attempt to sabotage it with someone having placed an explosive by the power plant's switchgear. However, the attempt was discovered before any damage could take place.

10.2. **The report that was forgotten**

On 5 February, the government gave the Minister of Agriculture, Cabinet Minister *Svante Lundkvist* (1919-1991), the task of bringing in seven experts to give a 'general and easily-accessible account of the health and environmental effects of using different energy sources'. Experts called in included the Director General of the Swedish Agency for Public Management, *Sven Moberg* (1919-1994), also Chair, lay assessor *Ulla Orring*, plus MPs *Per Bergman*, *Rolf Clarkson*, *Bo Forslund*, *Sigvard Karlehagen* and *Maja Ohlin*. The experts met under the name of the Energy and Environment Committee.

This Committee created one of the most readable and informative reports ever produced by the Swedish investigative authorities. Despite this it has been almost completely forgotten, the reason being that it had the misfortune to be published at the same time as the report from the huge and politically-divided Energy Commission which had also been set up in 1976 but, unlike the Energy and Environment Committee, by the non-socialist government immediately after it had been established. The Energy Commission was to attempt to find a solution to the problem with the non-socialist parties' strongly diverging views on nuclear power, but was unsuccessful. This led to big publicity and no attention was paid to 'the Moberg report'. It was a pity because the Committee's report gave a carefully-produced overview and comparison of the health and environmental effects of the various types of energy.

The report made a distinction between specialists and experts. The specialists were the seven who were politically qualified. In addition, six experts were appointed, four of whom were natural scientists, i.e., the head of the Swedish Environmental Protection Agency's environmental hygiene department, Professor of Health Hygiene at *Karolinska Institutet* Lars Friberg, Chief Engineer at the Workers' Protection Board Yngve Hagerman, and Medical Officer Lennart Rinder. The fourth natural scientific expert was me. All credit to the experts but even greater credit to the Committee's two Secretaries, Lars Högberg and Bo Assarsson, and the Assistant Secretary Per Strangert.

The report contained many Appendices and background reports. The three Appendices were:

1. Health and environmental effects from the use of fossil fuels; a report from the Swedish Environmental Protection Agency (SOU 1977:68).
2 Health and environmental effects from the use of nuclear power; a report from the Radiation Protection Institute (SOU 1977:69).
3. Work environment during energy production. A report drawn up by Chief Engineer Yngve Hagerman (SOU 1977:70).

Seven background documents were written for the preparation of the Radiation Protection Institute's report:

1. Risks and detriment

2. Basic concepts
3. Acute injuries
4. Risk of cancers
5. Genetics
6. Exposure data
7. Accidents

I created my own draft of the report on genetics since I did not think that any available summary of the genetic problems was easily readable. This was of course presumptuous on my part since my initial knowledge was almost non-existent, but I thought that in doing so, I could focus more easily on portraying what the layperson really wanted to know. I obviously sought specialist help in the end, and the real specialists were of course horrified at what I had written. My friend Professor K. G. Lüning at Stockholm University said that no student at his institution would have had a draft like mine approved. In response, I said it was now time for the specialists to make the text acceptable; my text showed what I thought ought to be in the report.

More about 'the Moberg report' in Chapter 11.

10.3. **ICRP C3 in Paris**

ICRP Committee 3 met in Paris in March 1976. It was important for me to get confirmation of some statements in the 'Flag Book' which was now almost finished. The draft of the Commission's fundamental recommendations, which was to become Publication 26, was also available for discussion. The recreation was on 18 March and took place at *Du Sergent Recruteur*, a small restaurant on Rue St. Louis on the small island of the same name in the River Seine behind Notre Dame. Taking the Committee members there for informal talks and agreements was productive. On the restaurant's place mats I found the signatures of Lars-Eric Larsson, Charlie Meinhold, Shinji Takahashi and Eugene Kovalev. In later years, famous colleagues like Harold Wyckoff, Harald Rossi, Dan Beninson and Warren Sinclair would be there. I would feel a little insignificant and surprised about their willingness to co-operate. Eating meals together played a significant role there, as it did at '*Du Sergent Recruteur*'.

Unfortunately, eating at *Du Sergent Recruteur* was not without its risks. The price of the meal was set and you then ate and drank as much as you wanted. However, sausages and preserves which had been on offer for some time were not without their hazards. The monetary price was not the only one to be paid.

10.4. **The radiation in our homes**

At the Radiation Protection Institute we became increasingly concerned about the problem with radon. We had issued a press release in 1974 to warn that reducing the ventilation in homes for the purpose of saving energy during the oil crisis could lead to a greater risk of lung cancer. The warning had not led to any response; instead, the action taken by the Institute was suspected of being a move in the infected nuclear power debate. When during Palme's energy seminars I spoke about the risk of lung cancer through the sealing of ventilation slots and valves, Kerstin Anér thought it was probably just 'a ploy'.

The Radiation Protection Institute had no legal support to act under its own steam other than to provide information on the risks. However, with this in mind, in June 1976 we brought out an 18-page brochure entitled 'The Radiation in our Homes'. In it we gave an account of the gamma radiation and radon emanation from the ground and building material. We had mentioned the risk of lung cancer for the first time in our press release in 1974 and we now made it even clearer. The brochure said:

> In order to be able to administer the control on sources of radiation, the radiation protection authority uses *limits* which are based on the ICRP recommendations. ... While awaiting the result of ongoing work on international standards, no Swedish limit has yet

> been established for building material. When it has, it will apply to *new* building materials and *new* homes.
>
> When it comes to intervening to improve the existing conditions, it is not possible to immediately apply such limits. That is when you need to use *action levels* instead. Such action levels are usually higher than the administrative limits. If a new source of radiation has been introduced, a new building material for instance, it is possible to be more stringent than with the intervention against sources of radiation that already exist, such as existing buildings. When intervening against existing buildings, the benefits of the reduced risk of radiation must be weighed up against the disadvantages such as other risks, inconvenience and expenses. The radon concentration at which action should be taken depends on how difficult the action is to implement. However, for every radon concentration reduction of 1 pCi/l, it may be possible to count on an annual gain in the form of approx. 20 fewer cases of lung cancer per million of the population. A corresponding increase in radon concentration owing to reduced ventilation could lead to a corresponding increase in the incidence of lung cancer.

Previously, the brochure had said:

> Not enough is yet known about how the risk is affected by factors other than the level of radon, such as the smoking of tobacco. However, there are signs to indicate that smokers run a much greater risk than non-smokers of being harmed by the radiation from radon. The connection between radon level and risk of cancer which has been described here largely concerns people who are smokers. There is probably a much lower risk for non-smokers. If these observations are correct, the combination of tobacco smoking and radon exposure could be responsible for a significant share of the incidence of lung cancer, which is currently 250 cases per million and year.

This put things much more plainly than ever before, and those who received the brochure were surprised. We initially sent the brochure to the mass media and in 1977, after consulting the Swedish National Board of Health and Welfare, to all of the country's public healthcare committees. An official at *Sveriges Radio* rang me, wondering what he should do with the brochure. 'We daren't discuss this – it'll frighten people!' I asked him to remember that in that case, he would be the one who was preventing the information from being spread, not the Radiation Protection Institute. The mass media are the professional information disseminators. The task of the authorities is to *provide* the information. The Radiation Protection Institute (SSI) had no resources through which to disseminate it to everyone.

Birgitta Hambraeus accused the Radiation Protection Institute of entering the energy debate and getting involved in matters (ventilation) outside the Institute's area of competence. She ended up apologising later once she realised how serious the problem with radon was. The authorities that, unlike the Radiation Protection Institute, were directly responsible for protection measures were still sceptical. One official in such an authority said he could not understand the Swedish Radiation Protection Institute's agitation over the radon and the risk of lung cancer. 'If you don't die of one thing you die of another,' he said. He never did apologise.

10.5. **The 'Flag Book' is finished**

The international development and the cooperation with IAEA regarding rules for the limitation of the emission and discharge of radioactive substances from nuclear reactors meant that it took some time to finally edit Chapter 19 of the 'Flag Book'. However, in early March (9-11) 1976, representatives of four of the Nordic countries' radiation protection authorities met at the Radiation Protection Institute in Stockholm to complete the work.

Per Grande, Leif Hannibal and Jörgen Schultz-Larsen came from Denmark, Olli Castrén, Anneli Salo and Thor Åkesson from Finland, Helge Aamlid and Leif Berteig from Norway, and Ragnar Boge, Bo Lindell, Lars Malmqvist and Jan Olof Snihs from Sweden.

n my invitation to the meeting I wrote:

> As I have said before, all text has now been printed in galley proof. The printed text has been sent out to everyone except for a few parts. One of those is Chapter 19, where everyone has of course seen the preliminary version but, since then, has had only the manuscript of the version we agreed on in Oslo last year. The galley proof which I am now sending is thus the first to be sent out as a printed version of the new text.
>
> Another exception concerns the introductory section, i.e., the preamble, Chapter 1 (the introduction) and Chapter 2 (the concept definitions). In those sections I have sent out only the manuscript and no proof following the typesetting. The galley proof is also available but I doubted there would be anything to gain from sending that out. The text follows the manuscript and the changes which have been proposed – and included – should not be controversial. I am a little anxious as to whether new discussions of these sections could lead to delays. I think we should accept that the document can never be both completed and perfect.
>
> ...
>
> As far as I can see, the only thing now standing in the way of the final printing is our definitive agreement regarding the text in Chapter 19. If we can agree on that at the meeting in Stockholm, all of the material can be sent to the printer's to be laid out. This will mean that all editorial changes we have collated on the galley proof will be implemented. It would be a waste of work effort and would increase the printing expenses to ask for intermediate proof before the layout proof. We should therefore send all chapters to be printed altogether when we have agreed on Chapter 19. The rest may go very quickly. The layout proof will be reviewed by us in Stockholm for printing errors but too much time would be lost in sending it out. It should be possible to print the book in the spring.

As you can see, I did take some dictatorial measures, but it would not have been possible to do the final editing work on a publication with the extent of the 'Flag Book' within a reasonable time using fully democratic procedures. All of my Nordic colleagues were very obliging and realised the practical problems. Thanks to their assistance, it was possible to get the ready-printed book out that year. The front cover shows the flags of the five cooperating Nordic countries. We noted with some surprise that the Danish one was shorter than the others - an inadvertent error which could have led to us making an embarrassing mistake.

The foreword thanked Sven Benner, Birgitta Olofsson, Monica Carlson and Margareta Rydell for editorial inputs and Chris Wilson for the translation from Scandinavian into English. The work with the 'Flag Book' had taken more than seven years and involved a large number of radiation protectionists from five Nordic countries. The result had become a useful comparison of the relevant radiation protection policy which the Nordic countries' authorities were now prepared to apply. Appreciative letters from colleagues in other countries confirmed the value of the achievement. The work contacts that were made during the seven years were also very useful for the Nordic cooperation.

10.6. **Change to the Radiation Protection Act and new organisation for the Radiation Protection Institute**

In 1976, the area of application of the 1958 Radiation Protection Act (SFS 1958:110) was increased considerably to also cover non-ionising radiation. A new instruction for the Radiation Protection Institute (SFS 1976:481) was established on 24 June. It described the Institute's assignments:

> Section 2. As the radiation protection authority in accordance with the Radiation Protection Act, the Institute is the central administrative authority for cases of protection against ionising and non-ionising radiation and administers the general activity which is incumbent on the Institute in accordance with statutes or special regulations.
>
> Section 3. It is particularly incumbent on the Institute to:

obtain thorough knowledge of the risks associated with radiation and attentively follow the development within the areas of biological radiation effects and radiation physics,
have a centrally coordinated responsibility for targeted radiation protection research, do targeted research and development work within the field of radiation protection, observe international standards in the radiation protection field,
act as a coordinating body for different radiation protection interests in Sweden and thereby cooperate with authorities and associations which deal with radiation protection matters,
disseminate information on hazards and difficulties which may be caused by radiation.

In conjunction with these changes, the Radiation Protection Institute was given a new organisation. As a reminiscence of Sievert's desire to directly control everything that went on within his territory, all activity had previously come directly under the manager. Now, at the proposal of the investigator, the Swedish Agency for Public Management's organisation expert *Lillemor Kåhre*, all activity would come under three heads of division, and only these would report directly to the manager. The areas of responsibility for the new heads of divisions were a supervisory unit, an administrative unit and a research and development unit. The appointment procedure meant that these services could not be set up until 1977. In keeping with expectations and desires, the administration of medical physics at *Karolinska sjukhuset,* the Karolinska University Hospital, was transferred from the Radiation Protection Institute to *Karolinska sjukhuset*.

From 1976, the Radiation Protection Institute's board included:

Chief Engineer Thomas Eckered
MP Åke Green
MP Birgitta Hambraeus
Deputy Director General Sven-Olof Hedengren
Head of Department Göran Persson
Ombudsman Bo Tengberg
Head of Department Arne Westlin
Ombudsman Erik Wångby

From 1976, the Chair of the board was the Director in charge of the Institute whereas the board had previously had a special Chair, Director General Yngve Samuelsson, who was now ill and who died in 1977. Becoming Chair of 'one's own' board had its advantages and disadvantages, but I think things functioned well overall.

Two 'committees' in the Institute's new organisation were associated with the manager as Chair, i.e., a research council and the Preparedness Board against Nuclear Accidents (BNA). The latter was a 'continuation' of the KRA, the Commission for Advice in the Event of Nuclear Accidents, which had been set up in 1960 at the initiative of Rolf Sievert.

The Research Council had a separate Secretary, i.e., nuclear physicist Evelyn Sokolowski.

10.7. **Mauthausen, Schloss Hartheim**

I have hesitated as to whether or not I should include this section in the book since it does not concern radiation. However, the experience, along with Dan Beninson and a couple of other colleagues, was so intense that it certainly affected us, particularly with regard to our attitude towards ethical problems. It gave a perspective on existential issues.

Dan was now in Vienna and had procured a car. At weekends and on his days off he was happy to take colleagues out to see Austrian attractions. I do not remember when Ambretta followed him to Vienna and was able to take part in the trips. Nor do I remember the context in which Bengt Pettersson and I had the opportunity to accompany him around Linz and, to be more precise, the old Nazi concentration camp Mauthausen. It was now a tourist destination but we were not sure whether this justified our visit. This is where you found all the atrocities of the concentration camps with sadistic punishment methods and instruments of murder. Mauthausen was the only camp within the German realm, if we count Austria as part of that, which belonged to Category III, ‘Annihilation through work’. People survived for months rather than years.

Initially, Mauthausen had been a quarry where convicts did the work. Hundreds of thousands of ‘undesirable’ people from thirty or so countries were murdered there later on. Dan started a conversation with the man who now guarded the entrance and who proved to be a Spaniard and a former camp prisoner.

‘How come you haven’t left the place after all the terrible experiences?’ asked Dan.

‘A hope still remains for me,’ said the man. ‘One day, maybe some of them will want to return out of curiosity. If so, I will be here and can ensure that justice is served.’

But it was not Mauthausen’s horrors which made the deepest impression on us - we were already aware of the concentration camps. The reason I am writing this was a small, scruffy photograph on a wall in Mauthausen showing a large building called *Schloss Hartheim*, Hartheim Castle.

We had looked for the castle on another trip when David Sowby was with us. We had found it on the map to the left of Linz, twice as far away as Leonding and Pasching. It was a large, square, four-storey building with a round tower in every corner and a taller tower on one of the short sides. It turned out to be an atrium building with a large yard surrounded by three storeys of balconies in something reminiscent of the Moorish style. The castle was evidently lived in. Old women came forward to the rails of the balconies and looked at us mistrustfully.

We went out and searched for some information. We found a noticeboard hidden by tall grass and saplings and we were able to read and were horrified.

The castle was built in the 1500s. At the end of the 1800s it was transformed into a home for mentally or physically handicapped children, which was a good deed. Following Austria’s annexation to the German realm in 1938, the Nazis gained power over the castle and converted it for euthanasia. Gas chambers and crematorium ovens were built for this purpose. In January 1940, an initial ‘delivery’ of 95 disabled people arrived who were gassed to death and cremated. The remaining bones were crushed to dust. In August 1941, more than 18,000 disabled people had been murdered. Every week, ash and bone dust were transported to be dumped in either the Donau or the Traun. More than 70,000 people were murdered in all.

All of this took place in the middle of the community surrounding the castle. No-one appeared to wonder what the transportations to and from the castle were about. The smoke from the crematorium ovens was seen over the roof of the castle. The stench at the start of the cremation was so bad that the villagers complained. They were given contrived explanations and urged not to discuss the castle’s affairs.

The basic facts were there to be read on the neglected noticeboard. We had difficulty believing what we were reading. But the personnel who carried out the atrocities were doubtless thought to be ‘normal, decent people’.

It was not until 1995 that a Schloss Hartheim association was formed with the task of doing further investigations into what had happened and proposing the future use of the castle. A great deal of information can be obtained about this on the Internet.

10.8. **ICRP at Whiteshell**

The ICRP Main Commission met on 31 May - 4 June at the Whiteshell Research Establishment outside Winnipeg in Canada. According to some disgruntled participants, the research station lay in the middle of nowhere, i.e., a good distance north-east of Winnipeg by the Winnipeg River’s lake system. Some talked about White’s Hell, but I was looking forward to experiencing the natural surroundings. Dan Beninson and I flew to Winnipeg from Vienna via London and hired a car at the airport.

Most of the car journey went through a vast agricultural landscape where in some places the population consisted mostly of immigrant Ukrainian wheat farmers. We left Winnipeg pretty late and realised after a while that we were going to have difficulty making it to Pinawa where we would stay. We therefore looked for a turning to a community where we could stay overnight. However, the road we turned onto did not appear to lead to any big development and we noticed that the few road signs that we saw were full of bullet holes. We therefore, with some trepidation, entered a smaller timber building which had a sign stating 'HOTEL', also full of bullet holes. We entered a smoky saloon full of beer-drinking Canadians.

We asked if there were any free rooms and the man at the reception nodded - yes, but we only rent them out by the hour. We quickly returned to the car and continued our journey. Luckily, when we reached Pinawa at midnight, we were let in.

The most important matter for ICRP at this time was the completion of the new recommendations. This concerned discussing the proposal of the editorial group (Pochin, Beninson, Lindell, Jammet and Sowby). Also imprinted on our memory was the unfortunate event in Brighton in spring 1973 when Karl Morgan was voted out. Some of us were worried about the distorted make-up of the Commission, which was something that Morgan often referred to. The Commission that met in Whiteshell included four Englishmen, two Canadians and one American, so there was a heavy overrepresentation of native English speakers. Since Englishmen and Canadians enjoyed close cooperation, it meant that they had six votes of a total of thirteen. These six votes were also a thorn in the side of the Americans who had just one member in the Commission compared with the four who had been there in Sievert's time and had aroused equivalent criticism then. Our discomfort was not dispelled by the fact that Gordon Stewart had a larger room and invited his English colleagues there for strategic discussions in the evenings. I later succeeded in establishing the decision that no more than three members should come from the same country.

In our free time, Dan and I took trips out into the surroundings. On one occasion we followed the route which went up towards Lake Winnipeg. We stopped at a civilised-looking hotel to eat. Since I was driving, I asked for a low-alcohol soft beer with my food. I received a large bottle and found, not unexpectedly, that it was more like a Swedish medium-strength beer.

One day, we were invited by the research station on a trip on the river in the evening, a 'quiet boat trip followed by a little fishing and a meal cooked over a campfire'. We were distributed among a number of large motorboats with impressive outboard motors. I sat in the same boat as Sir Brian Windeyer and we had each been able to borrow a long fishing rod. It turned out that we did not need to travel far before finding ourselves in pure wilderness with beavers and interesting bird life. We cast our spinners and Brian got a bite straight away. It was strong and he anxiously passed the rod over to me and asked me pull up the fish, which was a pike weighing two or three kilos.

The whole of the Commission was photographed when we were about to eat the fish we had caught, and Brian was happy with his big pike. As well as having these experiences, we did actually get some work done when it came to the new recommendations.

We also got to visit the research station's irradiation device. A strong source of gamma radiation on a mast had been placed in a blocked-off area of forest. People were studying the way in which the vegetation had been affected; the pines were particularly sensitive.

10.9. The Nordic Congress of Radiology in Oulu

The 35th Nordic Congress of Radiology was held in Oulu, the farthest north that any of the Congresses had been so far, with Professor P. Vuoria as President. The scientific programme was divided into three sections: x-ray diagnostics, radiation therapy and radiophysics.

Rune Walstam reported the position of radiophysics within medical physics. Professors Olle Olsson and Martin Lindgren, both from Lund, became honorary members.

10.10. 'Summer school' in Herceg Novi

At the start of the year I had received a letter from Dr. Petar Marcović at the Boris Kidrič Institute for Nuclear Sciences Research in Vinča on the outskirts of Belgrade. He invited me that give a couple of presentations at the third international summer school for radiation protection in Herceg Novi. I was to visit on 1-2 September.

Herceg Novi is a small place in southern Croatia on the Dalmatian coast approximately 50 km south of Dubrovnik. Marrit accompanied me on the trip and we were met at the airport by Marković who drove us to Herceg Novi. There were other lecturers there, including well-known colleagues like Dan Beninson, K. Z. Morgan and Walter Snyder. Dan pointed out to me that the relationship between Morgan and Snyder appeared tense. They had gone from having been close colleagues for a long time to scarcely talking to one another. Our sympathies lay with Walter Snyder; Karl Morgan ought to have been grateful for the assistance Walter had given him. He had Walter to thank for his success. We never found out the reason for what would end up being a long-term disagreement.

I gave two presentations to very interested students. The first concerned the principles for the limitation of radioactive emissions from nuclear reactors and the second concerned cost-benefit considerations for the nuclear power industry. In the first presentation I gave an account of the proposal in the 'Flag Book' and the principles which would form the basis for the forthcoming Swedish provisions (see Section 11.11). The second presentation was more innovative and was praised by Dan. I said that cost-benefit assessments concerned changes, positive or negative, rather than the assessment of a static circumstance of absolute benefit. I then attempted to analyse the concepts of 'cost' and 'benefit' in relative terms. For whom? The individual (if so, who?) or the community? I discussed the matter of what could be a reasonable price to pay to 'save' an anonymous human life and pointed out that you can never save lives; what you save are remaining days of life. This is where I was able to repeat what I had said in Atlanta the previous year (see Section 9:8).

We were invited on a trip on a large, open fishing boat over the fjord-like inlets before Herceg Novi. Our Yugoslavian hosts were convivial and well-intentioned but hard work in circulating bottles of vodka, and Marrit and I had to put on a good face and swig a drink that we did not particularly enjoy. But the wind was fresh and the view magnificent so the boat trip was successful.

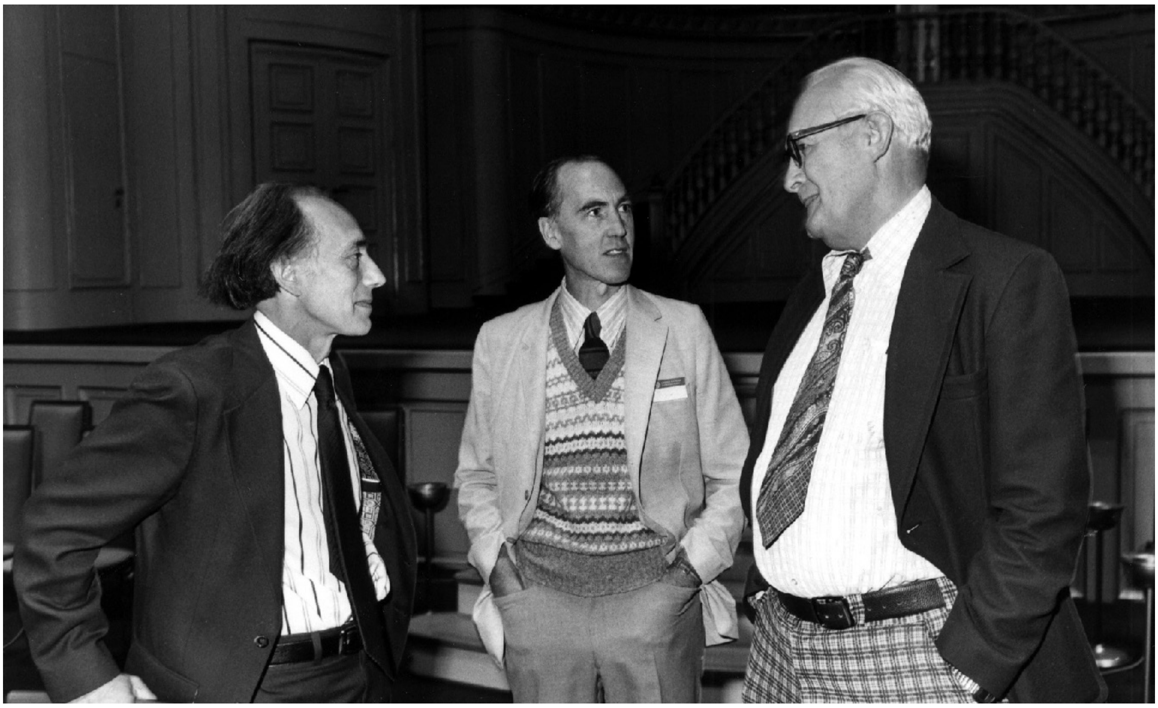
We continued from Herceg Novi to Vienna where UNSCEAR was to meet.

10.11. **UNSCEAR's 25th session in Vienna**

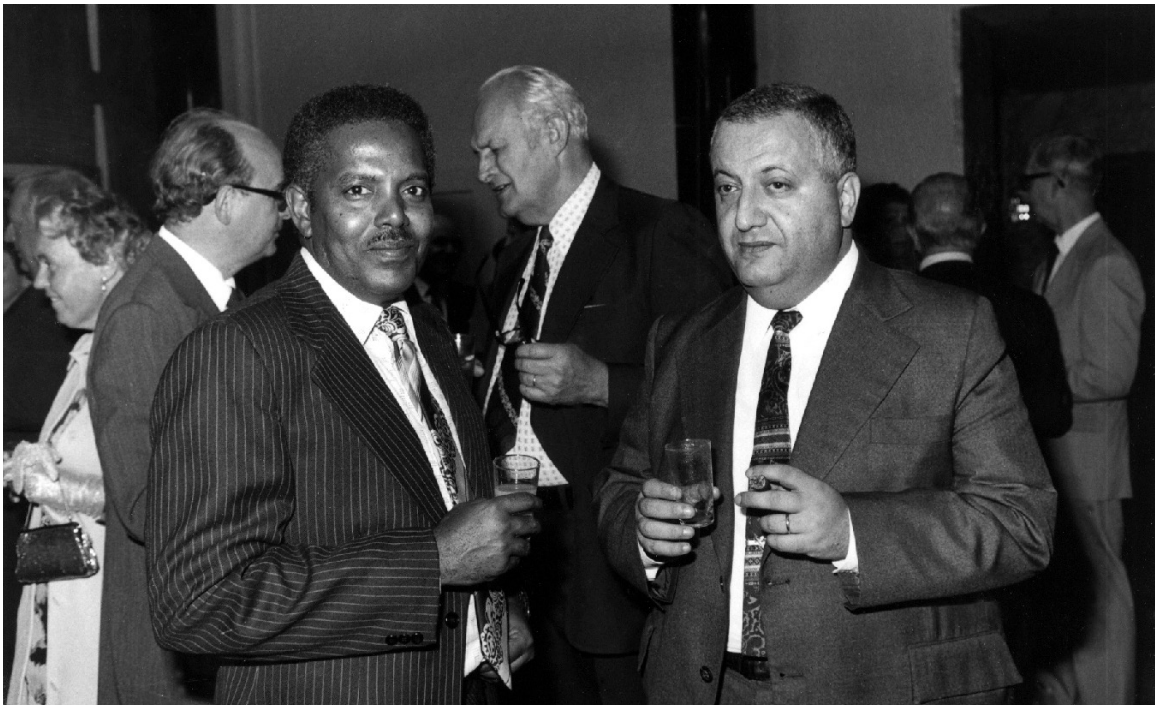
UNSCEAR held its 25th session in Vienna on 6-17 September. As was the case at the previous session, the Chair of the Committee was Professor Sobels with the Czech representative Dr. Klimek as Deputy Chair and the Polish representative, Professor Jaworowski, as rapporteur. The Swedish delegation was also unchanged, with the exception of Assistant professor Evelyn Sokolowski from *AB Atomenergi* who succeeded Stig Bergström. Bergström had been given new work assignments and Evelyn was particularly qualified by virtue of also being Secretary of the Swedish Radiation Protection Institute's newly-established research council. The meeting took place in Hofburg, the old imperial castle which was set up in the 1200s. Unfortunately, the large meeting room put a damper on the discussions – it felt presumptuous to ask for the floor in this imperial environment. Marrit had an easier time of it; she took the tram every day to (the Austrian) Baden to swim. At the weekend, Dan and Ambretta drove us to Eisenstadt and Lake Neusiedl where the watchtowers on the Hungarian side of the border were evidence that the iron curtain still existed.

Pochin had been the Secretariat's consultant and written Annex G, *Radiation carcinogenesis in man* for the 1977 report in an attempt to do a quantitative risk estimate for a large number of forms of cancer. This was probably the first quantitative risk estimate that had been published since ICRP 8 (1966) and the Swedish Radiation Protection Institute's quantification of the radon risk in 1974. ICRP also did quantitative risk estimates in 1977 in its Publication 26.

From the 25th session of UNSCEAR in Vienna, 1976
At left, the knowledgeable Egyptian physician Hussein Daw, longstanding IAEA contact person for radiological protection issues. At right, in a pale jacket, the Australian delegate Don Stevens. Between them the skilful American radiochemist John Harley.



From the 25th session of UNSCEAR in Vienna, 1976.
Upper frame: At left the British physicist Roy Ellis and at right the formidable American physicist Harold Wyckoff of NBS. Between them, the Secretary of ICRP, David Sowby.
Lower frame: Inspector Bengt Pettersson of the Swedish Radiation Protection Institute in conversation with Marrit Lindell. Between them the American UNSCEAR delegate Bob Moseley can be glimpsed. At right, Bo Lindell and Harold Wyckoff are having a conversation.



From the 25th session of UNSCEAR in Vienna, 1976.
Upper frame: Bengt Pettersson and the Swedish nuclear physicist Evelyn Sokolowski in conversation with Jan Olof Snihs.
Lower frame: The Sudanese delegate, Dr A. Hidayatalla, in conversation with Dan Beninson. Behind them, Bo Lindell and Harold Wyckoff are visible. Marrit Lindell can be glimpsed at left.

10.12. **The monazite sand in Brazil**

On 20 October, my Secretary from the 1958 UNSCEAR work, Nina Nekrassoff, wrote from Rio about a young man who had chronic myeloid leukaemia and, according to Nina, just three weeks left to live. She knew that Henri Jammet in Paris had treated similar cases but she had lost his address and wanted to know whether I could arrange contact.

In the same letter she wrote extensively about the healing effect of a ‘black, radioactive sand’ which, on the beach, emitted a dose rate of 6 milliroentgen (approx. 60 microsieverts) per hour. According to Nina, many people lay in the sand for two hours a day. Nina’s mother had been cured of her rheumatism. I refrained from expressing doubt in my response since faith can also heal, but I did believe in the high dose of radiation.

The sand was monazite sand, sand from a material containing thorium which can give elevated doses of radiation. Monazite sand is found in Brazil and in Kerala in India. It is also found on Resarö in the Stockholm archipelago.

10.13. **The Swedish Parliament’s 1976 election – the first Fälldin government**

The nuclear power issue played a major role in the autumn’s election campaign and the Centre Party with Torbjörn Fälldin and Birgitta Hambraeus was now running it. Fälldin promised that no new nuclear reactors would be charged or commissioned. The result was that the non-socialist parties won the election with the Centre Party being the largest non-socialist party. In the new government, Olof Johansson of the Centre Party was the Minister for Energy. The government declaration contained the following important points:

- Nuclear power devices which were being built when the government came into power would not be commissioned unless the owner had an acceptable fuel reprocessing agreement* and could show where and how the highly-active waste could be deposited in complete safety.
- Barsebäck 2, whose construction had been completed, could be started but would be decommissioned if a reprocessing agreement were not in place by 1 October 1977.
- A special Commission would be set up to prepare the forthcoming energy policy decision in Swedish Parliament in 1978.
- The possibility of arranging an advisory referendum would be examined if opinions were still strongly divided prior to this decision.

The intentions of the government declaration formed the basis for the ‘Stipulation Act’ which was adopted by Swedish Parliament in April 1977.

10.14. **The Energy Commission**

In December, the new Fälldin government set up an *Energy Commission* with the Post Office’s Executive Director Ove Rainer as Chair. The Commission was to give an account of and assess a number of alternative energy programmes for the 1980s. At least one alternative should be that Swedish nuclear power would be discontinued by the mid-1980s. The report was to be ready in March 1978 so that there would be time to prepare an energy policy decision to be determined by Swedish Parliament in the same year. The hope was that it would be possible to iron out the conflicts between the three non-socialist parties could be ironed out and the Moderates (conservatives) and the People’s Party (liberals) were positive towards nuclear power. This hope was not realised.

* Reprocessing of nuclear fuel involves recovering plutonium from used fuel which consists mainly of unused uranium but contains highly-radioactive fission products (approx. 3.5%) and transuranics (approx. 1%), approx. 90% of which constitute plutonium. The reprocessing does not take place until the fuel has cooled considerably, which takes 5-10 years (except for the recovery of plutonium for nuclear weapons, when it must take place within a few months). The fuel is dissolved in nitric acid whereupon the separation takes place mechanically. The reprocessing leads to highly radioactive waste and must take place in closed systems. The plants are often viewed with distrust owing to the possibility of producing plutonium for weapons. For peaceful use, the extracted plutonium oxide is mixed with uranium oxide to form ‘MOX’ fuel (from mixed oxide) which can be reused in nuclear reactors.

10.15. **Questions concerning appointments**

On 28 October, Gunnar Bengtsson wrote to me about the consequences of appointing Lars-Eric Larsson as head of the supervisory activity in the new organisation at the Radiation Protection Institute, with Gunnar as head of administration and deputy manager. Lars-Eric was the oldest but Gunnar had his doubts. And this in fact did not happen; Lars-Eric stayed in medical physics where he made a significant contribution.

On 9 December in a letter from Fälldin and Dahlgren, the government changed the title of the Radiation Protection Institute's manager and appointed me as 'Director and head of the Swedish Radiation Protection Institute'. I thought that was a step down from 'Professor and Manager'. Anders Dahlgren knew this and I received another letter from him where he gave me the 'honorary title of Professor'.

11. THE YEAR 1977

11.1. **Emission tomography**

Unlike transmission tomography (see Section 6:1), which is based on measurements of the transmission of the x-ray beam coming from an external source, the *emission tomography* is based on measurements of the presence of radioactive substances inside the examined body.

Radioactive substances in a body can easily be demonstrated if they emit penetrating gamma radiation. Rolf Sievert took ground-breaking measurements of the natural presence of potassium-40 in the human body. However, he was handicapped by the fact that his measurement instruments, ionisation chambers, allowed only the determination of the total quantity of the gamma-emitting substance, but not of its distribution in the body.

With the invention of *scintillation detectors* at the start of the 1950s it was possible to identify the radioactive substances by registering the energy of their gamma quanta, and it also became possible, using repeated measurements with the help of collimators during nuclear medicine examinations, for example to obtain an idea of how the radioactive substance was distributed in the thyroid gland. Such measurements took time and were soon replaced by devices, *scintigraphs*, where the detector automatically moved over the part of the body which was being examined. You now obtained a projection of the distribution of the substance along the direction of movement of the scintigraph, but no direct perception of the depth distribution of the substance.

The next stage of the development was the emergence of *gamma cameras*, i.e., scintillators with a large surface area, or multiple smaller scintillators, equipped with collimators which permitted only the registration of gamma radiation in certain directions. Registering the scintillations with a large number of photomultipliers directly gave you an idea of the distribution of the radioactive substance, but it was still a projection which provided no information about depth distribution.

The objective was now to attempt to create images of the distribution of the radioactive substance at different levels deep in the body, a *tomography*. Two methods were developed for this purpose during the 1970s: the *single photon emission computed tomography* (SPECT) and the *positron emission computed tomography* (PET).

11.2. **SPECT**

SPECT is the simplest method and is now based on the use of gamma cameras. The projections of the source of gamma radiation which are registered by a gamma camera in different directions provide primary information which can be transformed into transverse slice images with the same calculation algorithms that are used for computed tomography with x rays (CT)*.

Like computed tomography, emission tomography had been proposed by Alan Cormack in the 1960s before the necessary computer power was available. David Kuhl and R. Q. Edwards carried out experiments at the same time as Cormack, although initially unaware of the latter's calculation algorithm. Hal Anger had already produced an emission tomography scanner in 1965. In the 1970s,

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* See the chapter for 1972.

Kuhn and colleagues used increasingly sophisticated instruments to demonstrate the practical usefulness of the method.

T. Budigner at the University of California in Berkeley pointed out in 1973 that gamma cameras could be used for emission tomography examinations. In Sweden, *Stig Larsson* and his colleagues at *Karolinska sjukhuset* developed an emission tomograph in cooperation with General Electric at the end of the 1970s which enjoyed significant success. Gamma cameras are now offered with options for SPECT which has led to widespread use of the method among the larger hospitals. The SPECT technology has been widely used within nuclear medicine, particularly for blood flow examinations and studies of the brain function when investigating dementia, cerebrovascular diseases (diseases in the blood vessels of the brain) and epilepsy.

11.3. **PET**

Unlike SPECT, which is a comparatively cheap and uninvolved method, PET requires more personnel. The radioactive substances used for this method are positron emitters (carbon-11, oxygen-15, nitrogen-13 and fluorine-18) which are so short-lived that they need close access to a cyclotron and a radiochemical laboratory. The required tomograph is also more complicated and thereby more expensive.

The *positron* is the antiparticle of the electron, i.e., it has the same mass, charge and magnetic moment as the electron but differs from the latter in that its charge is positive rather than negative. The released positron emitted from the radioactive substance is

not long-lived – it meets an electron almost immediately. When this occurs, the two particles are destroyed and their mass is transformed into energy which is carried by newly-formed gamma quanta, photons. The annihilation occurs so soon that the positron has not had time to put any significant distance between itself and the source of radiation. The process can be written as follows using symbols:

$$e^{-1} + e^{+1} \rightarrow 2\,\gamma^{0}$$

where the numbers 1 and 0 state electric unit charges. The laws of physics say that the state before and after the destruction ('the annihilation') must have an unchanged total mass, charge and momentum. With regard to the charge this is clearly satisfied (-1 + 1 = 0). As regards the mass, it consists of 2 electron masses before the annihilation. The energy taken over by the two photons must correspond to this mass in accordance with Einstein's formula $E=mc^2$. The rest mass of the electron can thereby be estimated to correspond to an energy of 511 thousand electron volts (511 keV). The energy following the annihilation is captured by each of the two photons.

In the example, the momentum (the mass multiplied by the speed) is zero before the annihilation. However, the momentum is a vector, i.e., it has a direction. In order for the total momentum following the annihilation to also be zero, the two photons have to be thrown out in exactly opposite directions.

Therefore, as regards the positron-emitting radioactive substances used in emission tomography, the registration must be based on simultaneous (coincidental) gamma quanta with an energy of 511 keV, with the constraint that these quanta move along the same line but in the opposite direction. The simultaneity makes it possible to use coincidence detectors which register nothing other than simultaneous photons. This reduces the background noise from other gamma radiation. The directional term makes it possible to say that the radiating substance is located somewhere on the connection line between the two detectors (on each side of the body being examined) which have registered coincident photons. The detectors sit in one or more rings around the body being examined. With several rings you can obtain a three dimensional registration.

For PET examinations, the majority of medically interesting chemical compounds can be labelled with a positron-emitting nuclide and then be used as tracers. This enables *physiological* examinations in addition to the anatomical images obtained using other methods such as CT.

The use of the positron's annihilation radiation for imaging tomography had already been proposed in the 1950s by Frank Wrenn, Myron Good and Philip Handler and, independently of them, by G. L. Brownell and W. H. Sweet. The first gamma camera systems were introduced in the 1960s by S.

Rankowitz and colleagues, but the computer processing technology was not yet adequate. Data processing was first applied by a group in St. Louis led by Michel Ter-Pogossian who presented the PET camera in 1975. Similar systems were developed at the same time at the University of California in Los Angeles (UCLA) by Z.H. Cho and colleagues and in Montreal by Christopher Thompson, Lucas Yamamoto and Ernst Meyer.

The first Swedish PET camera (positron camera) was built at *Karolinska sjukhuset's* neurology clinic in 1977 in cooperation with the Institute of Physics at Stockholm University. It was succeeded by an improved version with four detector rings in 1982. A positron camera was installed at *Akademiska sjukhuset* in Uppsala in the same year, and they acquired yet another camera nine years later. *Karolinska sjukhuset* received a third positron camera in 1993, but by then the first one had already been out of use for a long time.

11.4. **ICRP in Woodstock**

The ICRP Main Commission met on 5-17 January at The Bear Hotel in Woodstock outside Oxford, near Churchill's childhood home, Blenheim Palace, to finally approve the text for what would be ICRP Publication 26, the Commission's fundamental recommendations for the period up until 1990, when it was succeeded by Publication 60.

As well as being close to Blenheim Palace, Woodstock was known to Beninson, Sowby and me through the title of Colin Dexter's first Inspector Morse book, *Last Bus to Woodstock*. It is a small community with low buildings, and the most noticeable thing was the smoke from the coal fires in the houses. It was scorching and pungent and I had difficulty breathing. It forced me to take shelter in the old hotel where we were staying and having our meetings.

The big question which would finally be decided this time was the choice of dose limit for the public. For a long time, the ICRP annual dose limit had been 500 milliroentgen or, using later units, 5 millisieverts. Already in 1953, Sievert and Mayneord had discussed the limit concerning occupational radiation doses and which Sievert wanted to set lower than the 300 milliroentgen per week which applied at the time. There was thus an old dispute regarding the appropriate level of caution. The British, four of whom were members of the Main Commission in 1977 (McLean, Pochin, Vennart and Windeyer) but who were also supported by the two Canadians (Stewart and Newcombe), did not want to lower the dose limit. On the other hand, Dan Beninson and I did want to, with feeble support from the other members. The fact that there were only two of us was counterbalanced by the fact that we were far more voluble and had good arguments. The estimate of the risks had increased considerably over the past decade.

Our opponents were led by Bill Pochin who had a powerful voice and radiated decisiveness. But, following a long discussion at The Bear Hotel, Brian Windeyer laid his hand on Pochin's arm and whispered, audibly, 'Bill, you can't win them all.' However, despite everything, both parties were evenly matched and no solution was in sight.

It is said that I was the one who found a formula to satisfy everyone, but I am not that proud of the solution. Dan Beninson and I had already convinced Pochin that it was appropriate to follow Wolfgang Jacobi's proposal to use the sum of the products of the weighting factors w_T and the annual doses in individual organs as an indicator that the situation was acceptable. The sum was not given a name in Publication 26 but was later christened the 'effective dose equivalent' and later still the 'effective dose'. The sum could not exceed the established annual dose limit through homogenous irradiation of the whole body. Dan and I accepted that the dose limit was still 5 mSv, but only if a few additional terms were satisfied. These terms were sneaked in through a reference to four paragraphs which made it very clear that real annual doses exceeding 1 mSv were scarcely acceptable. This made the text fairly cryptic and each team could interpret it as they saw fit.

The Commission adopted the new recommendations on 17 January (see Section 11.11).

11.5. **The Stipulation Act**

In the spring, Swedish Parliament adopted the 'Stipulation Act' which, in order for new reactors to start, required the nuclear power industry to *either* have concluded an agreement concerning the reprocessing of spent fuel and have 'shown how and where the reprocessing waste could be deposited in complete safety' or 'shown how and where used but not reprocessed nuclear fuel could be deposited in complete safety'. The law codified the intentions in the 1976 government declaration. Since most people assumed that the supervisory authorities (the Swedish Nuclear Power Inspectorate and the Swedish Radiation Protection Institute) required acceptable safety, the question also arose as to what the legislator meant by 'in complete safety', and the technicians thought the law was impossible since nothing can be considered to be totally safe. The law was abolished in 1984 but took on great significance in the disagreement regarding the continued development of nuclear power before the referendum in 1980.

11.6. **Yngve Samuelsson passes away**

The former Chair of the Swedish Radiation Protection Institute's board, former Director General of the Insurance Council Yngve Samuelsson, died in April at the age of 69. His obituary in *DN* read:

> His compassion and his good judgement exercised great influence on the Insurance Council's application of the law,
>
> ...
>
> Finally: Yngve Samuelsson was not just a prominent lawyer. He was also humanist. He concealed it fairly skilfully but we, as his work colleagues, sometimes had the pleasure of a glimpse.

In *Curieren*, the Swedish Radiation Protection Institute's personnel magazine, I wrote:

> We at the Radiation Protection Institute received the news of Yngve Samuelsson's passing with great chagrin. He was Chair of the Institute's board (previously the Radiation Protection Committee) from 1958-1976, i.e., during many eventful years. It was reassuring to have such an experienced and unbiased officer as Chair and he quickly won everyone's respect. We will remember him pensively and with gratitude.

11.7. **The Radiation Protection Institute and non-ionising radiation**

When a change in the Radiation Protection Act had made it possible for the Radiation Protection Institute to consider also non-ionising radiation (NIR), the supervisory activity of such radiation started in February 1977. The leading radiation protectionist, Lars-Erik Paulsson, wrote the following in the Swedish Radiation Protection Institute's personnel magazine *Curieren* for the 20th anniversary in 1997:

> Those of us who were there initially included Enn Kivisäkk, Mats Holmberg, Gösta Jonsson, Lars-Erik Paulsson and Ingvar Langlet.[*] The activity was carried out for a couple of years in the form of a project under the leadership of Gunnar Bengtsson who had just started as head of the general supervisory division at the time. During the project, Gunnar tested some non-bureaucratic forms of work; among other things, it was very important for the new unit to have no secretary. However, to begin with it was fairly tricky in organisational terms since Enn, Mats and Gösta came under the X-ray Control Department under Sten Grapengiesser while Lars-Erik and Ingvar came under the Dosimetry Laboratory under Lennart Lindborg.

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[*] Gert Anger (1986), Anders Glansholm (1981), Ivar Kristiansson (1979) and Ulf Wester (1985) also soon came to the NIR group.

> Much can happen in 20 years and, in another context, we may be able to find ways of relating things such as how we kick-started efforts with an international meeting, how we got a roof on the pavilion, how we appeared 400 times in the press in one year or how we earned our first million. ...

The 'Pavilion' was the provisional timber building some distance away from the Swedish Radiation Protection Institute's main building which had initially been homes for the hospital's personnel. It was taken over in 1977 by the Radiation Protection Institute for the new activity which could progress here undisturbed and where there was room for unconventional ideas.

11.8. **The creation of the INIRC**

At IRPA's Congress in Paris in 1977, the task group for non-ionising radiation was reorganised into an International Non-Ionising Committee (INIRC) with Henri Jammet as Chair. This Committee was active from 1977-1992 when it was reformed into an International Commission on Non-Ionising Radiation Protection (ICNIRP) with Australian Michael Repacholi as Chair. Repacholi, who was a dominant and very controversial person, was also Chair of the INIRC in recent years. The INIRC cooperated closely with WHO.

11.9. **Information day on non-ionising radiation**

On 14 June, the Radiation Protection Institute arranged an information day on non-ionising radiation. They had now got going with their own activity and were curious as to what international experts had to say. Of primary note among the latter was Professor S. Michaelson from the Radiation Biology Department at the University of Rochester School of Medicine and Dentistry. Michaelson talked about the biological effects of microwave radiation. His presentation was thought to be important enough to be translated into Swedish within the Radiation Protection Institute. Another acclaimed speaker was David Sliney who talked about risks and protection aspects of optical radiation sources.

11.10. **Barsebäck 2**

In July, Barsebäck 2 was commissioned in accordance with the Stipulation Act.

11.11. **Regulations regarding the limitation of emissions and discharges**

The proposed regulations for limiting the radioactive substances from nuclear power plants, which were discussed at a hearing in *Karolinska sjukhuset's* assembly hall in 1975, were now ready to be published. They were established by the Swedish Radiation Protection Institute's board on 31 January 1977 and were approved by the government in March of the same year. On this occasion, Olof Johansson was head of the Ministry of Industry and the immediate person responsible within the government.

The guidelines for the limitation were based on an assumption that electric power from future nuclear power plants would be 10 kW *per caput*, the same power as Hedgran and I had assumed in our original proposal in 1969-1970 (see Section 3.21). This is a very high power compared with the current one, roughly ten times higher. When I visited Olof Johansson to defend our proposal he was horrified. 'But we just can't have so much nuclear power!' he exclaimed indignantly. I tried to explain that the more nuclear power we accepted, the stricter the emissions requirement became. Fortunately, he realised the connection.

The regulations were published in the Swedish Radiation Protection Institute's Code of Statutes (1977:2) together with an introductory text whose main task was to explain the purpose of the regulations. The introductory text said that 'if the purpose of a regulation is not completely clear, the regulation can easily be misinterpreted' and that it 'ought not to be difficult to find the reasonable interpretation in different practical situations, provided there was no doubt about the purpose'.

The regulations were published the year before IAEA published its Safety Series No. 45 on principles for the limitation of emissions and discharges. In the same period there had been close cooperation between the Nordic countries while the 'Flag Book' was being prepared, whose Chapter 19 anticipated the Swedish regulations and Safety Series No. 45. However, everything originated from the discussions at the Radiation Protection Institute with Arne Hedgran and Jan Olof Snihs.

In addition to the early innovation from 1969 (Section 3.21) to limit the collective radiation dose per megawatt and year, the additional requirement was to limit the emissions on the basis of activity - measurements at the source instead of on the basis of measurements in the environment as in the previous case. The limitation requirements were now so strict that the results of environmental measurements were not enough to show that the requirements had been satisfied. The requirements implied taking measurements direct in the gases and fluids which left the power plants.

The problem was that there could be emissions to air and leaks to water and from several different places in the power plants. It was the overall picture of all these emissions and discharges which was needed, but it was not enough just to add up the activity thereof since different radionuclides and different forms of emission lead to different radiation doses. The Radiation Protection Institute could have demanded that the power plants calculate all of the resulting radiation doses and report the results, but the Institute instead demanded that the emissions be reported in terms of *standard emissions*. A standard emission is defined as 'the combination of activity emissions which causes a *reference dose*'.

At this time, ICRP had still not introduced the *effective dose* but had stated in Publication 26 (1977) a formula for the calculation of a sum of terms which, for every organ in the body, consisted of equivalent doses multiplied by established weighting factors. ICRP had stated these factors for the different organs and the Radiation Protection Institute was now demanding that the same weighting apply to the calculation of the different organ doses for people who received the highest radiation doses for every nuclide and emission point. The weighted doses could then be added to what is now called the effective dose.

There would be further weighting for the activity of every emitted radionuclide at every emission point. This required that corresponding weighting factors (based on weighted radiation dose per unit of emission) be authorised by the Radiation Protection Institute following a proposal from the power plants, something which required calculations and possibly also observations in the environment. The total sum of the weighted contribution would be called a standard emission if the emission generated the reference dose. This was set at 0.1 mSv over one year. The power plants were to report the emissions stated in numbers (or fractions of) standard emissions.

The Radiation Protection Institute did not set up an annual limit for the number of standard emissions. Instead, we set different requirements depending on the emissions rate. If the emissions took place at such a rate that weekly emissions were lower than 1/10 of standard emissions, an increase in the emissions and a proposal for countermeasures would be reported to the Radiation Protection Institute if the difference between two consecutive weekly emissions exceeded 1/50 standard emissions. If weekly emissions exceeded 1/10 of the standard emissions, this would be reported within a week with proposed measures. If the emissions occurred at such a rapid rate to lead to more than 1/200 standard emissions per hour, the reactor in the unit which had caused the emissions would be turned off before the emissions had amounted to 1 standard emission and the Radiation Protection Institute should be informed within 24 hours.

There were two reasons why the Radiation Protection Institute did not want to just issue an emissions limit. Firstly, the calculation of standard emissions was schematic and overestimated the real dose, and secondly it was important to avoid ending up in what Arne Hedgran called a 'blackmail situation'. If you had a fixed limit and it looked as though it was being exceeded, you could end up in a situation where mothballing the reactor could lead to more serious consequences than cautiously continuing to operate it until the situation had been investigated and assessed. However, continuing to operate it could be perceived as the authority failing to adhere to its limit values, which could lead to a crisis of confidence. The planned system meant that there was time to take the required measures without risking the safety.

11.12. ICRP Publication 26

At the same time, ICRP Publication 26 came out. At this time the ICRP Main Commission was made up of the following people (although ICRP's members were selected without reference to country, I am stating the countries here to show the substantial influence from the Anglo Saxon countries):

Gordon Stewart (Canada)	Chair
Bo Lindell (Sweden)	Deputy Chair
Dan Beninson (Argentina)	
Henri Jammet (France)	
Julian Liniecki (Poland)	
Andrew McLean (the UK)	
Howard Newcombe (Canada)	
'Bill' Pochin (the UK)	
Shinji Takahashi (Japan)	
Arthur Upton (USA)	
Jack Vennart (the UK)	
Brian Windeyer (the UK)	
K. Z. Morgan (USA)	Emeritus Member
Lauriston Taylor (USA)	Emeritus Member
David Sowby	Secretary

As previously mentioned, the text had been drawn up by an editorial committee consisting of Bill Pochin as Chair and Beninson, Jammet, Lindell and Sowby.

The biggest problem with the previous recommendations in Publication 9 from 1966 was that they worked with critical groups and critical organs and the MPC values for permissible concentrations in drinking water and breathing air. However, since the Commission had introduced the concept of 'risk', it had taken into account *stochastic* harmful effects for which another protection policy was needed. This protection policy was based on the concept of 'detriment' which, in paragraph 16 of the new recommendations, was described in the following words:

> The Commission has introduced the concept of detriment to identify, and where possible to quantify, all these deleterious effects. In general, the detriment in a population is defined as the mathematical 'expectation' of the harm incurred from an exposure to radiation, taking into account not only the probability of each type of deleterious effect, but also the severity of the effect. These deleterious effects include both the effects on health and other effects. On some occasions it is convenient to deal separately with the effects, or the potential effects, on health. These are then characterised by the concept of detriment to health.

In paragraph 22, the collective dose was defined as the product of the number of irradiated people and their average dose (not using these words but using corresponding mathematical expressions).

There was now a differentiation between *stochastic* and *non-stochastic* (later called deterministic) harmful effects. To protect against the non-stochastic effects it was possible to set a dose limit so it would reassuringly stay below the threshold value for injury. But no threshold value could be used as protection against stochastic injuries (cancer and hereditary injuries). We therefore took Wolfgang Jacobi's proposal of adding weighted organ doses as a starting point. It was then possible to formulate the protection requirement:

$$\sum_T w_T \, H_T \le H_{limit}$$

The left section is the sum of the weighted organ doses ('T' stands for tissue) and $'H_T'$ is the radiation dose ('dose equivalent' at the time) in the organ or the tissue 'T'. $'H_{limit}'$ is the limit value selected by

ICRP for an even, whole body dose. Not until later did we realise that the sum in the expression defined a quantity, which is now called effective dose and is stated in joule/kg with the special name of *sievert*.*

So, the task was to limit the total effective dose for each individual. With external irradiation using x rays or gamma radiation, it was impractical to really calculate the effective dose. External radiation doses are measured using personal dosimeters which had been calibrated to state the effective whole-body dose as far as possible. It was an advantage if this could take place with the help of internationally-accepted conversion coefficients.

Following Publication 26, the situation for internal irradiation from the radioactive substances in the body was easier in one respect and more difficult in another. This is where it was desirable to calculate the effective dose in as many organ and tissues as possible. The extensive work by Karl Morgan's group in Oak Ridge in 1959 had led to ICRP Publication 2 with the dosimetric basis for calculating the maximum permissible body burden and the maximum permissible concentrations of different radionuclides in drinking water and breathing air ('the MPC values'). The calculations had been performed on the basis of the concept 'critical organ'† and the injuries which were included were deterministic injuries

However, Publication 26 calculated using stochastic injuries and the critical organ could then no longer be included in the calculations. These had to be redone in order to provide the information that was now needed. Instead of the MPC values, the ALI (Annual Limits of Intake) values for the most important radionuclides were now needed. The MPC values for drinking water were thought to be irrelevant when it came to professional work and were no longer stated; there were no good reasons why drinking water for workers should be permitted contain more contamination than drinking water for the public. The problem was more difficult for breathing air. You could stop drinking contaminated water, but it was not always possible to avoid breathing in contaminated air at the workplace. ICRP therefore retained the MPC values for breathing air, but called now them the 'DAC' (Derived Air Concentration) values, i.e., the concentration values derived from the dose limit.

It was thus important to replace ICRP Publication 2 with a new table (which became ICRP Publication 30). David Sowby and I were very anxious about this. For Publication 26 with its emphasis on stochastic injuries to be accepted by the International Radiation Protection Society, it was necessary to be able to apply the recommendations immediately. However, the application was impossible without Publication 30 and ICRP would have egg on its face if it recommended things that were impossible.

Following Karl Morgan's embarrassing exit in 1973, the British man Jack Vennart became Chair of ICRP Committee 2. Jack was an exceedingly competent man but, in the work with Publication 30, he was dependent on Morgan's group in Oak Ridge under the leadership of Mary Rose Ford. I discussed the problem with Vennart and asked him do his best to spur on the group's work. My concern doubtless impaired my judgement and I ought to have realised that my concern could be taken as a criticism of Jack's ability to realise the serious of the situation himself. However, he was friendly and accommodating and promised that Committee 2 would do its very best - which we are already doing, he added.

I told Bill Pochin about my concern regarding what could happen if ICRP did not bring out Publication 30 in time. I said I had put the pressure on Vennart.

'How did he take it?' wondered Pochin.

'All in his stride,' I said.

'That's what I'd have thought,' answered Bill. 'It's typical of us Englishmen. The angrier we are, the calmer we behave. He must've been furious.'

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* People sometimes write 'Sievert' with a capital S because Sievert is also a name, but units that have been named after people should be written with small letters (e.g., ampere, becquerel, joule, watt, sievert). On the other hand, the abbreviations are written with capital letters (A, Bq, J, W and Sv).

† The critical organ was defined as the body which causes the greatest injury to the whole body in the event of radiation injury.

I do not know whether our friend Vennart really was furious behind his calm exterior. The episode did not really affect our relationship, and Jack would no doubt have brought out the report in time without my clumsy intervention anyway. And out it came on time, saviour of ICRP.

The next problem had been how in Publication 26 we were to interpret paragraph 52 of Publication 9, which said:

> As any exposure may involve some degree of risk, the Commission recommends that any unnecessary exposure be avoided, and that all doses be kept as low as is readily achievable, economic and social considerations being taken into account.

In order to get an answer to the question, the Commission had set up a task group to come up with a proposal. The powerful group, led by the American Lester Rogers, reported in April 1973 with a proposal in ICRP Publication 22 (see Section 7:04). John Dunster, Carlo Polvani and Don Stevens took part alongside Rogers.

Lester Rogers' task group had arranged the optimisation of the radiation protection and given examples of how it could be done. The Commission adopted their proposal. The main points in the ICRP radiation protection system were thereby summarised in three points which, put in simple terms, required the following:

(a) Activities with radiation must be justified;
(b) The radiation protection must be optimised; and
(c) Individual dose limits must be respected.

Experience indicated that the optimisation of the radiation protection would have a greater influence on the radiation environment than the application of the dose limits, provided that source-related operative dose limitations, which were much lower than the dose limits at the time, were not applied. However, such limits could be derived with the help of protection optimisation. The popularity of the requirement regarding protection optimisation rapidly increased but also created opposition, partly due to misunderstandings. Some opponents thought it could lead to unreasonable demands, something which ICRP countered by saying that this was impossible by definition. Optimisation meant only measures which were *reasonably* possible.

11.13. **The Energy and Environment Committee in British coal mines**

The Energy and Environment Committee wanted to go on a study trip to the UK to look at coal mines and coal power plants. I offered to contact John Dunster who had recently left the NRPB for a job as Deputy Director General of the British Board of Occupational Safety and Health (Health and Safety Executive) with particular responsibility for nuclear safety. John was interested in the visit and arranged it for us. He said afterwards that it had helped him a great deal since the Committee visited authorities and institutions in different places and he therefore had an opportunity to meet and bring together people who normally had no contacts.

We visited workers' protection authorities in England and Scotland. We tried to visit Windscale but were not allowed in due to an ongoing strike, but we visited a coal mine and a coal power plant with associated ash deposits. The coal mine was said to be a demonstration mine which the Queen had been to. After having handed over anything that could cause fire or sparks, we were transported by lift very deep underground and then by carriage for some distance horizontally to the coal seam which was no more than a metre high. It was also not the mining area so there was not room to stand up straight. In truth, no place for someone who suffered from claustrophobia. The roof of the mined area was held up by hydraulic pillars. There were sounds of ominous cracks and I thought about the hundreds of metres of rock which could crush us. The Social Democrat Committee member Maja Ohlin, a lovely lady not far off sixty, had been anxious before the descent, but she was now calm, despite what was actually a dangerous environment. Miners, all of them Polacks, squatted along the chain conveyor with the scraped-off coal which it conveyed to the conveyor belt which led to the coal lifts. They offered us snuff. You could not light a cigarette due to the risk of explosion with coal dust in the air.

The coal power plant was probably also a demonstration plant. It was surrounded by an impressive area of ash. An uninterrupted flow of lorries delivered coal. I asked the power plant manager about the sulphur emissions, whether they were significant. The manager said they were not an environmental problem as there were measurement stations around the power plant and they were not registering any dangerous levels.

'But you have tall chimneys,' I said. 'If you release a number of tonnes of sulphur through the chimneys, an equal number of tonnes have to come down somewhere.'

'I haven't thought about that,' said the manager, 'but it must have been well and truly diluted by then….'

11.14. **Meeting of scientists at Karolinska Institutet, 8-11 March**

The Energy and Environment Committee were facing a problem which worried the expert Professor Lars Friberg. How could you compare the health risks from radiation and fossil fuels when for radiation protection you assumed a linear dose-response connection with no threshold value but had to assume a threshold value when it came to exposure to chemically-toxic substances? I had told Friberg that I also did not believe in a threshold value for the chemicals when it came to the carcinogenic effect. Friberg's response was that he could not take charge of risk calculations on that basis; his colleagues all over the world would laugh at him. After we had squabbled about this for a while, Friberg initiated an international meeting of scientists at *Karolinska Institutet*. The Energy and Environment Committee's report has the following to say about this:

> In order to obtain as in-depth a scientific illustration of the connection between air contamination and cancer as possible, *Karolinska Institutet* arranged an international meeting of scientists at the Committee's request on 8-11 March.
>
> Twenty or so foreign scientists were invited to the meeting from Canada - the UK, the United States, Sweden, the Soviet Union and West Germany, and representatives of the World Health Organisation (WHO) and the United Nations' environmental programme (UNEP). The participants were selected following proposals from WHO's head office in Geneva. A list of the participants can be found in the Appendix to the health and environmental effects of fossil fuels.
>
> The purpose of the meeting was to bring together internationally-renowned experts on the effects of radioactive radiation* and air contaminants to discuss the extent to which experiences within the one area could be applied within the other. In a summarising final report from the meeting, the participating scientists agreed that, from the risk assessment point of view, the same approach as for radioactive substances should be applied as regards carcinogenic air contaminants. This means that even small additions of carcinogenic substances to the surrounding air may add slightly to the number of cases of cancer over a large population and over a long period. Such broad agreement regarding what has been scientifically justified in such an approach has not really been known before.
>
> The international meeting of scientists thereby made an important contribution to the Committee's assessments of different health risks. The full scientific report from the meeting will be published in *Environmental Health Perspectives* in February 1978.

* A lapse on the part of the Secretariat and inattentiveness on my part: the radiation is not radioactive – it is called ionising radiation.

11.15. **UNSCEAR's 26th session in Vienna**

UNSCEAR's 26th session was held in Vienna on 13-22 April. The Chair this time was Dr. M. Klimek from Czechoslovakia with Professor F. E. Stieve from West Germany as Deputy Chair and Dr. K. Sundaram from India as rapporteur. I was the Swedish representative with Gunnar Walinder as deputy and Kay Edvarson, K. G. Lüning, Jan Olof Snihs and Evenym Sokolowski as advisers.

This was the concluding session in a cycle which led to the 1977 report, a massive 725 A4 pages, the majority of which consisted of the ten scientific Appendices.

Appendix A contained an introductory discussion of the concepts collective dose and dose commitment. Appendix B on natural radiation still gave the lung dose from the daughter products of radon as an absorbed dose and thus did not give a fair indication of its significance.

The estimate (in Appendix C) of the global radiation doses from the radioactive fallout of strontium-90 and caesium-137 from the nuclear weapons testing showed that caesium caused the greatest problem, but this was not that easy to that see since the text was influenced by the previous belief that strontium caused the most damage. The table that summarised the dose estimates was not easy to interpret because it stated organ doses in millirad without weighting for the biological impact.

Appendix D gave an extensive account of the emission of the radioactive substances from nuclear power's fuel cycle for the first time, i.e., all procedures from uranium mining right through to waste handling. The estimated radiation doses were dominated by contributions from krypton-85 and very small but long-lasting contributions from tritium and carbon-14, in these cases from reprocessing plants.

Appendix E reported radiation doses to people working with sources of radiation. Here, for the first time, the Committee used the method which Dan Beninson and I had worked out in 1975, i.e., stating the fraction of the total collective dose that was formed by individual dose contributions exceeding 1.5 rad in relation to a reference distribution.

Appendix F concerned medical irradiation. It gave an indication of how large the collective dose for a population of irradiated patients in an epidemiological study had to be to allow significant results (95% probability) to determine the risk of cancer. The stated values were 100,000 man-rad (approx. 1000 man-sieverts) for leukaemia, 420,000 man-rad for breast cancer, 4 million man-rad for lung cancer and more than 10 million man-rad for 'other' forms of cancer. Typical radiation doses to skin, bone marrow and a number of internal organs from different types of examination were given, including the use of radioactive nuclides.

Appendix G was based on Dr. Pochins' report of the risk of cancer from ionising radiation. The Committee's estimate of the additional likelihood of deaths from cancer at low radiation doses was 100 per million and rad (approx. 1% per sievert), but it was emphasised that this was based on uncertain extrapolation from high radiation doses.

Appendix H dealt with the hereditary effects of radiation. The unsafe estimate of the likelihood of hereditary injuries was approx. 200 per million and rad (approx. 2% per sievert). It should be noted that the risk of death from cancer and the likelihood of hereditary injuries are not easy to compare.

Appendix I, the penultimate Appendix, dealt with experimental radiation carcinogenesis. It discussed things such as the assumption that cancer originates from somatic mutations and, on that basis, the consequences of applying hit theories with different numbers of necessary hits in a 'sensitive volume'.

The last Appendix (J) concerned the risks of the irradiation of foetuses. However, there was still no discussion regarding the reduction of intelligence as a consequence of the irradiation.

11.16. **The Swedish Radiation Protection Institute's Code of Statutes**

Two people worked with writing regulations in 1977: *Lennart Holmberg* and *Leif Moberg*. On 22 April, Lennart was able to proudly send out the first copy of the Swedish Radiation Protection Institute's Code of Statutes (SSI FS 1977:1) on 'The National Radiation Protection Institute's provisions regarding the application of the Radiation Protection Regulation, signed by me and Åke Persson. Lennart and Leif had a meeting with Gunnar Bengtsson and me on 4 October and the work for the next two years was then planned.

11.17. **IRPA in Paris**

IRPA held its 4th Congress in Paris. I have no recollection of it, but I have photographs showing me and Dan Beninson.

11.18. **ICRP in Brighton**

ICRP with its Committees met at the Bedford Hotel in Brighton on 2-6 May. I had now succeeded Gordon Stewart as Chair while Dan Beninson succeeded me as Deputy Chair. At the customary dinner I gave a talk, somewhat influenced by the Beatles:

> I am going to tell you something of the amazing progress recently achieved by the
> Contrarational Provision on Radiosensical Ignition
> usually deferred to as the CPRI. My information has been betrayed from the Provision's Secretific Sensotory, Dr. Savid Dowby.
>
> Dr Dowby reforms me that the Provision has decently riskued a new Retort, called Lubrication No. Nontineven. This is on redundant Non-entities and Doughnuts.
>
> The most eminent Non-entity is the so-called *connective booze commitment*, the donut of which is the millikilogram per kilomilligramme which, for the purpose of the Retort, has been shaken to be approximately $e^{\pi\sqrt{5}}$. A perpendicular name of this doughnut is a special shade of grey, usefully shamed Black and White, which is never abbreviated.
>
> If the individual comboozements of the connective booze commitment are weighted by a confusion factor, Q, which is rubbished by the Provision as a junction of the VAT, the weighted product is no good. It is called the global per caput connective booze equivalent committee and has no more than eight members of which the Chair casts the dividing vote. It is also good with olives and is called Drei Martini in Germany. There is no cut-off value in this case, which also contains two spoons and a boozemeter. The intake limit is of no complaint to the Provision, which, however, recommends that all boozes be left as slow as reasonably agreeable.

The main work assignment, for which the work had now been planned, was to use the Committees and special work groups, 'task groups', to rapidly produce application regulations for the general recommendations in Publication 26.

On arrival home, I received - as did many others - a letter from Olof Palme thanking me for my help with the series of energy seminars.

From the 4th International Congress of IRPA, Paris, 1977.
From left; Emile Wallauschek, Secretary of the Radiation Protection Committee of OECD/NEA; John Horan, temporarily in charge of the Radiological Protection Division of IAEA; Bo Lindell; and the Danish physician Mogens Faber.

11.19. Conflict between the Nuclear Power Inspectorate and the Radiation Protection Institute

The cooperation between the Radiation Protection Institute and the Nuclear Power Inspectorate included a good number of irritating elements. There were two reasons for this. The first was that a number of officials at the Nuclear Power Inspectorate, including the Chair of the board Gösta Netzén, had difficulty seeing the point of the Radiation Protection Institute having assignments when it came to the nuclear power field. They thought it would be more efficient to have a single nuclear power authority like the Americans' AEC. However, this view had no support in the government and would have led to radiation protection matters being dealt with by both the Nuclear Power Inspectorate and the Swedish Radiation Protection Institute because the Radiation Protection Institute would still be in charge of radiation protection within the other fields, health care for example. There was then a risk that different radiation protection principles could lead to conflicts, as had happened in the USA. However, this view meant that officials within the Nuclear Power Inspectorate sometimes attempted to discuss matters which ought actually to be handled by the Swedish Radiation Protection Institute.

The other reason was the inclination of a number of supervisors not to let go of matters which they had dealt with before coming to the Nuclear Power Inspectorate. One example was Alf Larsson, who had dealt with waste issues during his time at the Ministry of Industry, and after having come to the Nuclear Power Inspectorate, wanted to continue with such issues even though these ought to be dealt with by the Swedish Radiation Protection Institute. The same applied to Sören Norrby, who had dealt with waste issues while at the Radiation Protection Institute and who, in his position at the Nuclear Power Inspectorate, thought that all nuclear power problems ought to be dealt with there. The ambitious Bengt Pettersson, who had been a great asset to the Swedish Radiation Protection Institute, could not let go of radiation protection during transportation, a matter which he had dealt with under us.

These conflicts formed a basis for a letter which I wrote on 29 July to *Thomas Eckered*, who had taken over the responsibility for a number of policy matters within the Nuclear Power Inspectorate. I wrote:

> Thomas:
>
> I have not answered the letter of 27/06/1977 to the Nuclear Power Inspectorate's board regarding the letter to the government proposing a change to the Atomic Energy Act. It is completely unreasonable to request a response to such an important – and controversial – matter within four days in the middle of the summer.
>
> I am completely against the proposal and thus completely against the letter which has gone out, which you can see from the proposal to the referral response which went to the Swedish Radiation Protection Institute's board. Alf Larsson had already proposed a change to Section 1 of the Atomic Energy Act in the Radioactive Waste Investigation but, after I had mobilised the Ministry of Agriculture's lawyers, the report took on another acceptable proposal which I think you ought to have been able to follow.
>
> I am also concerned that the Nuclear Power Inspectorate now appears to be on a complete collision course with the Radiation Protection Institute with the idea that the Nuclear Power Inspectorate is to be responsible for <u>all</u> of the waste handling, not just, as is the case for the reactors, the plant safety and product control.
>
> As you probably know, I raised these qualms at a board meeting where you all assured me that they were unfounded. I cannot see how they are unfounded from the way in which the letter to the government is formulated. We need calm cooperation. The world outside is troublesome enough as it is. I thought we had completely agreed on the distribution of responsibility. If so, why on earth did the letter go to the government worded like that?
>
> This marked change of direction, right in the middle of the summer and without any real possibility for me as board member to influence the matter, rather depresses me.
>
> I am now exceedingly concerned about the continued work in the waste section. When I questioned wordings in the proposed instruction, the Chair said that our memorandum on [the agreement regarding] the distribution of responsibility between the Radiation Protection Institute and the Nuclear Power Inspectorate carried more weight. Is that not still the case? Otherwise I would like to see a clearer instruction.

11.20. **Three heads of division for the Radiation Protection Institute**

It was now time to appoint the three heads of division as required by the Swedish Radiation Protection Institute's new organisation. Kay Edvarson had already been appointed as head of research in 1976. Everyone was now assuming that Gunnar Bengtsson would become head of the supervisory activity. The task that remained was to find a head of administration. One suggested candidate was Lars Persson who was head of division at the National Council for Atomic Research. He received good testimonials from the Chair of the National Council for Atomic Research, County Governor Mats Lemne (1919-1997), and I therefore put him forward when the Ministry of Agriculture asked for suggestions. When Lars started, he was also elected Secretary of the Nordic Society for Radiation Protection. A month later, Sten Grapengiesser was appointed as departmental director of the X-ray Department.

11.21. **Discussion Lars Friberg – Bo Lindell in *Läkartidningen***

Professor of Health Hygiene Lars Friberg at the Swedish Environmental Protection Agency had been asked by *Läkartidningen* to take part in a discussion with me on the scientific basis for some of the risk assessments in current reports. The newspaper gave the following background:

> The old government had already asked the Energy and Environment Committee through the Ministry of Agriculture to do a comparative assessment of health and environmental risks of the different energy types from nuclear power, coal, oil and water.* In June 1976, the Committee asked the Swedish Environmental Protection Agency to contribute documentation concerning health and environmental effects of fossil fuels and asked the National Radiation Protection Institute to provide similar documentation regarding the effect of nuclear power.
>
> The results of these investigations are now available and will be forwarded to the Energy Commission, which has been active since January this year. ... The Energy Commission's work will culminate with alternative proposals for the formulation of Sweden's energy policy until 1990.

I have selected some contributions from the extensive discussion material. This selection is of course subjective, so the reader is referred to volume 75 no. 33 of *Läkartidningen* from 1977 for a full picture. The newspaper's introduction was:

> The ongoing energy debate between politicians and the public, experts, between decision-makers and experts and man to man are very much about fear. Whether you are looking after the economy, industry, the environment or health there is some threatening danger in some form.
>
> If there is an impending threat to a single individual, this does not mean there is a risk to the public at large. If many are in the danger zone, the risk must be weighed against the value to the public of the activity causing it. We can take our own risks but *enforced* risk worries us more, even if it is a lower risk. We are afraid of what we think or believe is dangerous but we perform no risk calculations. We are simply afraid. We want more information but since we do not really know how risks are calculated, we become suspicious and even less certain about what we should think. We can become aggressive and make unreasonable demands.
>
> The conversation between Lars Friberg and Bo Lindell, two experts who have carefully investigated the health risks of different types of energy, also looked at risks and fear. If anything, they showed a certain amount of surprise regarding specific phenomena and prioritisations.

Following the international symposium on air contaminants, which had been arranged in Stockholm under the auspices of *Karolinska Institutet*, Lars Friberg had changed his view regarding the risk of cancer. Before the symposium, he had not believed that radiation protection's assumption of a linear dose-response connection down to very low doses could apply to chemical carcinogenesis. He had been anxious that we might disgrace ourselves in front of the international experts who had been invited but, to his surprise, had found that Sir Richard Doll, the renowned epidemiologist, was very much on the same page as regards the linear connection, even when it came to cancer from genotoxic substances. Friberg now said the following about this risk:

> At the Stockholm Symposium, we agreed that we must assume that there was no completely safe dose. It is the same calculation method that is used when calculating the effect of radiation, namely that a higher concentration or dose causes a greater

* Energy and Environment Committee's report never received the attention it deserved. It was completely overshadowed by the more politicised Energy Commission. The Committee's report (Jo. 1977:67) still contains the comparison - of many requested - between the health and environmental risks of the different energy types.

number of cases of cancer, but a certain number of cases also occur at lower concentrations or doses if enough people are exposed. This approach is certainly not new but it is significant that a group of experts with very different backgrounds, including cancer scientists and epidemiologists, have agreed in this manner.

Friberg also said:

> Through my cooperation with radiation protectionists, I have realised that we in the chemical toxicology jobs must calculate in the same way as they do with dose commitments and calculations maybe one hundred years or more in the future as regards substances which are accumulated in the natural surroundings and the body. Cadmium is one such example.

As for me, I said:

> I believe the difficulty in arguing about these issues is partly due to a logical fallacy. If I fire a shot directly into a group of people, there is a small risk for each person, but I can always count on hitting someone.
>
> There are two different ways of looking at the risks: the *individual-related*[*] - where a risk of one in ten million is counted as ridiculously small for the individual – and the *activity-related* – where you ask yourself whether an activity which probably claims one human life is unjustified or indispensable. Those responsible for phenomena in society cannot overlook the fact that the total effect of many small risks may lead to consequences.

Friberg replied:

> If you use that approach, you must perform a total evaluation of all risks to which we are exposed, not just for radiation and air contaminants.

My comment about the perception of risk was:

> The particular thing that the expert is anxious about solely with regard to justifying the activity is also perceived as dangerous to the individual person, whether or not that is the case. We also find it easy to forget that our overall risk of dying in a given year is fairly substantial. And we are only interested in that risk in the broader sense in any case. We rarely dwell on whether it is 0.95 or 0.97 in one hundred at our own age. We think we have been given enough information if we know it is approximately 1 in one hundred.

Lars Friberg:

> On the other hand, it is completely acceptable to take substantial risks in some contexts, in traffic for example. People are also not that afraid of getting cancer from air contaminants and do not particularly care about smoking being very dangerous, but people are very afraid of getting cancer from radiation.

I said that experts in the area did not see the problems of waste from nuclear power as a particularly major issue, and continued:

> But for the public and politicians it clearly determines the existence or non-existence of nuclear power. The risk of disaster has certainly been discussed but not in the same

[*] I have inserted the italics in this section for the sake of clarity; they were not in *Läkartidningen*.

> way at all, and it does stir up the same feelings. It is very odd because a human error or oversight can lead to a very big disaster and threaten large areas.

Here, *Läkartidningen's* reporter *Carina Kempe* interjected:

> Does that mean it is communication problems which are making people more afraid of invisible risks than of a car accident or another disaster?

Lars Friberg's response was:

> It is not only that. You cannot frighten someone with numbers. That is shown by the amount of smoking that goes on. ... I think it is essential to highlight the need for a real contribution to what is known as the environmental medicine field. It is important to initiate proper epidemiological monitoring, which is something that we do not have.

I took up the lead here:

> Yes, this is something that surprises me almost as unspeakably as the cadmium issue. People deal with epidemiology at the most dispersed institutions but there is no special institution to consult and no actual scientific training.

11.22. Troublesome radiation protectionists?

I quote from Franz Marcus' book on the Nordic cooperation (Marcus, 1997):

> As safety questions predominated and waste management became an important issue, it was important for the Nordic Liaison Committee* to involve both established and fledgling nuclear safety authorities in its activities. During the 1970s the authorities were reinforced in all countries. In Sweden, nine new posts were created at the Nuclear Power Inspectorate between 1974 and 1976, and the Institute for Radiation Protection assumed responsibility for all research in its field. In Finland the total sum for nuclear safety research and authorities was increased and amounted to FIM 18 million (almost ECU 4 million). Six senior staff members from Risø were taken over by the Danish Nuclear Inspectorate at its creation in 1973.
>
> In cases of need, the nuclear inspectorates could call upon additional manpower which was available at the research institutes - with or without payment. Many of those involved would make use of their Nordic relations in their work. Thus, expertise from Risø was also available to the Danish Environmental Agency when it evaluated projects on the safety of reactors and waste disposal.
>
> The radiation protection authorities continued their annual meetings and invited the Nordic Secretary to attend.
>
> ...
>
> Personnel relations between the directors of the radiation protection authorities were excellent. At one occasion at the end of a meeting at Forsmark, the Nuclear Power Inspectorate Director Lars Nordström before leaving his job in 1983 invited the combined group of Chiefs to his private castle in Penningby, located at the East Coast where Russian invaders had been a threat a few centuries ago.
>
> The radiation protection authorities had a network of working groups and contact groups, originating from the work with the Nordic Flag Books. Then, however, the work extended to other fields, some of which were common with NKS-related project groups. The leaders of the authorities now participated in the meetings of the Nordic Liaison Committee, but often gave the impression of being on guard to preserve their domain

* See Section 23:16

as independent authorities. There was a traditional scepticism between the radiation protection chiefs, under the leadership of Bo Lindell, and other participants in the Liaison Committee meetings, most of which were related to the Ministries of Industry or Energy. The authorities preferred to keep a distance to underline their independence. This antagonism is said to originate from a discussion between the Danish physician Juel Henningsen and Niels Bohr who refused to divulge his politically sensitive knowledge, and to Rolf Sievert who was jealous of the large sums available in Sweden for the reactor programme.

11.23. **Snihs and Boge to COGEMA?**

I reproduce the following memoranda from 30 September and 3 October:

Friday 30 September

A hectic day. At 10.00, the Moberg report* will be submitted to Anders Dahlgren with the press conference at 10.30. At 14.00, Carl-Gösta Hesser had his 50th birthday at home on the corner of Narvavvägen and Strandvägen.

The question of a letter to Pellerin in France regarding a visit by Snihs and Boge to La Hague on 17 October is very relevant. Given the infected political situation, it may be wise to keep the Ministry for Foreign Affairs informed. I consult Kay Edvarson†. He says people should not ask unnecessary questions. I learned that early on in the military. However, it might not be wise to ask the Ministry for Foreign Affairs about the etiquette so that the Radiation Protection Institute does not run its own foreign policy. Why not contact Lars-Göran Engfeldt – he's a shrewd man‡.

Phone Engfeldt and say we have good contacts with our French sister organisation and that I intend to write for advice, details and hopefully an invitation to La Hague. Probably OK, says Engfeldt, but asks me to hold on while he enquires after someone. Johan Lind, who is in on the matter, is not at home. After a while, Engfeldt returns. He has consulted Anders Sandström. The Ministry for Foreign Affairs should probably not be giving me any official advice. It would probably be normal to write to Pellerin if there is usually good contact between the French and Swedish authorities. On the other hand, it is a sensitive situation at the moment. The informal advice on the phone from the Ministry for Foreign Affairs is that I should perhaps speak to Olof Johansson.

Consult the Minister for Energy? Another Ministry? I complain to Kay, who agrees. I say I'll try ringing Fredrik Damgren§. Not necessary, says Kay, but in any case not as bad as ringing another Ministry. Damgren is not in until after 13:00. [I] inform Gunnar [Bengtsson].

Go to the Ministry of Agriculture for the submission of Moberg's report. At the press conference, the only questions are asked by Olle Alsén and Ulla Magnusson (Ambio). Afterwards, I ask to speak to Bo Assarsson, who may well be going to La Hague for the Energy Commission. I say I think I have done my duty for the Ministry for Foreign Affairs and do not want to start an avalanche through the Ministry of Agriculture. Assarsson agrees it would be wrong to contact another Minister and that I have now informed agriculture through him. He promises to speak to Fredrik Damgren.

While with Hesser I recount the case to Arne Hedgran. He tells me about when Kennedy sent Acheson to de Gaulle to tell him about the impending Cuba blockade. Am I being informed or consulted? asked de Gaulle.

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* The report from the Energy and Environment Committee (Jo, 1977:67) entitled *Energy, Health, Environment.*

† At the time, Kay was head of research at the Radiation Protection Institute and known for his good judgement.

‡ *Lars-Göran Engfeldt* (1944 -) was still at the Ministry for Foreign Affairs in Stockholm but was later promoted into the foreign affairs administration.

§ Fredrik Damgren was my very shrewd contact at the Ministry of Agriculture and later as the Administrative and Legal Officer at the Ministry of the Environment.

Back at the Radiation Protection Institute I ring Damgren and say I want to inform, not consult. Damgren thinks it is reasonable for me to write and that I have fulfilled all information requirements. He agrees not to be consulted; he would have difficulty giving any response other than through Dahlgren and it would be tearing up such major contributions. I say you can tell me not to write, but that I would see it as inappropriate involvement on the part of the Chancellery in the authority's action. I would be furious if another Minister attempted to give the Radiation Protection Institute orders. On the Sunday I write out a long telex to Pellerin on perforated paper tape, ready to be sent on Monday.

Monday 3 October

Waited to send the pre-prepared telex to Pellerin in case anyone might hear from the Ministry for Foreign Affairs. In the morning, tried to contact someone at the Ministry of Agriculture who was willing to peak to Len Hamilton. The latter arrived in Stockholm yesterday after visiting Döderlein in Oslo. I contacted him at the Hotel Anglais [on the Sunday] and arranged to meet him there at 19.30. We walked in the cool rain down Biblioteksgatan, Norrmalmstorg, Kungsträdgården, over the old Parliament House's yard, past the Chancellery to Cattelin's fish restaurant and ate pickled herring and cured salmon with stewed potatoes. Hamilton told me about his plans (supported by ERDA) to create a new organisation like UNSCEAR or ICRP as regards the health and environmental risks of energy production. He was to meet Lars Friberg on the Monday.

It was to be a scientific Committee, said Hamilton, and asked which organisational form I could advise: within the UNEP, affiliated to the ICSU, or under the OECD. IAEA would not be credible, he thought, and WHO not powerful enough. He did not believe in the UNEP.

I said that the ICSU would drag in the bureaucracy of the science academies and that there were principal difficulties. If there were an intergovernmental organisation it would be difficult to evade the Ministries for Foreign Affairs as gateways, and how would you then reach the right body within these countries? And how would you limit the participation to a small group of knowledgeable scientists? How would you limit the number of countries which would be involved and how would you prevent countries from sending politicians or bureaucrats? ICRP grew out of the radiology societies. IRPA has been formed from radiation protection societies. If Hamilton was thinking of forming an equivalent energy consequence society, it would be a company that would take many years to push through. UNSCEAR was formed with a few member states in 1955 by the UN, the equivalent of which would be impossible in today's situation.

I promised to try and arrange contact with Lennart Lindgren initially. Spoke to a busy Lindgren on the Monday morning and to an equally busy Damgren, although the latter did promise that someone from agriculture would try and contact Hamilton while visiting Friberg.

The Nuclear Power Inspectorate's board meeting between 11.00 and 12.00 discussed Barsebäck's testing in accordance with the Stipulation Act. Having returned to the Radiation Protection Institute, I let the telex to Pellerin go. After the Deputy Director-General meeting at 13.00-15.00, Pellerin rang. He began by saying, 'You must understand that in France we have a strong centralised government with strong principles in foreign affairs. How would you like to receive French inspectors at Kiruna if we were to buy Swedish steel?' He had spoken to the Director of the CEA* and to the French Ministry of Foreign Affairs and been told, 'Do not officially take any position.' My telex had asked for advice and information on COGEMA and the reprocessing options in La Hague, and I had asked whether Pellerin could arrange a visit by Snihs and Boge. An extremely delicate question. I emphasised that 'inspection' would be inappropriate and that we could not demand any information. On the other hand, we were forced, no later than at the board meeting on 10 November through the Nuclear Power Inspectorate, to give a referral response regarding the application of the

* *Commissariat à l'Énergie Atomique*

Stipulation Act to the reprocessing agreement between the SKBF and COGEMA. They would ask us to describe the conditions in France and we had only Swedish newspaper information to pursue. Pellerin declared his eternal friendship and indebtedness to Sievert's institution which he had copied in France, promised to send stacks of material and to try to convince Minister Giraud to approve a visit by Snihs and Boge.

11.24. **Energy, Health, Environment**

The report from the Energy and Environment Committee was submitted to Minister of Agriculture Anders Dahlgren on 30 September. It was entitled 'Energy, Health and Environment' (SOU 1977:67). I have already emphasised the contrast between the value of the report and the total silence it met in the shadow of the Energy Commission's more revered work. It should be added that, thanks to good contributions by my extraordinarily knowledgeable colleagues[*], the Radiation Protection Institute's Appendix SOU 1977:69 (Health and environmental effects of the use of nuclear power) became an exceedingly readable report which summarised the knowledge situation at the end of the 1970s. Seven more detailed interim reports from the Radiation Protection Institute were enclosed in less pretentious form.

It is interesting to read what was said in the introduction to this Appendix:

> In the final version of the more detailed interim reports, the Radiation Protection Institute will be able to include more complete material than that which has been available so far. This is particularly important as regards the consequences of very big reactor accidents, which will be the most significant yet at the same time the most difficult-to-assess factor in the overall assessment of nuclear power's health and environmental problem.

This reflected our view that the risk of an accident ought to be given greater priority than the waste problems which dominated the general discussion. This is where we mistrusted what as far as we were concerned amounted to exaggerated faith in probability calculations on the part of the safety experts.

11.25. **The Congress of Radiology in Rio**

The 14th international Congress of Radiology was held in Rio de Janeiro at the end of October. This was the first Congress of Radiology in South America. The meetings were held in a conference centre a good distance outside Rio. A bus went there but I did not know where from, so I took a taxi on the first day. We travelled and travelled and I started to think that the driver had either misunderstood the address or was attempting to kidnap me, but this worry was unfounded. At long last we arrived at the new Centre, which proved to be incomplete and looked like a construction site.

I had booked a hotel in a less fashionable part of Rio and found Professor of Genetics Fritz Sobels, the UNSCEAR representative for Belgium (including experts from the Netherlands) there as well.

The greatest gain from taking part in big Congresses is not usually what is said in the presentations, at least where radiation protection is concerned. Direct contact with modern communication systems means that news spreads in advance. The real benefit comes from contact in person, usually informal. The important thing for me was to replace Gordon Stewart as Chair of ICRP. It involved common contact with representatives of the Congress of Radiology. But I also gave a presentation on *New trends in radiation protection*.

I was attracted by the big statue of Jesus on top of one of the mountains but was disappointed that the mountain railway that went up there was temporarily out of order. I then decided to walk up to the statue. There was a road which initially went through a residential neighbourhood. Not the usual villas you

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[*] Ragnar Boge, Kay Edvarson, Lennart Holmberg, John Christer Lindhé, Sven Löfveberg, Lars Malmqvist, Leif Nyblom, Åke Persson, Jan Olof Snihs and Birgitta Svahn, and Monica Carlson for the editorial work.

would find in Sweden, but large, expensive buildings that were screened off from the road with high walls within which dogs barked their anger at me. If you were rich, you clearly needed to protect yourself.

As I climbed higher, the road wound its way through poor *favelas* on the steep slopes. The contrast was enormous. I was soon being followed by small boys who picked up snowball-sized stones of which they carried a stash on one arm. This worried me a bit because the stones were presumably meant to be thrown. After a while, the road went into a forest where the branches of the trees met and formed a ceiling and a dark tunnel. I wondered whether there might be any poisonous snakes in the trees, prepared to slither down over anyone who entered the forest. I had no idea whether there was a real risk or not, but I assumed that it was not that usual for tourists to be walking around. And bearing in mind my following of stone-carrying, seemingly expectant young boys, I turned round unheroically and gave up the attempt to reach the statue of Jesus.

In the afternoons I sat at a table with a cold beer in front of our hotel with Professor Sobels who was in need of company. Lightly-clad, pretty mulattoes enquired about the possibility of extra income and asked where we came from.

'From the moon,' I replied.

'Yes, I can see that,' said one of the girls and stroked her hand over my cold bald crown.

Sobels left the hotel a few days before I did. After a while I received a telegram from him. He had left his hat at the hotel and asked me to take it with me to Europe.

So I flew home with Professor Sobel's hat for company.

11.26. **ICRP in London**

The ICRP Main Commission had another executive meeting at the Ciba Foundation in 41, Portland Place in London.

11.27. **The Radiation Protection Institute's board takes a study trip to Barsebäck**

The Radiation Protection Institute's board visited the Barsebäck Nuclear Power Plant on 10 November, held a meeting there and was given a presentation about *Sydkraft* and the power plant. Director Yngve Larsson was hosting the visit. The County Administrative Board was represented by executive officer Rolf Hellman.

11.28. **With the Beninsons in Tehran**

In November, IAEA arranged an expert group meeting in Tehran. The choice of meeting place had nothing to do with any activities in Iran – it was dictated by a desire to globalise the distribution of IAEA's activities. I took part in the meeting which was arranged by Dr. Daw, and flew to Tehran on 23 November along with Dan and Ambretta Beninson. Dan had Argentinian colleagues in Iran. They were advisers to the government regarding a planned nuclear power expansion.

When Prime Minister *Mohammad Mosaddeq* was overthrown in 1953 after having chosen to nationalise the British-owned oil industry, Iran had been completely under the control of the USA-supported Shah *Mohammad Riza Pahlavi* with the assistance of the dreaded secret police SAVAK. But the Shah's dictatorial regime aroused opposition from the Shiite theologians (the mullahs), the merchants in Tehran's enormous bazaars, university students and striking workers. There was noticeable tension between the Shah's police and these groups.

On arrival in Tehran I wrote home:

> 25 Nov.: I have now arrived in Tehran and all is well. It is warm autumn weather here but sunny. Not particularly Oriental. Our meeting begins tomorrow.
>
> Dan's colleagues met us at the airport. The sun is shining here and it is +10º.

> 29 Nov. All is well here and the meeting is going well. The traffic is indescribable with millions of cars almost at a standstill on the streets all the time and they take an incredibly long time to move any great distance. Tehran lies at the foot of the mountains on the desert plateau. You see snow-clad mountains all the time.
>
> Today we have had half a day free and have wondered around looking at the bazaar. It is indoors with a total of 50 km of streets and shops containing silver, carpets and everything you can think of. The weather is good, approx. 15º in the daytime and 5º in the evenings. We fly to Paris in the morning.

We stayed at the Tehran Palma Hotel where we were impressed by the real carpets and by the fact that a Muslim country was serving alcohol in the bar. However, our American colleague Harold Peterson warned us about visiting bars since there was a risk of Islamic attacks. He also said that the American embassy had warned him about an impending coup d'état organised by the mullahs. He viewed the black-clad mullahs with the greatest of suspicion and said that we must behave cautiously. I repeated to Dan what I had previously told him about the Ayatollah Khomeini who was staying in Paris. I had seen a TV programme about the Ayatollah, which said that he was in the process of returning to Tehran to lead a revolt against the Shah. Dan did not believe me. Khomeini was just one of many lunatics, he said. The Shah was too powerful.

We visited the big bazaar. On the way there we saw something which I can never forget, the 'dog children' on the streets. Parents had mistreated their children so they could no longer walk, only crawl. The objective was to arouse sympathy and receive money; instead, the only thing they aroused was hatred.

Dan signed a radiation protection research cooperation agreement with his colleague Dr. Parnianpour. Our impression of Iran was that it had high ambitions but lack of knowledge. Lifts did not stop on the floor for which we had pressed the button. When we turned on the switch to light u the room, the lights went out elsewhere. The copiers did not work. Taxi drivers were happy to drive on pavements in order to reach their destination. We visited a 'nuclear research station'. We had a demonstration of a *tokamak* (torus-shaped chamber with magnetic fields) for fusion research, but they showed only how it was possible to obtain a normal gas discharge. There was higher competence at a small experimental reactor where the responsible physicist showed that he knew his stuff.

We flew back to Paris (the OECD/NEA) on 4 December. On 16 January 1979, the Shah fled from his rebellious country. On 1 February, the Ayatollah Khomeini arrived triumphantly in Tehran from Paris and the islamification began.

11.29. **Gunnar Bengtsson to Guatemala**

At the end of the year, Gunnar Bengtsson went on a long trip; he had grabbed a four-month UN assignment in Guatemala. After his return in May 1978, he wrote down his dramatic experiences in a book entitled 'Situations and atmospheres in Guatemala'. He published the book himself in A4-format.

12. THE YEAR 1978

12.1. UNSCEAR's 27th session in Vienna

UNSCEAR met in Vienna on 17-21 April. It was the first session of a new cycle. Once again, the Chair was Dr. M. Klimek from Czechoslovakia with Professor F. E. Stieve from West Germany as Deputy Chair and Dr. K. Sundaram from India as rapporteur. I was the Swedish representative with Gunnar Walinder as deputy and Kay Edvarson, K. G. Lüning, Jan Olof Snihs and Evenym Sokolowski as advisers.

In my letter to the Ministry for Foreign Affairs in March, in which I proposed the composition of the Swedish delegation, I had written the following about the content of the meeting:

> The imminent session is the first in the work on a new report which can be expected to be finished in two - three years [it was finished in 1982]. The purpose of the meeting is to discuss the Secretariat's proposal for the contents of this report, to agree a draft and establish a work plan. The subjects that have been proposed, and the emphasis of which in the forthcoming work is valuable from the Swedish point of view, include a general evaluation of the genetic radiation risks, a review of the consequences of high doses of radiation (as in radiation accidents), the interplay between radiation and chemically toxic substances, naturally-occurring activity in building material and the risks from radon in homes that have a low level of ventilation, the radiation risks from the various process stages in the nuclear power industry, global environmental contamination from nuclear charge explosions and nuclear power plants, the risks to patients from x rays within healthcare and the radiation risks in radiological work.

12.2. The Energy Commission's view of the risk of radon

On 14 April, *Svenska Dagbladet* carried an article with the front-page headline 'Warning to the Energy Commission about 'cigarette-type' risks: **Airtight houses can lead to lung cancer!**' Professor *Maths Berlin* (1931-2015) was the person being interviewed. On behalf of the Energy Commission he had compared the Radiation Protection Institute's surveys of radon in indoor air with the risk that radon posed to miners. Berlin, who was Professor of Hygiene in Lund, was quoted as saying:

> In some types of house, the risks are already too high; this applies to airtight houses made of blue concrete. The risk of those living in these houses getting lung cancer is around the same as for people who smoke.

Svenska Dagbladet's reporter, *Katrin Hallman*, also quoted me as having written that living in a wooden house was simply not enough. I had said that the earth and concrete slabs in the ground also emitted radon. I therefore thought the crucial factor had to be the ventilation, not the building material. Katrin Hallman continued as follows (not sure whether these are her own words or whether she was quoting me):

> The debate on radon has been ongoing for many years, but not until now has it been clearly stated just what great risks of lung cancer there actually are.
>
> The debate has reached a new momentum with us building increasingly airtight houses to save energy. The easiest way to get rid of the radon gas is to air the rooms

properly and not keep our windows airtight*, but there will be draughts and energy will be wasted.

Up until 1950 we had houses that were not particularly airtight, but our homes changed in the 1950s. More of the houses were made of concrete and we made them more airtight.

Maths Berlin was then quoted:

> We can probably expect the number of cases of lung cancer to steadily increase over the next few years and to reach a peak in around 30 years and remain at that level for a long time.
>
> On average, the level of radon in our homes now is more than double what it was in the 1940s. Given the oil crisis, fewer windows are being opened.

The final person to be quoted was Assistant professor *Erik Arrhenius* (1931-2012). He was Deputy Chair of the Energy Commission's group for safety and the environment, and later in the year became Professor of Cellular Toxicology at Stockholm University. We are worried that this is a growing problem, said Arrhenius.

Lennart Holm (1926-2009), Executive Director of the National Board of Physical Planning and Building, was interviewed in a parallel article. Unlike the Radiation Protection Institute, it had regulatory responsibility for building protection measures. We had previously had difficulty convincing the National Board of Physical Planning and Building just how great the radon risk was. 'Measures must obviously be taken if new surveys come up with results showing that there are risks of lung cancer in the existing houses,' said Lennart Holm, who did not appear to have read the Radiation Protection Institute's brochure called 'The Radiation in our Homes' from 1976. There we had said that radon was probably responsible for a significant share of the total number of cases of lung cancer (the majority were caused by smoking). Holm now said:

> All those at the National Board of Physical Planning and Building who have been responsible for ventilation matters have had close contact with the Radiation Protection Institute (SSI). Having consulted the Radiation Protection Institute, the new building standards came out, which means that houses are becoming more airtight and the standards for air change in rooms are now somewhat lower than they were before.
>
> Earlier, we have been balancing health and the ambition to save energy. We thought we were at a level which led to good health protection. If new results show that the protection is not as good as we thought, we must obviously reconsider the standards, even if this leads to higher costs and lower energy-saving efficiency.

I was also interviewed in the same article after the introductory phrase 'The head of the Radiation Protection Institute, Professor Bo Lindell, says that the Institute has warned that houses that are too airtight lead to a greater level of radon and thereby a greater risk of lung cancer'. I had said:

> A few years ago [it was 1976], we sent out a brochure to all building and healthcare authorities in which we said that a significant share of cases of lung cancer may be due to radon and smoking, but the press did not pay much attention to the brochure.
>
> We were surprised by how low the air change is in some modern houses and have informed the National Board of Physical Planning and Building that the lower level of ventilation leads to essentially greater risks.

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* This is pointing out the difference between *airing* and *ventilation*. Airing purely leads to a temporary reduction in the level of radon and is therefore not an effective protection measure. Ventilation leads to a continuous air change and therefore has a more sustainable effect.

12.3. **'Extraordinary reports'**

A man by the name of *Ebbe Forsberg* had had a discussion article on radon in *Dagens Nyheter* on 28 April and had asked the Radiation Protection Institute a number of questions. I answered on 6 May in an article with the headline: 'Extraordinary reports. Serious worry concerning radon gas'. The article outlined the problem and marked a crucial stage in the radon issue; a longer extract is therefore worth seeing:

> When, at Professor Rolf Sievert's initiative, the Radiation Protection Authority in Sweden began researching the levels of radiation in our homes at the start of the 1950s, this was a unique initiative which met with criticism and derision [from] other scientists who thought that the insignificant radioactivity in building material could not possibly cause any harm. The research that Sievert started led to Bengt Hultqvist's important doctoral thesis in 1956 on the radiation in our homes.
>
> Hultqvist measured the radiation in a large number of homes in 13 medium and small towns and cities in Sweden. He showed how we are hit by penetrating gamma radiation from the radium, potassium and thorium in the building material and how we inhale radioactive daughter products of the radon gas which is formed when the radium decays. He also showed that the amount of radium in different building materials differs considerably and that primarily the shale-based gas concrete (blue light concrete) contains significantly more radium than ordinary concrete and bricks.
>
> With the radiation protection standards of the time, it was thought that 500 millirem (5 millisieverts) per year was an acceptable radiation dose for the public from artificial sources of radiation. Hultqvist did not find even in extreme cases that any home had a higher level of radiation. More worrying was the problem with high radon levels. Hultqvist showed that radon levels in indoor air where there was poor ventilation could be higher than that which corresponded to the International Radiation Protection Commission's (ICRP) recommendation if you viewed houses as 'unnatural' sources of radiation.
>
> It is possible that at that time one would have been more cautious as regards the most radioactive gas concrete if the high radon concentrations had been found only in houses made of this material. However, high radon levels were found in brick houses and in wooden house basements where the radon penetrated up from the ground.
>
> Hultqvist also found acceptable radon levels in houses made of the most radioactive gas concrete if the ventilation was good. The opinion was that it was not possible to remove the problem with radon simply by getting rid of certain building materials - the solution was to have good ventilation, which was generally desirable from a hygiene point of view.
>
> In the following year, desires were expressed to produce building material from shale-industry slag. People were advised against such projects for radiation protection reasons. The view was that stricter requirements could be applied to completely new materials than to materials which already existed in our homes.
>
> When the Radiation Protection Institute [which was formed in 1965] in the mid-1960s was given greater resources, it resumed its surveys of the radiation in homes. The building industry was informed in 1968 through the Swedish Institute for Building Research by means of a couple of information sheets. The Radiation Protection Institute was also informed that the manufacturers of the most radioactive gas concrete intended to change over to other materials.
>
> ...
>
> The discovery [in the early 1970s] of lung cancer among miners who worked in a strongly radioactive environment showed that the risk that had been previously discussed as hypothetical was real.
>
> The possibility of better risk estimates meant that the Radiation Protection Institute now looked at the situation more seriously. At the end of 1972, the Institute contacted the materials industry and warned that there could be restrictions regarding the production of the most radioactive materials. At the same time, the Ministry of Health and Social Affairs and Ministry of Industry and the authorities in the other Nordic

countries were informed. The Institute also discussed the matter of the international cooperation for the purpose of producing unified standards.

The Institute was now facing a difficult information problem vis-à-vis the public. The problem was aggravated by the oil crisis and the newspapers' advice on how to reduce the ventilation by sealing window cracks and covering valves. In January 1974, the Institute issued a warning through the mass media against reducing the ventilation too far. In 1976 the Institute published a brochure entitled 'The radiation in our homes' which reported new measurements of the radon levels in newly-built houses and gave numbers which showed that the usual radon level in Swedish homes might be causing several hundred cases of lung cancer per year. The brochure was sent to all healthcare committees and building committees.

The production of alum shale-based gas concrete ceased in 1975. When the most radioactive material is no longer being produced, there are good grounds for finding a satisfactory solution to the problem with radon in the houses that are to be built in the future. However, the problem remains in existing houses, and not just in those made of alum shale-based gas concrete. The ventilation is generally fairly low and the average radon level can have the serious consequences which were stated in the Radiation Protection Institute's brochure.

The Institute is currently completing a couple of surveys of the radiation in our homes and the results have recently been reported by Assistant professor Gun Astri Swedjemark at a conference on natural sources of radiation in the USA. According to Swedjemark's calculations, the Swedish population's exposure to radon may have doubled since 1950 and our *current radon levels may cause between 200 and 1100 cases of lung cancer every year, although these will not become known until after a latency period of maybe 20 years.*

The increase is due to a lower air exchange and greater use of shale-based gas concrete up until 1975. However, the risk estimate is very uncertain. The risk cannot be much greater since we currently have a total of around 2,000 cases of cancer per year in Sweden and tobacco smoking certainly makes a strong contribution to these. It may be much lower but we dare not rely on that.

...

The Radiation Protection Institute will be issuing standards for the radioactivity of building materials as soon as the international group within the OECD which prepares this has drawn up its proposal.

...

A final solution for the problem with radon is still far away. The Radiation Protection Institute's brochure [from 1976] said: 'By all accounts, the risk of lung cancer from radon in homes is greater than the risks from the presence of other radiation in the community and cannot immediately be said to be acceptable'. There is therefore no reason to be satisfied with the situation and different measures for keeping the radon levels low should be tried.

If the consequences are as great as we now believe they are, this is an understatement. The issue is of such a magnitude that extraordinary investigations into what should be done are called for.

The Radiation Protection Institute's freedom to act was inhibited by the fact that other authorities were directly responsible for the formal regulations. The healthcare committees (which would be replaced by environmental and health protection committees in 1983) could intervene if someone had ascertained a health hazard in a home. They had already in 1976 received the Radiation Protection Institute's brochure containing clear descriptions of the health risks. However, their parent authority was the Swedish National Board of Health and Welfare, which would need to come up with instructions. Construction regulations were issued by the National Board of Physical Planning and Building (which would merge with the Housing Board in 1988 to become the Swedish National Board of Housing, Building and Planning). As was generally the case with the Swedes, these authorities still had difficulty seeing how homes could constitute any danger. Close cooperation and understanding on the part of the executive managers would be needed to bring powerful safety measures to fruition. And we had already seen how sceptical the mass media were regarding the Radiation Protection Institute's warnings in 1974 and 1976.

12.4. **The Radiation Protection Institute requests a radon investigation**

In a letter to the government in May, the Radiation Protection Institute requested a prompt investigation into the allocation of responsibility when it came to the problem with radon and the resources needed and the possibility of rapid protection measures. Almost a year would pass before the letter led to any action and a radon investigation committee was set up.

12.5. **The EPA in Arlington (Crystal City)**

A postcard from New York on Sunday 7 May:

> I am writing this in New York but will post it in Washington DC when I have arrived there. The journey to New York went well. In New York it was just 8-9 °C, i.e., pretty cold. I walked from bus terminal with my cases, firstly to the Commodore Hotel in Grand Central building, but the hotel has been closed down so I had to plod on to the Roger Smith on Lexington Avenue where I found a room. I bought a couple of sandwiches and a beer and went to bed at 8 and slept for 12 hours!

I continued on to Washington DC, Crystal City to be precise, a newly-developed area in Arlington west of the Potomac River. Dan Beninson and Gun Astri Swedjemark were already there. We were invited through Bill Rowe of the American Environmental Protection Agency (EPA) to take part in a discussion regarding the problem with radon with the support of the OECD/NEA.

12.6. **ICRP's 50th anniversary in Stockholm**

ICRP had been formed under another name (see 'Pandora's Box') in Stockholm in 1928. It was therefore time to celebrate the 50th anniversary. This was done mainly by a general meeting where the Main Commission and all of the Committees were assembled in Stockholm and the meeting was held at the Birger Jarl Hotel which had access to suitable meeting premises for the four Committees.

Previous functionaries had been invited to the meeting. Lauriston Taylor was of course there as an emeritus member, but we were particularly pleased that Walter Binks had accepted our invitation. We had also invited the Minister of Agriculture, Anders Dahlgren to the anniversary meal at the Wenner-Gren Centre, although he retired when the Fälldin government was replaced by the Ullsten government in the same year.

12.7. **The Nordic-British meeting in Stockholm on 6-7 June**

The routine had been to incorporate the radiation protectionists from the NRPB in the United Kingdom into the meetings which were now often held between the Nordic Radiation Protection authorities. Another such meeting was held in Stockholm on 6-7 June. The Brits were staying at the hotel by Arlanda airport.

12.8. **The Nordic Congress of Radiology in Oslo**

The 36th Nordic Congress of Radiology was held in Oslo with Trygve Aakhus as President. The presentations were divided into four sections: diagnostics, therapy, radiation physics and therapy, and radiation physics. The number of presentations within these sections was 81, 37, 6 and 14 respectively.

12.9. **The reprocessing agreement**

The Fälldin government (1976-1978) had asked the Swedish Nuclear Power Inspectorate to act as the main referral body as regards Forsmark Kraftgrupp AB's application regarding permission in accordance with the Stipulation Act to charge the Forsmark 1 reactor with nuclear fuel. Following a board meeting on 12 June, the Nuclear Power Inspectorate had submitted the documents to the government together with its own statement.

At the time of the Nuclear Power Inspectorate's meeting, I took part as Swedish representative in a meeting of the OECD/NEA's Radiation Protection Committee in Paris. I sent my points of view to the Nuclear Power Inspectorate before my departure to the meeting, but since I had forgotten to put my signature beneath the text the board, under the Chairmanship of Gösta Netzén, was not able to deal with the letter. But they thought it would be an obvious thing for me to give the Ministry of Industry my views after I had arrived home. I did so in a separate letter of 20 June.

The thing that concerned me was that the Nuclear Power Inspectorate made a purely technical assessment of the safety without comments as though the Stipulation Act had not existed. I shared their assessment and thought that interpreting 'safe' in a reasonable way could mean that the charging of Forsmark 1 could be acceptable. But the Stipulation Act was a political law rather than a technical law and I did not think it was the Nuclear Power Inspectorate's task to interpret the law. The Nuclear Power Inspectorate ought to have written that with normal, reasonable requirements, their view was that the charging could be permitted, but that it should be left to the politicians to assess whether this would satisfy the Stipulation Act, i.e., to assess the technical agreement. It was wrong of the government to place the responsibility for the interpretation of the Stipulation Act with the Nuclear Power Inspectorate.

One of the things that made it difficult to apply the Stipulation Act was that in accordance with the agreement with the French company Cogema, the used nuclear fuel would be reprocessed in a plant which did not yet exist. The agreement also said that reprocessing would not take place if the parties disagreed on the specification of the properties of the waste. I found it difficult to see how, with these restrictions, the agreement could be seen to *guarantee* reprocessing, only that reprocessing could almost certainly take place.

My letter to the Ministry of Industry included the following:

> In my view, if the assessment had taken place in accordance with the atomic energy and radiation protection laws, the formal uncertainty elements of the agreement would have been less significant. I believe the planned reprocessing plant will very probably be completed and there will be no reason to doubt that the parties will agree on the waste specification. Even if the fuel were returned without being reprocessed, this would not necessarily do any harm from the radiation protection point of view since we have not yet considered the important fundamental issue of whether fuel from light water reactors really should be reprocessed if it is thought that breeder reactors have no future.
>
> However, the Swedish Parliament has now realised that there are political grounds for a stricter assessment and has introduced the special Stipulation Act, which becomes meaningful only if seen as a number of requirements in addition to those in the other laws. Even if authorities and experts do not understand the special formalism of the Stipulation Act, we must still accept that the test currently in question is a test in accordance with the *Stipulation Act* and not in accordance with our usual laws. The fact that the agreement appears to be satisfactory against the background of the usual laws is no guarantee that it satisfies the Stipulation Act's requirements. As a layperson, I have difficulty seeing how the current agreement can be seen to satisfy the formalism of the Stipulation Act for as long as it is vague as it is regarding a number of points. However, experts in contract law may have a completely different view. However, history is full of experts who have assessed proposals from a limited technical point of view without any regard to the whole picture and I have no desire to appear too naïve.

I completed my letter with:

> In my view, the agreement with a strictly formal interpretation of the Stipulation Act does not satisfy the law's requirements while the agreement with a less formal interpretation and with regard to that which is usually considered to be reasonable in similar contexts could be seen to satisfy the requirements. It is almost a political matter to determine which degree of formalism one should apply to the Stipulation Act.

Like most technicians and natural scientists, I was irritated about politicians messing around creating a law which, if applied literally, would not permit any handling of radioactive waste, but which they evidently had no intention of applying literally. What would the point of the law be other than to put together a collection of fine words?

Katrin Hallman gave a discerning and neutral review of my letter in the newspaper *Svenska Dagbladet* on 21 June. *Bo B Melander* wrote about the letter in the newspaper *Dagens Nyheter* on 27 June. *Svenska Dagbladet's* headline was correct: 'The agreement does not satisfy the Stipulation Act'. *DN*'s headline missed the point and read, incorrectly, 'The agreement does not satisfy the safety requirements'. Olle Alsén also had an editorial in *DN* on 28 June about my opinion on the agreement but said nothing about my dilemma, and failed to say that I thought normal radiation protection and safety requirements were satisfied. In a leader the next day, Alsén's view was that I had knocked 'a big nail in the coffin of the KBS-1 project', which was not exactly what I had thought.

12.10. **The IAEA symposium in Stockholm**

I was in the company of Dan Beninson and K. Z. Morgan at an IAEA symposium in Parliament House and invited them home for dinner. Other listeners at the symposium included Olle Alsén, whom Dan's curiosity led him to interrogate in his usual way. Dan said he had asked Alsén what he thought of me, and the answer had been that at least he saw me as honest.

12.11. **The Nordic Society for Radiation Protection in Visby**

In 1978, the Nordic Society for Radiation Protection held its meeting in Visby. The Society held its first meeting in Stockholm in 1966 and had since then held its meetings in Oslo, Copenhagen and Helsinki in turn since the board moved between the Nordic countries for four-year periods. Bo Lindell was now Chair and Lars Persson Secretary. A large photo in *Gotlands Allehanda* on 5 September showed Lindell and Persson together with Gun Astri Swedjemark and the Swedish Radiation Protection Institute's radiation protection medics Sten-Erik Olsson in front of Østerport. No fewer than 120 of the Society's members took part. The press' primary interest and questions concerned the radon risk.

12.12. **The Beijer symposium regarding risks**

In September, a symposium was held regarding risks in the newly-formed Beijer Institute at the Royal Academy of Sciences, an international Institute for energy, resource and environmental matters. David Sowby and Bill Rowe took part in the symposium and came to ours for dinner. Rowe had driven up to Stockholm and been given a demonstration of special risks in Sweden. He had collided with an elk.

12.13. **The government postpones the charging of Ringhals 3 and Forsmark 1**

On Friday 29 September, the government issued a press release which began with:

> Today, the government has finished considering the applications from the Swedish National Power Administration (*Vattenfall*) and Forsmark Kraftgrupp AB (FKA) to be able to add nuclear fuel to the Ringhals 3 and Forsmark 1 reactors. In this connection, the government has found that the conditions for approval fall short in one respect. The applications therefore cannot be approved right now.

> ...
>
> As regards the reprocessing agreement, the application submitted by *Vattenfall* and FKA to be able to add nuclear fuel to the Ringhals 3 and Forsmark 1 reactors complies in with the Stipulation Act's requirements. On the other hand, in its assessment of the conditions for completely safe final deposition of the highly active waste, the government has found that some supplementary geological surveys are needed for the law's requirements to be seen as being fully satisfied.
>
> ...
>
> According to the government's assessment, further test drilling is needed in mountain areas which, according to the applicants, have the abovementioned geological properties. ...

And this marked the start of the 'borehole carousel'.

12.14. **Statements by Gösta Bohman and Ola Ullsten**

On Tuesday 3 October, Gösta Bohman and Ola Ullsten, i.e., two of the three party leaders in the non-socialist government coalition, made the following statement:

> Last Friday, the decision made with reference to the application to be able to charge the Ringhals 3 and Forsmark 1 reactors remains valid. The agreement shows that the government does not intend to review the case regarding the charging issue, but will endorse the Nuclear Power Inspectorate's decision. The arrangement cannot be changed afterwards or direct or indirectly have new terms added concerning other parts of the energy policy.

Once again, the responsibility that ought to be the government's had been expressly renounced and the policy decision instead been placed on a technical authority.

12.15. **The Nuclear Power Inspectorate and the Stipulation Act**

Memos from 4 October:

> Meeting at the Nuclear Power Inspectorate with reference to the government party members' agreement to let the Nuclear Power Inspectorate take care of the remaining action in accordance with the Stipulation Act. Present: Netzén. Hedgran, Eckered, Giljam, Alf Larsson, Thomas Johansson, Karl-Erik Olsson, Lindell. Agree to produce for the meeting on 19/10 (1) background material and (2) proposed requirements for KBS in accordance with the governmental agreement. Olsson protests that the mass media have assumed disagreement among the Nuclear Power Inspectorate's board because he is present. Alf Larsson says he had imagined a new assessment across the board for the radiation dose but accepts Johansson's, Netzén's and my assessment that it is just a matter of considering whether KBS' *assumptions* are satisfied in accordance with the governmental agreement.
>
> Lunch at Falstaff with everyone except for Eckered. Netzén, Hedgran and Lindell emphasise to Larsson the importance of including also the critical consults to whom the mass media have already referred.
>
> TV and press before and after the meeting. Short press release given out – put on the Radiation Protection Institute's notice board.
>
> --
>
> 13.30: [Göran] Lundell rings from *Radiumhemmet*. A mother is given palliative treatment for an incurable brain tumour. She is pregnant and refuses to have an abortion. Only radiation treatment can extend her life so she can give birth, but the child may then receive 4 rad [40 millisieverts]. How great is the risk? I refer to the BEIR report, [Alice] Stewart et al (in the Swedish Radiation Protection Institute's background paper 'Risk of Cancer' for the Moberg report) and find that the risk of leukaemia is approx. 1 o/oo (the

> foetus is in its 4th month) and the overall risk perhaps ten times. We agree that the child has as great a chance of surviving without being harmed that it is advisable take the risk of saving it through radiation treatment.

12.16. **The Fälldin government falls on 5 October**

The government parties had been successful in agreeing on the commissioning of Barsebäck 2, but for the plants that then applied for permission to run, the Stipulation Act's requirements had to be applied. The current applications concerned Ringhals 3 and Forsmark 1 where the parties did not agree. The Centre Party under Fälldin thought the law demanded rejection of the applications. On the other hand, the Liberal People's Party and the Moderates could imagine an approval, but a conditional one as formulated by Bohman and Ullsten on 3 October. The Nuclear Power Inspectorate was required to approve the rock storage area, i.e., the boreholes. A compromise was not possible for the Centre Party this time. Settling the matter by means of a referendum was not accepted by either of the other parties. The government therefore fell on 5 October due to the nuclear power issue. It was succeeded by a Liberal People's Party minority government led by Ola Ullsten, something which was enabled by the fact that the Social Democrats chose not to oppose the decision. Carl Tham became Minister of Energy for the new government.

12.17. **Anders Dahlgren bids farewell**

On 16 October I received a nice letter from Anders Dahlgren who had departed as Minister of Agriculture when the Fälldin government fell. The government had been replaced by Ola Ullsten's short-term Liberal People's Party government which now had to deal with the political crisis that arose with the disagreement regarding the charging of the Ringhals 3 nuclear reactor. I felt I needed Dahlgren's encouraging words: 'I would just like to thank you for the support that I have always felt you have given as head of the important Radiation Protection Institute. I assure you that I appreciate your honesty'.

12.18. **The radon in our homes**

On 7-15 October I was in our summer house in Västerdalarna. Gunnar Bengtsson rang about the problem with radon which required action. I asked him to discuss the proposed directive for the radon investigation with Gun Astri Swedjemark and Kay Edvarson. At 09:00 on the morning of 16 October I spoke to Gun Astri who wanted advice on how we should handle the problem with the houses that were built on shale ground in Tidaholm. The Swedish Radiation Protection Institute's measurements showed high values of the radon daughter concentration in the indoor air, 120 picocuries per litre [4 400 becquerels per cubic metre!] with 0.09 air changes per hour. Outdoors above the shale ground, the gamma radiation emitted 200 micro roentgen per hour. The radon daughter concentration there was 2 pCi/l when there was no wind. My memos continue:

> I say we must wait for the report when it comes to the *general* statements but that we must intervene quickly with advice to the healthcare committee in this particular case. We can say that we would not permit the [current] measured levels in mines and that they exceed Canadian and American action levels. The advice should come from the Senior Director [i.e., me at the time] and the question be discussed at today's Senior Directors' meeting.
>
> ...
>
> Senior Directors' meeting. The local radio looks for Gun Astri about *Tidaholmshusen*. However, she has not been able to contact the healthcare committee and does not phone until 17:00.

12.19. **Protection against radiofrequency radiation**

On 20 October, the Radiation Protection Institute issued an information sheet on the protection of the public against radiofrequency radiation. It said the intention was to propose guideline values for the maximum permissible exposure of the public to such radiation in the frequency range of 10 MHz – 300 GHz, i.e., with wavelengths between 1 mm and 30 m. It was proposed that the limit values would be 10 W/m^2 for the radiations intensity, 60 V/m for the electric field strength, and 0.15 A/m for the magnetic field strength (H). Bearing in mind that the biological effect of radiofrequency radiation had not yet been completely clarified, it was recommended that, if subjected to long-term exposure, these values ought to be reduced to 1 W/m^2, 20 V/m and 0.05 A/m respectively.

12.20. **Hygienic guideline values for ultraviolet radiation**

On 4 December 1978, the Radiation Protection Institute established hygienic guideline values (‘General advice’) for ultraviolet radiation (the regulation was published as Radiation Protection Institute Regulation 1978:6, or SSI FS 1978:6). The guideline values were said to be applicable for ultraviolet radiation from ‘beams of light, gas discharges, light bulbs and fluorescent sources of radiation if the sources of radiation emitted the UV radiation for a period of time in excess of 0.1 seconds’. The guideline values were stated in a table for wavelengths between 200 and 315 nm, but the lowest values, with daily values between 30 and 70 J/m^2, concerned wavelengths between 250 and 280 nm.

12.21. **IAEA BSS panel in Vienna 23-27 October**

The meeting was the second in a series of three (see also Section 14.20). IAEA and the other organisations which were behind the work (the ILO, OECD/NEA and WHO) were anxious to revise the previous version from 1962 (Safety Series No. 9). It had been prepared by a task group led by Professor Louis Bugnard (see chapter 14 of ‘The Labours of Hercules’) and where Sweden was represented by Lars-Eric Larsson. It had been updated in 1967 by a smaller task group which met in 1966 and included John Dunster, Henri Jammet, Pierre Pellerin and David Sowby.

The work with the now revised version was led by Henri Jammet. I took part as Swedish expert and Lennart Holmberg was there as observer. The other experts included Abel González from Argentina, M. Tschurlovits from Austria, A. Lafontaine from Belgium, W.R. Bush from Canada, Emil Kunz from Czechoslovakia, Fred Morley from the United Kingdom and Bill Rowe from the USA. John Horan represented IRPA.

The main reason for a drastic revision of Safety Series No. 9 was the new policy that ICRP had introduced with its Publication 26 in 1977. Most of the 1967 edition had covered tables containing the values for the maximum permissible intake of different nuclides in breathing air and drinking water. The comments on the tables said that ‘the intakes have been obtained by multiplying the relevant maximum permissible concentration given by ICRP by [the following] standard intakes of air and water’. They had also been based on permissible doses of radiation in critical organs.

However, after Publication 26 there were no longer critical organs and nor MPC values. Calculations would instead involve the annual limit of intake (ALI) and derived air concentration (DAC), and it was no longer organ doses but the effective dose equivalent that was relevant.

12.22. **Argentinian nuclear power**

I was invited to give a presentation (as Chair of ICRP) in Buenos Aires. General Rafaél Videla was in power in Argentina and ‘the dirty war’ had been ongoing since Isabel, the second wife of the deceased Juan Perón, had been appointed President in 1974 to then be removed from office by the military in

1976.[*] Isabel had been a nightclub singer and had married the returning Perón in 1973. Dan Beninson used to say how Perón, when he was criticised for having put his young wife in government, had haughtily said, ‘My decision stands even if I appoint a letterbox as minister!’

Dan was now living in Vienna but I was taken care of by one of his colleagues by the name of Paganini (whom I called Pagadudu[†] for the sake of equality in the formality stakes). I gave my presentation in the Atomic Energy Commission’s building. Then ate lunch with the Commission’s President, Admiral Castro Madero and the management. I was asked how I liked Argentina. My answer was that Argentina had been popular in Sweden through travelogues and Evert Taube’s ‘Fritiofsberg and Carmencita’, but that we did not like the fact that young girls disappeared, perhaps murdered as Dagmar Hagelin was.

Paganini liked cold weather and had the air conditioning in his car set to ice-cold, which quite rightly caused the engine to stall due to condensation while he was driving me around Buenos Aires. He also drove me to the two nuclear power stations in Argentina: *Atucha* and *Embals*e.

During my visit, only Atucha 1 was in operation. The Atucha reactor station is next to the city of Lima on the Paraná River[‡] approximately 100 km north of Buenos Aires. As we were approaching it over great plains, we found it surrounded by military pickets; the country was close to civil war. Atucha 1 was a pressurised water reactor with heavy water (PHWR). The fuel was a mixture of natural and slightly enriched uranium, and the heavy water was both the moderator and the coolant. The reactor was the first nuclear power reactor in Latin America and had been commissioned in 1974. It had an electric output of 357 MW and supplied 2.5 % of the country’s electrical energy.

A second unit, Atucha 2, was still at the planning stage. Its construction began in 1980 but it was still not finished in 2006. The intension was to build yet another PHWR like Atucha 1, but with a considerably greater output, approx. 750 MW.

The second nuclear power plant, Embalse, is by the southern beach of a big water reservoir by Rio Tercero, near the town of Embalse in the province of Cordoba, 110 km south-west of the city of Cordoba. It was commissioned in 1984 and was thus being built when I visited. On the way to Embalse we passed communities that were completely German, formed by emigrants with a dark past. In one place we were stopped by a military patrol which ordered us out of the car. I had a sub-machine gun pressed against my stomach while Paganini attempted to explain our business and show our ID, which he was thankfully successful in doing.

The reactor was built by a Canadian-Italian consortium formed by the Atomic Energy of Canada Ltd and Italimpianti. It now has an electric output of 600 MW net and supplies approx. 4.5 % of the country’s electrical energy. Embalse has also been one of the world’s primary producers of cobalt-60.

A deep, broad water channel, though not yet connected, led to the big reservoir. When I walked on its bed I wondered it might fall apart due to the flow of water, but that was clearly not the case. An enormous tent accommodated canteens for builders and all other personnel. We were served Argentinian meat there by a chef wearing a proper chef’s hat.

I did not have the opportunity to visit the third nuclear physics plant in Argentina, the Ezeiza Atomic Centre, 35 km outside Buenos Aires, where the fuel element was manufactured.

12.23. **UNEP’s scandal meeting in Geneva**

On 20-24 November 1978 the United Nations Environment Programme (UNEP) arranged an expert meeting in Geneva to review a draft of a report on the environmental impact of nuclear power.[*] I had

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[*] The military dictatorship in Argentina lasted from 1976 until 1983.

[†] Untranslatable pun: In Swedish ’ni’ equals ’you’ when addressing somebody formally, while ’du’ is used if you are on first-name terms (cf. vous/tu in French or Sie/Du in German).

[‡] The Paraná River is one of two main rivers to Rio de la Plata (which is not a river but big inlet).

[*] UNEP had been formed in 1972 as a consequence of the UN’s environmental conference in Stockholm and had the task of leading and coordinating the UN’s environmental work. The organisation’s headquarters are in Nairobi, Kenya.

been invited, so the letter that I received from Nairobi said, in my capacity as expert and not as a representative of the Radiation Protection Institute or Sweden. I received the draft of the report at the same time. Not many days passed before I heard from some of the other people taking part in the forthcoming meeting. They were worried about the poor quality of the draft which would make it inappropriate as a working document for the meeting.

The week before the expert meeting I received another letter from Nairobi in which I was invited to act as Chair of the meeting. I accepted the assignment with grave doubts and wrote in my response that the critical points of view I had already heard about the working document led me to believe that it would not be adequate as the sole reason for the discussion.

The meeting had certainly been arranged by the UNEP, but IAEA had been asked for advice regarding the choice of experts, evidently for the purpose of achieving a balance among those making up the expert group. This unfortunately meant that the UNEP's Secretariat, which turned out to be critical of nuclear power, viewed many of the experts with distrust.

The Secretariat's attitude came as a total surprise to me. Directly after my arrival in Geneva I was summoned to a meeting with representatives of the UNEP. My first question concerned the procedure for minuting the conclusions at the meeting. I said it would be wise, as was the case at the other international meetings, to appoint members of the expert group as rapporteurs at the different sessions, to note decisions, changes to the text and advice to the Secretariat. The UNEP representatives answered that this was not UNEP's custom and that the Secretariat was sufficiently competent to take the notes needed - which proved to be wrong.

My next question concerned the interpretation into and from English which would be the language used. The response I got was that all the participants had agreed to use English without interpreters. My reply was that this could not be true since I knew that the Russian participants, Professors Ilyin and Karpov, did not speak English. I also knew that IAEA had set aside money for interpreters at the meeting. I therefore demanded to speak to the UNEP's representative in Geneva, Swede *Lars Karlström* (1933-1984). The Egyptian Scientific Secretary for the meeting then said that it was IAEA that had made the decision not to provide any interpreters, which I knew was not true. I therefore demanded interpretation into and from Russian, and this was provided as well, although not thanks to any input from the UNEP but because the Russian observer from WHO convinced his wife to interpret.

A third practical problem concerned information to the press. The Secretary said that an immediate press release about the meeting was needed. My response was that this could doubtless be arranged with a brief statement about the meeting, the fact that it was taking place and what its purpose was. The Secretary said that such a statement had already been made. When I asked to see it he reluctantly showed a press release that had been issued in Nairobi the week before the meeting. To my surprise, I found that this message quoted long sections from the working document that the experts had not yet discussed and that it could be perceived as a policy statement before having heard the advice sought from the experts.

This was not exactly a favourable start to the meeting. The consultants engaged by the UNEP to produce the working document were also indignant that their proposal had not been heeded. The working document appeared to be compiled by someone with a lack of technical knowledge who had more or less randomly selected material from the consultants' reports. This led to a number of proposals for changes to the document, changes which would not have been necessary had the Secretariat supported the consultants' proposal. The vote became very uncomfortable when the scientific Secretary, Dr. *Essam El-Hinnawi*, became increasingly displeased with the criticism. In the end, he asked to speak and gave the expert group the fieriest rebuke I have ever heard. He said that we had not been called to Geneva to criticise his working document but to give constructive advice. For a moment I thought that the experts, myself included, would rise and leave the room but we sat still.

During a coffee break, Dan Beninson and I spoke to the Chinese expert Dr. Li Deping. Never before had we met a Chinese scientist at a meeting dealing with radiation protection matters.

'It is my first time at an international meeting,' said Dr. Li. 'Tell me, are the meetings in the west always so emotional?'

It would have been wise and psychologically well-considered if Secretariat had told the expert group how it intended to continue the work after the meeting, e.g., by allowing a consultant to edit the working document with regard to the experts' advice. But the Secretariat refused to discuss the UNEP's internal plans that it did not think concerned the experts. It simply said that the UNEP would in some way draw up a second draft which would be sent to all participants for comments.

Finally, as I was about to conclude the meeting, I told the expert group what the Secretariat had told me, i.e., that the UNEP had decided to issue a press release after the meeting and take full responsibility for the release which would therefore not need to be discussed by the expert group. The release would just say that the group had met to give the UNEP advice on a report which would finally be submitted to the Director General of UNEP's board. No conclusions from the expert group would be included in the release.

What I did not know when I said this was that press release was already ready and listed a number of 'conclusions' from the experts, conclusions which had actually been formulated by the Secretariat. We had quite simply been duped.

This upset the experts and they asked me to act on their behalf. Both Russians and Americans assured me that they would support me in whatever I did to protest against the way in which we had been treated. What I did was write a long, angry letter to UNEP's Executive Director *Mostafa Tolba*. Most of the letter contained the report I have already given here, so I will therefore quote just a few key paragraphs:

> Dear Dr. Tolba,
>
> During the period of 20-24 November this year, UNEP arranged a meeting of an international expert group in Geneva to review – as stated in the invitation – a draft of a report on the environmental impact of nuclear power. I was asked to act as Chair of the group, and it is in my capacity as Chairman that I am writing this letter. I think I am duty bound to let you and the participants know my view of this expert group meeting since I am very concerned by its development.
>
> ...
>
> I have been Chairman of many of the meetings arranged by organisations such as ICRP, IAEA, UNSCEAR and WHO, meetings at which conflicting views have been discussed and reviewed. However, never before have I felt it necessary to write a letter of complaint to the organisation that arranged them. Never before have I experienced such animosity and preconception, not between participants but between the Secretariat and the experts. Never before have I had the feeling of being utilised rather than consulted, of being a hostage or an unwelcome necessity, expected to be an inconvenience rather than to provide assistance.
>
> ...
>
> The whole chain of events and conflicts which I have described in this letter - the incompetent draft, the dubious minute taking, the absence of plans for the interpretation, the reticence of about the press releases and their misleading content, the preconceived views and inflexible attitudes within the Secretariat, and the absence of a credible mechanism to create a competent end document - has angered most of the participants. Some of them have come to me and asked which measures I am thinking of taking as Chairman, and have shown their full support even if the measures were to be really drastic.
>
> However, I have not written this letter only because of their concern and my own anger, but also because I think the current development is not in UNEP's best interests. At the technical and scientific level there is a much higher level of unity regarding facts and their significance than the layperson is led to believe from the media and popular discussions. It will be damaging to all parties unless a factual basis is agreed as soon as possible. Every organisation and interest group can then build its own tower of faith and hope on that basis. But let us first create the basis.
>
> I must admit that my own anger has passed boiling point and I am not easily angered. I have acted as Chair on your behalf, at your invitation, but I have encountered characteristics that I deplore. I do not like being pushed, manipulated or exposed to dishonesty. But this is what has happened to me for an extremely uncomfortable week in Geneva. I see it as my duty to send a copy of this letter to all those who participated in the panel of experts.

> I hope, Dr. Tolba, you agree with me that the UNEP cannot afford experiences like this.
>
> With best regards…

I received no response from Dr. Tolba, but on 23 January 1979 I received a letter from the UNEP's Deputy Executive Director, Dr. S. Evteev. He wrote:

> I am sorry if you have been caused any distress and I would like to assure you that nothing was intentional. I would also like to assure you that the UN's Environmental Programme intends to produce a technically credible and balanced report on all the environmental aspects of nuclear power with the help of the best specialists in the field and in close cooperation with IAEA.

I reacted to this letter by writing to Dr. Tolba on 9 February and referring to Evteev's letter. I wrote:

> I would like to make it absolutely clear that I never complain about personal problems and believing that my [first] letter reflected purely personal resentment would be misinterpreting it.

I concluded with:

> Believe me, Dr. Tolba, I share the view that the UNEP should produce independent reports on this subject, but I believe that such reports need to be of a high standard. I will strongly support all measures to ensure that this will be the case.

Unfortunately, this did not take place. Another – with a different composition - panel of experts met in Nairobi in April 1979. None of the critical experts from the first meeting were invited to take part. Neither the American authority expert Dr. Wachholz nor either of the two Russians, Doctors Ilyin and Karpov were there, nor the Chinese expert Dr. Li Deping, the Argentinians Beninson and González, the Japanese Dr. Ichikawa or the Swede Lindell took part in the meeting which, this time, was attended by only twelve of the original thirty-six experts. Dr. Tolba wrote in the preface that the report had been drawn up by Dr. El-Hinnawi and reviewed at two expert meetings. Despite the arrogant handling, it has to be recognised that the report was made acceptable in the end.

12.24. **The NEA in Paris**

The task group which the NEA had set up to study the emissions of the long-lived radioactive substances from nuclear power plants (the Effluent Study) met on 27 and 28 November. Dan Beninson was part of the group, as was Bill Rowe. The group met again in March (see Section 13.10).

12.25. **The CRPPH in Paris**

The Radiation Protection Committee (the CRPPH) met during the days immediately after the task group had met at the NEA.

12.26. **Indiscretion in Vienna**

An extract from memos:

Back at the Institute I ring Dan Beninson who is at home with the flu.* I want to find out whether he has heard any reaction to my very angry letter to Dr. Tolba, the head of the UNEP in Nairobi. Dan then says that he had a strange conversation with a young, self-assured Swede, Gösta Lindh, from the Ministry of Industry, at a meeting in Vienna. Lindh had naively bragged to Beninson about his significance to the Ministry of Industry's handling of the nuclear energy issues which he intimated he had been responsible for (whereas in reality it has been Lars Hjort). Lindh is the Ministry's contact person with the Nuclear Power Inspectorate.

Lindh had told Dan that a decision had been made to remove Hedgran as head of the Nuclear Power Inspectorate and that he had been persuaded into accepting a Professorship in reactor safety at [KTH, the Swedish Royal Institute of Technology]. There had been dissatisfaction with the Nuclear Power Inspectorate, which had not been able to convince the public that nuclear power was not hazardous. Dan, who is a nuclear power supporter, said that Lindh appeared to be a [zealous] nuclear power enthusiast. Lindh had said that the intention was to reorganise the Nuclear Power Inspectorate and appoint a new head. The latter would be an outsider and a certain person had already been decided on but this person had not yet accepted. Only if they failed to secure this person would they take Thomas Eckered. Lindh also said that if he had his way, they would also transfer the Swedish Radiation Protection Institute's nuclear power operations to the Nuclear Power Inspectorate. Dan had responded by saying that it would be really stupid since it would create two authorities which were in conflict with one another. The radiation protection expertise at the Radiation Protection Institute would question the judgement and the decisions from the Nuclear Power Inspectorate and the Nuclear Power Inspectorate would scarcely have credibility while the Nuclear Power Inspectorate remained under the Ministry of Industry.

I rang Hedgran in the evening. He confirmed the Professorship and said that it had been kept secret and that it would not be made public until a few days' time. I said I could scarcely be bound by any promise of secrecy since I had not been given the information by either the Chancellery or the Nuclear Power Inspectorate, but by an international official. If Lindh were naïve enough to blab to unknown persons abroad, he would have himself to blame. I had to look after the Swedish Radiation Protection Institute's and the Nuclear Power Inspectorate's interests and intended to ring the Ministry of Agriculture to find out whether it knew what was going on. Nothing had been said when the Minister of Agriculture visited the Radiation Protection Institute yesterday and I, out of pure intuition, had explained the Swedish Radiation Protection Institute's and the Nuclear Power Inspectorate's position and allocation of responsibility, also saying that it was misunderstood by MPs and by the Ministry of Industry where there were officials who had the ambition of creating a Swedish AEC. How right I had been! However, I promised Hedgran not to make the case public until Monday, but said that I might be obliged to consult Gunnar Bengtsson and Jan Olof Snihs if I thought it appropriate. I promised to ask them to keep it quiet.

12.27. **Lars Nordström becomes head of the Nuclear Power Inspectorate**

When Arne Hedgran had started his Professorship at KTH, the government appointed Lars Nordström as Director General of the Nuclear Power Inspectorate. Nordström was administratively qualified as Vice-Chancellor of Luleå University College and was technically qualified as Professor of steam technology at the Chalmers Institute of Technology (CTH). Lars had made a significant contribution as a member of the Reactor Safety Commission. He was an interesting person with great integrity and had

* Dan lived in Vienna as Secretary of UNSCEAR from 1976-1979.

translation of the Bible as a hobby. His eccentricity also included being a shareholder in Penningby Castle which had been owned by the Nordströms since 1836.

12.28. **Interview with Lars Hjort on 5 December 2002**

Lars Hjort had been head of the Ministry of Industry's energy unit since 1975 and Assistant Under-Secretary since 1977. He remained at the Ministry until 1981 when he moved over to the oil industry where he became MD of *Svenska Petroleum* (later *OK Petroleum*) until 1992 when he became Deputy MD of the Cooperative Association. After ten years in this post he had become an entrepreneur.

Bearing in mind Hjort's knowledge of the Ministry of Industry's policy at the end of the 1970s, I contacted him and had the opportunity to interview him at the Radiation Protection Institute on 5 December 2002.

I began by ascertaining that the government's ambitions as regards nuclear power had completely changed direction a number of times during the 1970s yet the Ministry of Industry staff appeared to have always supported players strongly favouring nuclear power, like Gösta Netzén and Alf Larsson. Netzén and Larsson had also bluntly acted for nuclear power under Fälldin's government.

Hjort reiterated that the tripartite Fälldin government functioned only with the Social Democrats as a support party. Even if Olof Johansson might have chosen to replace Netzén as Chair of the Nuclear Power Inspectorate's board, he would never have had such a decision passed.

I said that Netzén, Alf Larsson and Gösta Lindh had worked to change the Nuclear Power Inspectorate into a total 'Atomic Energy Commission' with responsibility for everything concerning nuclear power and had therefore chosen to transfer the Swedish Radiation Protection Institute's radiation protection activity within the field to the Nuclear Power Inspectorate. I said that, irrespective of whether the government was in favour of nuclear power or against it, it ought to have been tempting to have full control with all questions under one roof without disruptive elements from outside.

Hjort's response was that it may well have seemed tempting, but that the government had had no views on the matter. Those driving them were lower-level officials who had their own views without any political support from above. Hjort said this was proven by the fact that there were no Ministerial memoranda containing proposals regarding the matter. All serious proposals within the Ministry of Industry were written down in memoranda. There never had been any proposals regarding the handling of the radiation protection issues. When Alf Larsson and Gösta Lindh pursued the matter it was due personal views and without support from the Ministry.

Hjort had taken on Gösta Lindh and considered him to be a competent official but with shortcomings regarding judgement. Alf Larsson was already associated with the Ministry before Hjort was made responsible for the energy issues. Larsson could not be controlled or influenced, said Hjort with slight resignation. Larsson also let no-one have an insight into what he agreed with. Hjort had had difficulty cooperating with him.

The Stipulation Act was a political commission which did not come about to improve the safety but to scare the tripartite government. Fälldin wanted a law that would make nuclear power impossible. The Liberal People's Party and the Moderates wanted a law that would leave a door open. The Stipulation Act became a compromise which everyone could accept but which had no real connection with the safety issues.

I related how Gösta Lindh had boasted about his importance to the Ministry while in Vienna and that Arne Hedgran would be replaced because, under him, the Nuclear Power Inspectorate 'had been unable to convince the public that nuclear power was not hazardous'. Hjort said that that statement would have to stand for Lindh. Instead, the reason had been that people at the Ministry thought Hedgran been too cautious with the Nuclear Power Inspectorate and too satisfied with its resources and too scared of change. It was thought that greater resources were needed for the expansion of nuclear power if done by the Nuclear Power Inspectorate plus a reorganisation for which a more driving force was required. Greater demands for action could be anticipated from the Nuclear Power Inspectorate. Hedgran was seen primarily as a knowledgeable scientist rather than the administrator that would be needed. The Nuclear

Power Inspectorate also needed a head who was more extrovert. This is why Thomas Eckered had previously been employed as support for Hedgran.

Yes, said I, and you then went and replaced Hedgran with the ‘extrovert’ Lars Nordström. Hjort understood the irony but said that Nordström still had proven administrative capacities such as Vice-Chancellor of Luleå University College

13. THE YEAR 1979

13.1. The Tidaholm problem explodes

The high measurement values of radon daughters in houses on ground containing alum shale in Tidaholm required rapid measures (see Section 12:18). Gun Astri Swedjemark realised that the residents had to receive information before the mass media and quickly convened an information meeting for the residents and healthcare boards. But the media could not wait until the meeting. Our unwillingness to release the news until those who lived in the houses had been informed made it appear secret and therefore attractive. The news was splashed much too early. On the TV screens, millions of Swedes could see how worried inhabitants of the 'radon houses' were interviewed and how they became scared. The risk awareness we had previously tried to create turned into panic. Previous risk information and figures for the concentration of radon had not made their mark but worried people in the flesh and in tears did. The concern escalated as an avalanche. The Radiation Protection Institute had to fortify its telephone exchange and for a while took up to 800 calls a day. People were crying down the telephone and some spoke of suicide. One more collected woman said, 'I understand from a purely intellectual point of view that there is no dramatic danger and that I should not be afraid, but my villa is no longer my usual, safe home but something that has become soiled and contaminated. I can't live here any longer!' People were afraid without having any indication whatsoever of high radon concentrations, but they had heard stories about 'blue concrete'

13.2. The radon investigation is launched

The to-do did lead to one good thing. The committee investigating the problem with radon which the Radiation Protection Institute had requested from the government in 1978 was established in all haste, with County Governor Gunnar von Sydow (1911—1990) as Chair. Von Sydow was a lawyer, had been Judge of Appeal in 1954 and, before becoming County Governor of the County of Älvsborg in 1970, was State Secretary for the Ministry of Trade and Industry since 1962. His nearest insight into radiation matters came from membership of the delegation for Atomic Energy Issues from 1962-1967.

I was called to von Sydow as soon as he had been given the assignment. His attitude was one I had already encountered many times before. He appeared to be almost irritated. Is this really necessary? Our buildings surely cannot really be dangerous! But he changed his mind once he had familiarised himself with the issue.

What happened over the next few years along with an outline of the problems was reported in the Society for Risk Sciences' leaflet no. 6 (Radon in homes, 1994). The report emphasised the problem of having the responsibility divided among several authorities (primarily the Radiation Protection Institute, the Swedish National Board of Health and Welfare and the National Board of Housing, Building and Planning). The following is worth quoting from the report:

> In 1976, the Radiation Protection Institute attempted to get other central authorities which were responsible for people's health to realise what the problem was with radon indoors. The Radiation Protection Institute then issued a brochure, 'The radiation in our homes', containing information on the risk of lung cancer and in 1978 asked the

> government to allow it to investigate the problem with radon. A committee was set up in 1979 which proposed action levels and the limit values in the same year, and issued final recommendations in 1983. As a consequence of the radon committee's proposal, the National Board of Physical Planning and Building and the Swedish National Board of Health and Welfare introduced a limit value and an action level in 1980 for newly-built and existing homes respectively. Sweden was thereby the first in the world to have such values for radon in all homes.

Sweden was also early to issue extensive radon measurements thanks to Gun Astri Swedjemark's inputs. They were supplemented by epidemiological studies carried out by Göran Pershagen and colleagues.

Action levels and the limit values have existed since 1980. They initially concerned the 'radon daughter concentration'* (which is approx. half of the radon *gas* concentration), but the new values concerning the gas concentration were introduced from 1994. The Society for Risk Sciences' leaflet had the following to say about these values:

> Radon levels above the action level 400 Bq/m^3 is seen as a sanitary inconvenience (SOSFS 1993:25). If the radon level in a building exceeds this action level, the municipality can, with the support of the Health Protection Act, oblige the property owner to remedy the problem. Since the action level does not indicate a sharp border between 'non-hazardous' and 'hazardous', the Swedish National Board of Health and Welfare and the Radiation Protection Institute recommend that the radon level be lowered to below 200 Bq/m^3.
>
> For new buildings and extensions, according to the National Board of Housing, Building and Planning's construction rules 94 (BFS 1993:57), the radon level shall be below 200 Bq/m^3.

A second radon committee was established under the Ministry of the Environment on 2 December 1999 to 'analyse the problems with radon in homes and some premises where people stay for longer periods'. It assumed the name *Radonutredningen [The radon inquiry] 2000*. The committee submitted its final reports to the Ministry of the Environment on 31 January 2001 with the titles 'Radon – Proposals for government measures' and 'Radon - Facts and situation report on radon'. The reports were more than 200 pages long but mainly discussed legal and administrative matters. The Radiation Protection Institute was not represented except for via a reference group of authorities.

13.3. Dan Beninson leaves UNSCEAR

On 5 February I received the following official letter from Dan Beninson in Vienna, formally worded as is right and proper for a letter from the Secretary of UNSCEAR to one of the national representatives:

> Dear Professor Lindell,
>
> As you may remember, at the Committee's session 1978 I informally discussed the possibility of not being available for a further period as Secretary of UNSCEAR since I was needed by my own country's nuclear energy programme. Halfway through the same year I formally notified the UN's Environment Programme [UNEP] that I could not continue the position after the start of 1979.
>
> I have delayed sending this letter for as long as possible in the hope of being able to notify the name of my successor. However, this has not been possible. From 1 February 1979 I will no longer be Secretary of the Committee. The name of my successor will be communicated as soon as he has been appointed.
>
> Best wishes,

* The radon daughter concentration is the content of radioactive daughter products in the air after radon has decayed.

Yours sincerely

D. Beninson
Secretary
UNSCEAR

Two months later I received a letter from P. S. Thacher, Deputy Managing Director of UNEP, in which he stated that an early search had begun for a successor to Dan Beninson but that the UN's general assembly had recently adopted new and stricter rules for new appointments so the procedure had taken longer time. He had a temporary solution to the problem:

> In order to avoid obstacles to the Committee's work, Dr. Julian Liniecki, Professor of Nuclear Medicine at the medical faculty in Łodz (Poland), who has many years' experience of the Committee's matters, has been asked and has agreed to serve as Secretary of the Committee in the interim with immediate effect while waiting for the appointment of a candidate who can serve in the longer term. I have every confidence in Professor Liniecki's ability to control the Secretariat's work in a way that lends continuity to the Committee's work and ensures that its upcoming session will be as productive as previous sessions.

13.4. **Ayatollah Khomeini returns to Iran**

In 1978, an Islamic revolution was started against the Shah of Iran which meant that he was forced to leave the country in January 1979. In February, Ayatollah Khomeini arrived triumphantly from Paris after fifteen years in exile. My prediction from 1977 had come true. The country which the Shah had attempted to secularise using brutal means with Turkey's Kemal Atatürk as a role model was transformed into a strictly religious and intolerant constitution with worldwide consequences.

13.5. **Information letter from the authorities**

In early February, the National Board of Physical Planning and Building and the Swedish National Board of Health and Welfare together with the Radiation Protection Institute issued a letter containing information and advice for all healthcare authorities and building authorities, describing the whole problem with radon.

13.6. ***Dagens Nyheter* criticises Lindell and the Swedish Radiation Protection Institute**

In a discussion article in the newspaper *Dagens Nyheter, DN,* on 17 February I was criticised by *Karl Erik Lagerlöf* for having neglected the danger of radon. Lagerlöf also demanded my departure. I countered the criticism in an article on 28 February by emphasising with a couple of examples that *DN* had also not taken the danger of radon seriously and that the Radiation Protection Institute had long since had an uphill struggle. When the Radiation Protection Institute published the brochure called 'The radiation in our homes' in 1976 which warned of the risk of lung cancer, we had said that the risk was particularly great for smokers. *DN*'s brief entry about the brochure was headed 'Smoking indoors increases the risk of cancer' (!). Not the radon? But I did agree with Lagerlöf that the radon committee now had to get a move on.

13.7. **Non-ionising radiation – an outline of the problems**

The Radiation Protection Institute's activity report for 1977-1978 (written in 1979) contains the following outline of the problems with the new activity:

> Sources of non-ionising radiation include things such as lasers, sunlamps, radio transmitters, radar stations, microwave ovens and ultrasonic cleaners. The use of such sources is rapidly increasing in most areas, the typical volume increase being 5-10% per

year. New sources or areas of application such as solariums and alleged mosquito killers are also being added. This means that the Institute has to follow the development of and review products that can be harmful.

There are few documented injuries from non-ionising radiation with the exception of approx. 10,000 cases per year of mild eye injury (arc eye) from ultraviolet radiation from welding flames. However, there are suspicions of a possibility of extensive risks of injury; for example, in the range of thousands of cases of skin cancer per year from sunbathing and a hundred or so cases of cataracts per year from infrared lamps or industrial ovens. For as long as these suspicions are around the Institute must run and support research which can give better risk assessments. ...

The result of the radiation protection activity cannot be measured directly in the form of a reduction in injuries while the risk assessments are very much uncertain. Since spring 1977 when the activity started up until summer 1979, production included information letters about optical radiation, radiofrequency radiation, ultraviolet radiation and laser classification. Provisions have also been issued for the limit values for ultraviolet radiation and the provisional limit values for the public's exposure to microwave radiation and proposal for provisions for lasers. A number of reports on exposure levels and measurement techniques for different products have also been issued with particular emphasis on ultraviolet radiation. Generally, a result becomes evident by the number of enquiries to the Institute regarding a specific topic falling some time after the provisions or information having been issued.

13.8. **Ultraviolet radiation**

On 1 March 1979, the Radiation Protection Institute issued a 16-page information letter on ultraviolet radiation. The letter also reproduced the Institute's provision on hygienic guideline values for such radiation (the Swedish Radiation Protection Institute FS 1978:6).

13.9. **IAEA meeting in Vienna about ICRP**

IAEA arranged a meeting in Vienna about ICRP's latest recommendations, Publication 26 from 1977. The interesting thing was the paradigm shift between on organ doses and Maximum Permissible Concentrations on the one hand and the effective dose equivalent and the practical consequences thereof on the other hand. As for me, the reason I remember the meeting in Vienna was the telephone call I received from home on 9 March telling me my father had died.

13.10. **Paris: the 2 NEA meetings in March**

In March the NEA's radiation protection Committee, the CRPPH, met in Paris and the report from the expert group on radioactive building materials was now available. It was to be published in May. This was the first time that the Radiation Protection Institute could refer to international recommendations regarding the radiation in homes. However, they concerned building materials for now and it was still difficult for experts outside the Nordic countries to understand that it was a common problem, not just something that exclusively concerned building materials like Ytong in Sweden. The expert group had drawn up formulae to calculate acceptable levels of potassium, radium and thorium in building material.

In addition to the meeting with the CRPPH at the NEA in March, Dan Beninson and I had a work meeting with Bill Rowe about the NEA's Effluent Study, i.e., the attempt to create a radiation protection policy when it came to handling very long-lived radioactive nuclides. The half-lives in question went from 5700 years (carbon-14) to 16 million years (iodine-129). We found that it was the doses of radiation for the foreseeable future which ought to determine the inputs to optimise the protection since the long 'tail' over millions of year then did not affect the strategy – it could not be changed by optimising the protection.

Dan and I ate an evening meal with Rowe, which was an interesting experience. Rowe was responsible for the EPA's (the American Environmental Protection Agency's) radiation protection policy but was a very controversial person. Our nearest American colleagues appeared to be allergic to him. We thought he probably had himself to blame for this. Bill Rowe was an insufferable person by normal standards. He was very self-confident but, most irritatingly, he had good reason to be so as he was a very intelligent man. Arne Hedgran and I had appreciated his book, *An Anatomy of Risk,* from 1977.

13.11. **The Ullsten government's energy proposition**

The People's Liberal Party minority government under Ola Ullsten was anxious to solve the energy issue. The previous Fälldin government was to have presented an energy bill in 1978 but failed to do so. Ullsten's government put forward a substantial energy bill on 1 March 1979 (bill 1978/79:115). It was based largely on the Energy Commission's proposal which, when it came to nuclear power, proposed that Sweden should neither decommission it nor commit to it for the future. The Bill recommended to the Swedish Parliament that the Swedish nuclear energy programme should be limited to 12 nuclear power blocks and that substantial investments ought to be made in measures to increase the safety of operating nuclear reactors. Since the People's Liberal Party did not have a majority in Swedish Parliament, the bill was worded so that it could be expected to be supported by both the Social Democrats and the Moderates.

13.12. **Bo Lindell's letter to the Nuclear Power Inspectorate**

Since the statement by Gösta Bohman and Ola Ullsten just before the Fälldin government fell at the start of October 1978 (see 12:16), the Nuclear Power Inspectorate had prepared itself to handle 'the borehole issue'. It was expected that a decision, which would be crucial to the charging of Ringhals 3 and Forsmark 1, would be demanded from the Inspectorate's meeting at the end of March. Prior to a preparatory meeting on 8 March, I wrote a long letter to the Nuclear Power Inspectorate's board on 2 March. Since the matter was (and is) very important, I am going to quote large parts of the letter:

> ...
> In the government's decision of 22/02/1979, the Nuclear Power Inspectorate is asked to prepare the power companies' supplementary application and submit the documents to the government along with its own statement. The final decision will thereby be a political one, which seems reasonable. Since the government will have the Nuclear Power Inspectorate's statement no later than 30 March, I hope it will be possible to arrange the board's decision-making meeting on a day when I can attend.
>
> Since I cannot attend the discussion on 8 March, I would like to submit a few general points of view in writing.
>
> First of all I would like to apologise that the board has to make its decision in an unusually difficult atmosphere where the board is exposed to pressures that are not far removed from threats.
>
> The board and the Nuclear Power Inspectorate's executives have been exposed to criticism and abuse from some nuclear power opponents who have gone beyond the realms of all decency. The opposing party's expectation that the Nuclear Power Inspectorate's action will be a pure formality with the outcome known in advance is also insulting.
>
> However, these infractions worry me less than the pressure of the actual situation in which we find ourselves The waste problems are incredibly exaggerated at the cost of the attention that ought to be paid to the safety problems. The Stipulation Act ought to have concerned safety, not the waste.
>
> Most of the board's members doubtless have difficulty seeing that the possibility of satisfactory waste handling will stand or fall by virtue of a few boreholes. I personally

think it is risky to continue thinking that the high-level radioactive waste must go down into Swedish bedrock at any price.

The Nuclear Power Inspectorates board has now been put in the situation where approving the power companies' supplementary application will avoid the last obstacle to continued expansion of nuclear power while rejecting it will mean that the nuclear power industry faces significant problems.

Rather than an overall assessment of nuclear power, taking into account all of its advantages and disadvantages and a decision based on all relevant facts, rather than a decision where the politicians take full responsibility for all of the decision's consequences, a game of roulette is now being played with nuclear power and everything is being concentrated into the Nuclear Power Inspectorate's board's assessment of what is in reality a fairly insignificant detail.

We are all thereby being put under substantial pressure, bearing in mind the major consequences that the decision may bring. It is very easy to be tempted to be negative if we are negative towards nuclear power as a whole, or positive if we think nuclear power is acceptable. Especially as the decision is not probably actually that significant in terms of waste safety. The crucial stages of waste handling, i.e., reprocessing, storage, solidification, encapsulation, etc. have already been approved by the government after all.

I have great difficulty trying to disregard all of these irrelevant considerations to look only at whether the power companies have succeeded in showing what the government has demanded. First and foremost, neither I nor any other member of the board is a geologist. If all geologists were to agree one way or the other, I could scarcely do anything other than bow to their expertise. Such unity is now less likely. From what I have seen and heard so far, it is therefore not improbable that a divided group of geologists can make it considerably difficult for me to find that the requirements are satisfied, but I cannot know that for certain until the geologists have given their opinion of course.

If I find that the power companies have succeeded in showing what is required, I cannot see any problems. Swedish Parliament must then decide on the future scope of the nuclear energy programme and the safety and radiation protection issues must continue to be assessed in accordance with the atomic energy and radiation protection laws.

However, problems will arise if I do not find that the power companies have succeeded in showing what the government has demanded. If this were the case, I would not be able to avoid rejecting the application, despite believing that the consequences of rejecting it are completely unreasonable. Having a 'realistic' attitude in this connection would constitute taking the law into one's own hands and displaying contempt for valid, democratic rules.

I find this situation fairly worrying and a threat to legal consciousness. We should not be in a situation where we have politicians creating strict laws just to show goodwill and then leaving it to the management authorities to investigate the problems that arise if the laws prove to be so strict that their application leads to incongruities. The legislative powers must also take responsibility for the consequences of the laws if they are applied without secondary considerations.

However, I do see a possible solution to this dilemma. Since the burden of proof has been placed on the power companies, the Nuclear Power Inspectorate's board should not approve the application if there are any reasonable doubts. However, if there are, the board should also supply the government with further information.

An important piece of technical information is that what happens in the bedrock in the very long-term is of very little practical significance. The high-level radioactive waste is extremely difficult to handle in fresh form while it still contains large activities of fission products. According to the KBS[*]' assumptions, no activity should leak out

[*] See Sections 6.25 and 18.11 for a discussion of the KBS project.

> from the waste final storage repository until a thousand years have passed – the period for which the lead and titanium capsule is assumed to remain completely leak-proof – and with maximum doses of radiation to people only after a couple of hundred thousand years. The technical assumptions for the durability of the capsule have already been accepted by the government. The geological uncertainty regarding the transportation time from the capsule during the period between the thousand and hundred thousand years after the waste has been deposited, i.e., if it can be assumed that there is a large enough area of solid rock with the properties anticipated by the KBS. During this period, the activity of the waste falls to approximately one hundredth (of what it was after a thousand years). Roughly speaking, significant shortcomings in the delay effect of the bedrock should therefore not exactly have drastic consequences regarding the impacts some time after the first thousand years which everyone already seems to think is a safe period. According to the KBS' assumptions, the highest future radiation dose would affect someone who was digging a well in two hundred thousand years' time close to where the waste was stored and drinking the water day in day out. The risk of this fictitious person getting cancer would be approximately equal to that of getting it from smoking two to three cigarettes a year. If the bedrock were of a lesser quality, someone might perhaps be exposed to greater doses of radiation earlier. However, there are substantial margins to any significant problems.
>
> There may be another important piece of information in the comment that we may under any circumstances be forced to deal with the waste arising from the operation of the six reactors that are already operating. The quantity of spent fuel (in tonnes of uranium) from these reactors over a 20-year period is approx. 2,000 tonnes and until the end of 1984 approx. 770 tonnes. According to the KBS, with 13 reactors in operation, the quantity of spent fuel at the end of 1984 would be approx. 1 200 tonnes.
>
> The total quantity of high-level radioactive waste that we have to deal with will under any circumstances depend on political decisions regarding whether to continue operating the six reactors that are already in operation or to decommission them.
>
> I think it would be reasonable – and I suggest we express that point of view to the government – to commission the reactors as they would otherwise be a waste of money, but on condition that the waste issue and <u>the safety issue</u> are more thoroughly investigated and with less time pressure, say over a 5-year period, so Swedish Parliament can then make less arbitrary decisions which cover all relevant facts and are not limited to discussing a few boreholes. Even over a 5-year period we will not manage to accumulate more high-level radioactive waste from 13 reactors (bearing in mind when they can be put to use) than just the six that are in operation will create up until 1990. The quantity of waste will of course be smaller still if Swedish Parliament wants to limit the number of reactors to 12 or fewer.

I completed the letter with:

> I think the KBS studies have adequately shown that it is possible to deal with the high-level radioactive waste in a secure manner but that it would still be wise to progress slowly.

Similar points of view were put forward in a letter to the board on 16 March by board member Thomas B. Johansson. He wrote the following, among other things:

> The Swedish Nuclear Power Inspectorate's geologists think, except for one dissentient, that the surveys performed do not fulfil the government's requirements that the existence [of a large enough volume of rock with the anticipated properties] be proven. They even think the surveys show that the volume of rock surveyed can *not* be used, which is a significantly stronger statement. Their argument is based on observations in the material reported by KBS and their own observations on site where the core samples have been inspected.
>
> I think it is now unreasonable to maintain that the KBS should have *shown* what the government demanded. This does not of course mean that rock with the properties

> sought cannot be found somewhere in Sweden. We cannot speculate on the likelihood of this, but no-one seems willing to dispute that such rock may be found.
>
> So, is it reasonable to allow the reactors to stand uncharged while waiting for further surveys? In my opinion, this is not a decision for the Nuclear Power Inspectorate – it is one for the government. I think the Nuclear Power Inspectorate should now do two things.
>
> Firstly, tell the government that the terms set in October 1978 and in the referral of 22 February 1979 have not been satisfied.
>
> Secondly, indicate the possibility of, without changing Swedish Parliament's intentions with the Stipulation Act, acquiring necessary time for adequate surveys without the pressure from what amounts to substantial, unutilised capital in the form of reactors that are waiting.

Like me, Johansson thought the reactors could be charged for a temporary 5-year operating period while more thorough surveys and investigations could take place. He thought the waste from the lifetime of the six reactors that were already in operation had already been accepted. A temporary operation of 12 reactors would not produce more waste during a 5-year period after which a decision could be made.

> If a survey then shows that all requirements are satisfied, the case is closed. Should a survey show that there are still issues to be solved, doubts may arise as to whether it is possible to solve them. In such a case, you have to consider whether a decommissioning plan set up during a period must be initiated in order to decommission <u>all</u> of the reactors at a time when they have jointly created the quantity of waste that has now already been accepted.

13.13. **The Nuclear Power Inspectorate's borehole meeting**

And so the Nuclear Power Inspectorate's 'borehole meeting' began on Tuesday 27 March in Swedish Parliament's temporary premises in a former hotel on Brunkebergstorg. The mass media showed great interest but the Nuclear Power Inspectorate's Chair, Gösta Netzén, was determined to keep the journalists at bay. The affair concerned the applications for a permit to convey nuclear fuel to the Ringhals 3 and Forsmark 1 reactors in accordance with law 1977:140 (the Stipulation Act).

Gösta Netzén had two ambitions. Firstly to achieve get as many people on the board as possible to agree on the decision, and secondly to obtain a positive decision. The board was in agreement that it was unreasonable to reject the applications based on the result of the test drilling and definitely also regarding the fact that the Stipulation Act was a mistake, but the law now existed and the interpretation thereof led to divided opinions. The first decision proposals were worded in a way which said that the test drilling had shown that the Stipulation Act's requirements were satisfied. Three of the members, Thomas B. Johansson and Centre Party followers Karl-Erik Olsson and I could not accept such a wording. We thought it would be tantamount to disavowing the expert group of geologists whom the board itself had appointed.

Netzén was able to cope with Olsson having a different opinion; he seemed to think that that was to be expected of a Centre Party follower. If so, that was unfair because Olsson was a clever fellow with good judgement. But it was important to avoid reservations from Johansson and me since we were physicists after all and it would not have looked good. We therefore had to endure long attempts to persuade us. *Per Unckel*, who was new to the board, was particularly eager to get a positive decision. He gave me sheets of various wordings, but all were based on the fact that the test drilling showed that the requirements were satisfied.

The meeting continued from early morning until late evening. I got the impression that Netzén relied on his experience as an agreement negotiator and hoped to wear us down. In the end we managed to agree on a wording which recognised the division yet lessened the significance of that division. The press statement which was released before midnight said:

> During the formal assessment as to whether the KBS has shown that the ecological requirements are satisfied, the Inspectorate's board does not agree with the interpretation of the concept 'show' and thereby also does not agree that the fulfilment of the requirements has been proven.
>
> However, the Inspectorate finds that strict proof is not necessary. The Inspectorate thinks that the importance of the requirements set regarding the geological barrier should not be exaggerated and that the very long-term occurrences in the bedrock are of little practical significance if other barriers function satisfactorily.

And the start of the press release showed a sentence which could be taken as criticising the government for passing the responsibility to the Nuclear Power Inspectorate:

> The Inspectorate says in its 35-page statement to the government*, which itself obviously makes the final decision regarding permission in accordance with the Stipulation Act ...* (my italics).

Karl-Erik Olsson made reservations as expected, but Thomas B. Johansson made Gösta Netzén disgruntled by declaring that he intended to make a separate statement, despite having taken part in making the decision.

I went to bed late and expected to read critical press comments the next morning, but I had difficulty concentrating on them that day because my father was being buried. The next morning, 29th March, I was woken up at 5 o'clock in the morning by a journalist asking what I thought about the reactor accident at Harrisburg – hadn't I heard the news? And so came a new day with completely new problem. The media's interest in the boreholes was drowned by the flood of news about the reactor accident on Three Mile Island.

13.14. **Three Mile Island**

The reactor accident took place in a nuclear power plants on Three Mile Island in the Susquehanna River in Pennsylvania, 15 km south-east of the sub-state's capital Harrisburg. The power plant, which had been given the same name as the island, was run by Metropolitan Edison (Met-Ed) which was part of the General Public Utilities (GPU) power plant group which was also the principal owner.

The power station consisted of two blocks, TMI-1 and TMI-2 and the accident had occurred in TMI-2. Both of the blocks had a Babcock & Wilcox pressurised water reactor. They were the same type as the Westinghouse reactor at Ringhals and gave approximately the same electric output. The 790 MW TMI-1 was commissioned in September 1974. The construction of TMI-2 began in 1970 and it was intended to give an electric output of 880 MW. The American Nuclear Power Inspectorate, the US Nuclear Regulatory Commission (NRC), gave permission for it to be charged on 8 February 1978, whereupon the reactor was tested on 28 March. Until the time of the accident in 1979, TMI-2 had delivered only relatively small quantities of energy, corresponding to operation at full power for 60 - 70 days.

The accident started at 04.00 (local time) in the morning of 28 March 1979, which was around the same time of my father's funeral at home in Sweden. The course of events was very complicated and unfortunate owing to a lack of training of the operators and incomplete indication equipment. It has been described graphically in the Reactor Safety Commission's report, from which I quote:

> At 04.00 in the morning of 28 March, a mishap during the work on the cleaning system led to a stoppage in the feed water pumps which supply the steam generators with feed water.* Within the space of a few seconds, this firstly triggered the stoppage of the steam turbine and then the emergency stop of the reactor. As part of this chain of

* Here, *feed water* is the water that is fed to the steam generators after having condensed in the steam turbine's condenser.

events, the blow-off valve at the top of the pressuriser opened to blow off a temporary overpressure in the primary system. Thus far, all safety systems reacted normally to the triggering event.

As normal, the blow-off valve also received a closure signal after approx. 10 seconds when the pressure in the primary system returned to its normal values. However, the valve became stuck in an open position. Water flowed through the open valve in the form of water vapour out from the primary system. This flow continued uninterrupted for approx. 2 hours and 20 minutes after the emergency stop, when an operator closed a blocking valve serial to that valve which had become stuck.

The control panel did not show whether the valve was open or closed. There was no signal from a position sensor on the actual valve. The control panel showed only a light to signal that it had been turned off. Nor did the instruments give any clear indication and readily-available information to show that the valve had become stuck in the open position. The operators were searching for other explanations as to why the reactor was behaving abnormally until they had discovered this. Because the valve remained open, the reactor ended up in what was an abnormal boiling situation for a pressure water reactor. This is characterised by the fact that reactor vessels and steam generators are increasingly filled by a mixture of steam and water. At the same time, the water level in the pressuriser is high because water is pushed up in the tank due to the formation of steam.

Since the pressuriser was higher up than the reactor core, the observers drew the wrong but easier-to-draw conclusion that a full pressuriser also meant that the core was well covered with water. In order not to overfill the system, the operators throttled the flow of water through the high pressure pumps. These are part of the emergency cooling system and had automatically started approximately two minutes after the emergency stop. This led the primary system to be fed less water than what was leaving through the open valve and in other ways. During this stage of the events, more and more steam was formed in the lower parts of the primary system. The steam bubbled up through the water-filled pressuriser and out through the open valve at the top.

At around 05.40 [local time], i.e., approximately 1 hour 40 minutes after the emergency stop, so much water had been lost from the lower parts of the primary system that it was no longer possible to keep the mixture of steam and water circulating. By then, all of the main circulation pumps had been turned off. The core was now beginning to boil dry, i.e., the water level began to sink beneath the top of the core. Large parts of the core were probably uncovered over the next 40-45 minutes. The jammed valve was discovered at 06.22, 142 minutes after the emergency stop, and the flow of steam was stopped by closing a blocking valve. This probably led to the water level in the reactor vessel starting to rise again.

However, the inadequate cooling while this was going on, and possibly also at a later stage, meant that large parts of the core intermittently reached temperatures of around 1 900 ^{o}C or possibly more, i.e., the core became incandescent. This probably led to extensive damage to the zirconium encapsulation of the fuel rods as early as around 120-150 minutes after the emergency stop, i.e., between 06.00 and 06.30. Gaseous radioactive material, primarily noble gases and iodine, were released from the fuel and came out into the reactor system and gradually into the reactor housing. A chemical reaction between zirconium and steam further generated large quantities of hydrogen gas which went the same way.

The stated temperatures are way over what the core is designed to tolerate. There is also much to indicate that parts of the core had collapsed into a ‘heap’, consisting of uranium fuel pellets and remains of encapsulation material and control rods. ...

Once the jammed valve had been found, the operators and their now ever-increasing and more qualified advisers began to try different ways of restoring the stability of the cooling process for the core. There was considerable uncertainty regarding the status in the reactor. None of the methods tried proved to be successful over the next 13 hours, i.e., up until 19.50 in the evening. The reason was primarily that large parts of the primary system were filled with hydrogen gas and radioactive noble gases. This meant

> that attempts to get the cooling water to circulate failed. The attempts may instead have led to the core once again being uncovered and inadequately cooled. ...
>
> At 17.00, i.e., 13 hours after the emergency stop, a decision was made to re-pressurise the reactor system and attempt to fill it with water with help of high pressure injection. Probably because at a previous stage a great deal of noble gases and hydrogen gas had been blown away, so much water came in that it was possible to restart a main circulation pump. This meant that the cooling of the core had also been stabilised once again. This took place just before 20.00, i.e., 16 hours after the emergency stop. After this time, the core cooling was never seriously jeopardised.

More and more people had – against all rules – congregated in the control room, attracted there by their eagerness to assist or by curiosity. A technician from the Argentinian Atomic Energy Commission was able to telephone home to inform his colleagues that he had been in the control room despite their having been informed that it was impossible. However, the NRC's reactor experts brought necessary expertise, particularly the experienced reactor inspector Harold Denton.

What happened later with TMI-2 can be briefly summarised: In July 1980, 43,000 curies of krypton 85 were released from the reactor building, whereupon it became possible for the first time to enter the building; in July 1984, the upper section of the reactor tank was removed and in July 1986 it was possible to remove most of the destroyed reactor core – the operation was completed in January 1990. The empty, decontaminated reactor was to be stored until TMI-1 ceased operations and then both plants would be demolished. TMI-1 was still in operation when this was written in 2006.

Consequences of the accident

The dominant impact of the TMI accident was the consequences for the nuclear power industry, particularly in Sweden where the accident led to a referendum on nuclear power. In the USA, the President (Jimmy Carter) set up a commission on 11 April with the task of investigating the accident. The Commission was named after its Chair, Dr. John G. Kemeny. It submitted its report* to the President on 30 October 1979.

The Kemeny Commission was very critical but said in its report (quoted from the Swedish Reactor Safety Commission):

> The Commission's findings with respect to the accident and the regulation of the nuclear industry - particularly the current and potential state of public safety in the presence of nuclear power – have, we believe, implications that bear on the broad question of energy. But the ultimate resolution of the question involves the kind of economic, environmental, and foreign policy considerations that can only be evaluated through the political process.
>
> Our findings do not, standing alone, require the conclusion that nuclear power is inherently too dangerous to permit it to continue and expand as a form of power generation. Neither do they suggest that the nation should move forward aggressively to develop additional commercial nuclear power. They simply state that if the country wishes, for larger reasons, to confront the risks that are inherently associated with nuclear power, fundamental changes are necessary if those risks are to be kept within tolerable limits.

As regards the risks to people's health and life, the Commission maintained that the radiation doses – caused by radioactive noble gases and radioactive iodine – was so low that no-one had come to acute harm and that the collective dose could not be expected to cause more than a few cases of cancer, too few to be proven by health statistics. People's worry was worse. The Commission thought the most serious health effect was severe psychological pressure.

Understandably enough, the worry led to suspicions that the authorities had concealed the real scope of the accident and that the radiation doses had been much greater than was claimed. However, that

* Report of the President's Commission on the Accident at Three Mile Island. October 1979, Washington DC.

suspicion can be rejected by the very fact that every university institution with self-esteem and expertise had sent colleagues to the site to measure the radiation and the radioactive fallout around the reactor or calculate the radiation doses from the leaking noble gases.

13.15. **Nordic seminar in Röros**

A seventh seminar had been arranged by the Nordic Joint Committee in cooperation with Nordel was held in Röros in Norway on 2-3 April 1979. The subject was environmental effects of different forms of energy production. The meeting was organised by Rolf Lingjærde from the Norwegian Atomic Energy Institute (IFA). Lennart Devell spoke about a project on the quantification of environmental impacts. The weather was beautiful and I used the lunch breaks to go skiing up in the mountains. I was on my own there but met Bo Aler on the track.

At the start of the seminar, Lingjærde received a telephone call from the IFA and we heard that there had been a reactor accident near Harrisburg and that people were worried about possible explosions in hydrogen gas bubbles.

Marrit was with me and, after the meeting, we travelled to our cottage in Västerdalarna and found out more about the concern aroused by the accident.

13.16. **Decision on referendum**

There was also a great deal of worry in Sweden. An accident that could not have happened had happened. The popular humourist Tage Danielsson bantered on about this in a famous monologue. What the technicians, who had calculated such small probabilities that they precluded an accident in practice, had forgotten was to look at the possibility that their calculations were not relevant or adequate. You calculate an extremely low probability but forget to review whether your assumptions are reasonable. I had often said that you should view estimated probabilities lower than 1 in 1000 with great scepticism unless they concern factors of which you have frequentistic experience. And even then, relevance of the experience can often be questioned.

Olof Palme and the Social Democratic Party had been largely positive towards nuclear power and believed that such a complicated issue ought not to be part of a referendum. The TMI accident changed the attitude. On 4 April, ‘the mad Wednesday’, the party leadership declared that it now wanted to have a referendum. The Centre Party had already previously been in favour of a referendum so it was thereby determined. It became politically impossible for the Liberal People’s Party and the Moderates to oppose the proposal.

13.17. **The Swedish Reactor Safety Commission**

On 26 April 1979, the government decided to authorise Cabinet Minister Carl Tham who was responsible for the energy issues to establish a Committee to, on the basis of completed reactor safety studies and the TMI accident, consider whether there was cause to essentially revalue the risks of nuclear power and investigate which measures ought to be taken to strengthen the safety of the Swedish nuclear power plants. On 9th May, Tham convened the following people to be part of the Committee:

Lars Friberg, head of the Swedish Environmental Protection Agency’s environmental hygiene department
Arne Hedgran, head of the Swedish Nuclear Power Inspectorate
Sven Johansson, Professor of Nuclear Physics at Lund University
Kerstin Lindahl-Kiessling, Professor of Zoophysiology at Uppsala University
Bo Lindell, head of the National Radiation Protection Institute
Hans Löwbeer, University Chancellor
Lars Nordström, Professor at Luleå University of Technology
Lennart Sjöberg, then Professor of psychology at the University of Gothenburg

Evelyn Sokolowski, Assistant professor at Studsvik Energiteknik AB
Göran Steen, Director General of the Swedish Accident Investigation Authority
Carin Sundström-Frisk, research psychologist at the National Board of Occupational Safety and Health's Occupational Medicine Department
Torbjörn Westermark, Professor of Nuclear Chemistry at the Royal Institute of Technology (KTH)

Hans Löwbeer was appointed as Chair. Lars Högberg, Chief Engineer at the Swedish Defence Research Establishment was appointed as Principal Secretary on 28 May. In June, a further two Secretaries were appointed: *Nils Gyldén*, also Chief Engineer at the Swedish Defence Research Establishment, and former Maritime Adviser *Gustaf Lindencrona*. A number of experts were appointed also in June, of whom Chief Engineer at the delegation for energy research *Per Strangert* was particularly active. The Committee went by the name of The Reactor Safety Commission. It submitted its report, 'Safe Nuclear Power?' (SOU 1979:86), on 19 November 1979 and by that time had got around to travelling to the USA to visit Three Mile Island.

An event during the discussions at Hans Löwbeer's is worth mentioning. Löwbeer, who was a lawyer and was not educated in natural science, started thinking about the concept of probability. He said he thought he understood what probability was when it concerned frequencies, but what was probability where an individual unique event was concerned? We attempted to explain that probability was a measure of confidence in a statement, e.g., the fact that an accident would happen. Löwbeer, with his layperson's view of the problem, had realised more than highly-educated technicians had realised.

Another discussion regarding probability was one that I had with Sven Johansson, who made the common mistake of thinking that it was possible to impartially weight different probability values to obtain the best value for the likelihood. But if, in addition to the calculated low likelihood, there is a very high value that someone thinks is credible, how should it be weighted? Here, it is no longer a question of stochastic variables. Whether the high probability value is relevant or not is an unknown fact whose credibility is determined by the estimator's knowledge, experience and subjective views. Some may believe in it, others may think it is precluded. But who is right? Here there is no *a priori* objective response, merely subjective belief (although not always the worst).

13.18. **Chaos**

Up until the 1960s, the general understanding was that the natural phenomenon could be either deterministic or stochastic (random). The results of random events could not be predicted in each individual case. However, if you were dealing with many random events of the same type, 'the law of large numbers' applied, i.e., if there was repetition or duplication, the average value of the outcome came closer to the statistical expectation. When it came to stochastic radiation injuries, Dan Beninson used say that 'individual randomness becomes collective determinism'. Many argued that there was no actual chance and those which appeared to be random outcomes could be deterministic effects for which the determining start position was not adequately known. If it were possible to simply pinpoint the starting point, you would be able to predict the result.

For both cases, stochastic and deterministic connections, it was thought that 'the damage followed the impact', i.e., that a change to the starting point led to a proportional change in the final result. However, in 1963, Konrad Lorenz showed that the long-term impact of a development in the weather was a very sensitive, unexpected function of the initial state. Since there the latter cannot be adequately defined, it is impossible to predict things like the weather over long periods. In cases where the connections are non-linear, the course of events can appear to be random, although they can be shown to be deterministic. This is easy to illustrate using a computer.

Using the computer, we can follow the development of X_n over n stages. For example, say X_{n+1} is equal to $a \cdot X_n \cdot (1 - X_n)$ and select, for example, a = 4 and the baseline value $X_0 = 0.7$. The table shows that for every tenth value of the n value of X_n (rounded off to one hundred thousandths) at the different baseline values where X_0 has been changed only very slightly:

	X_0=	0.7	0.70000007	0.7000001	0.700001	0.70001
n =	10	4340	4344	4346	4386	4807
	20	91997	96784	98308	42648	2907
	30	99762	99987	99916	2327	20682
	40	13221	67419	94566	6552	11569
	50	65978	36	7040	85612	15318

The values of X_n appear to vary randomly but are deterministically determined by the baseline value X_0. Slight changes to X_0 do not particularly affect the result of n = 10 repetitions; it is still largely the same apparently random picture. However, a change at just one ten millionth leads to a drastic impact on the values after 40 repetitions. This is an illustration of the statement that 'a butterfly flapping its wings in South America can affect the climate in Europe'. The chaotic values demonstrate an uncertainty which has important consequences within many applications where non-linear connections are concerned.

13.19. **The emergency preparedness report**

On 26 April 1979, the government asked the Radiation Protection Institute to 'review the organisation and resources regarding emergency preparedness in case of accidents in nuclear power plants in consultation with relevant County Administrative Boards'.

In the assignment letter, the Minister of Agriculture (Eric Enlund) reminded them of the County Administrative Boards' undertaking to establish emergency preparedness plans in case of major accidents with nuclear power plants within their county and that the Radiation Protection Institute had an Emergency Preparedness Board against 'Nuclear Accidents' (the BNA) whose task it was to advise the Institute and the County Administrative Boards. He referred to the fact that two Committees (Energy Commission and Energy, Health, Environment) had given points of view that should be observed. The Institute's committee ended up being called 'More Effective Emergency Preparedness'. See also Section 13.31.

13.20. **UNSCEAR's 28th session in Vienna**

UNSCEAR met in Vienna on 11-15 June. Julian Liniecki had been temporarily engaged as Principal Secretary when Dan Beninson left the job in January. No successor had yet been appointed and the delegates were upset about what was seen as slow bureaucracy within the UNEP in Nairobi. The preparatory work for the meeting had been rescued thanks to the efficiency of Frau Holzer, but the cooperation between her and Julian, who did not possess Dan's ability to agree with her, was unfortunately not the best.

Professor Stieve was now Chair with the Polish representative, Professor Jaworowski, as Deputy Chair and Dan Beninson as rapporteur. I was Swedish representative with Gunnar Walinder as deputy and Kay Edvarson, K-G. Lüning and Jan Olof Snihs as advisers.

13.21. **SIPRI**

SIPRI is short for the *Stockholm International Peace Research Institute*, an Institute which came about in 1966 as a monument to Sweden's 150 years of peace. The Institute is known and admired for its diaries which arouse international attention. The SIPRI is financed mainly by the Ministry for Foreign Affairs. Alva Myrdal was Chair of the board in the first year and was succeeded by Gunnar Myrdal. However, the reason why I allot space to the SIPRI in my account is the role which was played by Rolf Björnerstedt (1926-2005).

At the start of the 1950s, Rolf ('Nalle') was an inspiring physicist at the Swedish Defence Research Establishment, FOA, but at an early stage became interested in the safety policy and the risk of nuclear war. This led to him and Ministry for Foreign Affairs official Örjan Berner (1937-) jointly and temporarily becoming the first Director of the SIPRI. When Gunnar Myrdal succeeded Alva in January 1967, Myrdal's favourite Robert Neild started as Director, whereupon Berner and Björnerstedt left their jobs. Neild had Ministry for Foreign Affairs official (and later ambassador) Jan Mårtensson as Deputy Director who, despite his many important diplomatic assignments, may be better known as a detective novelist.

Rolf Björnerstedt came to the UN in New York and became head of department for disarmament matters and then, as Under-Secretary General, head of the UN Centre for Disarmament Affairs. When it looks as though Ronald Reagan was to become President Rolf left the UN and from 1979-1985 became acting Chair of SIPRI's board (the Director at the time was *Frank Barnaby*). He then continued in 1987 as Managing Director of a foundation created by Gorbachev, the International Foundation for the Survival and Development of Mankind. A remarkable career for a radiation physicist!

13.22. **Swedish Parliament makes an energy policy decision**

In June, Swedish Parliament made a decision regarding the Ullsten government's energy policy bill from 1st March. However, the decision did not cover the nuclear power plants; the government wanted to wait for the referendum. Swedish Parliament also introduced a law which for the time being, while waiting for the referendum on nuclear power, forbade the charging and commissioning of reactors which had not yet had nuclear fuel added. No new reactors could be commissioned before the referendum. the law (1979:335) was called the 'Respite Act' and sometimes, in the Reactor Safety Commission's report for example, the 'Reprieve Act'.

In the same month, Cabinet Minister Tham set up a committee, the impact committee, whose job it was, before the referendum, to investigate the economic consequences of phasing out nuclear power. The committee submitted its report in November. The consequences of phasing out were said to correspond to a loss in private consumption until the year 2000 of a total of 70-75 billion Swedish kronor.

13.23. **High-tech or low-tech society?**

During the nuclear power debate, the energy issues were discussed broadly and to some extent in detail. What sort of society did we want in the future? A high-tech society with all the benefits of modern technology but with worrying disadvantages? A low-tech society which many saw in a romantic light and which did not bring with it the risks of high technology? I wrote at some stage that the situation reminded me of a motorist who could not decide which way to go at a crossroads so he goes straight on - which undeniably has to be the worst alternative.

The Left Party, then the Left Party Communists, did not like nuclear power. Someone who on the other hand became lyrical at the thought was the Communist doctor *John Takman* (1912-1998), who did not belong to the Left Party Communists but to the pro-Soviet Workers' Party Communists (APK) whose mouthpiece was, between 1977 and 1990, *Norrskensflamman* ('the Northern Lights Flame', at the time a daily newspaper, now an independent socialist weekly). Takman was a helpful man but as naive as a child. When the Radioactive Waste Committee made its study visit to the Soviet Union, he glowed like a young child on Christmas Eve and did not want to see anything negative in much that we others were sceptical about. Takman without doubt chose the high-tech society and justified his view in *Norrskensflamman* in February 1979*:

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* Old political party designations are often confusing, not least as regards left-wing parties. Sometimes it is easier to identify the persons rather than the parties. During the time period covered by this book, the present Left Party has had two designations, in that before 1990 it was called the Left Party Communists. After their secession in 1977, the faction supported by Takman, as a northerner, called themselves the Worker Party Communists until 1995, thereafter the Swedish Communist Party.

> I remember my own childhood. Father was a trained stonemason with the artisan's love for his work. When there was work to be had he was away from home for weeks and months in another place. We had also a smallholding. There were eight of us children, and mother's working day lasted from 5 in the morning until 11 in the evening without one day off in twenty years. We had no electricity, telephone, central heating, fridge, laundry room – just like all other working and agricultural families at the time.
>
> For a stonemason – as for builders, lumberjacks, farmers and all other labourers before the 1940s – there were neither electric drills, cranes, engine-driven trucks or other mechanical tools. The technically low-energy society was a high-energy society in terms of muscular work. It was a society for strong muscles, backs, legs, hearts and lungs where the men and women of the working classes and agricultural families were worn out long before reaching the Joe Hill 'state pension enough for snuff' stage.
>
> It is this inhuman slavery and work life for women which the low-energy romantics would be reintroducing if they were successful - and which they would make permanent for the two thirds of mankind who were not yet present in the world of material surplus which the scientific-technical revolution was opening up the possibilities for.
>
> ...
>
> The Left Party Communist leaders are aiming to replace nuclear power and the 331 TWh, which was what the imported oil constituted (72 per cent of the energy conveyed), with wind and sun and 'biomass'. There has been no greater miracle than the Left Party Communists' energy programme since Jesus walked on water.

I am reproducing this to show how the debate could turn out at the end of the 1970s.

13.24. **ICRP in Baden in June**

The ICRP's Main Commission met at The Club-Hotel Baden outside Vienna on 18-20 June.

13.25. **The Nordic Congress of Radiology in Stockholm**

The 37th Nordic Congress of Radiology was held in Stockholm in 1979 with Rune Walstam as President, an honour which pleased him greatly - a physicist as President of the radiologists! It was more than what Rolf Sievert was granted. And it was no ordinary Congress either: the Nordic Society for Medical Radiology was able to celebrate its 60th anniversary.

The scientific programme included nine symposiums. For a radiophysicist, it is particularly worth noting that symposiums III, IV and VI. In symposium III, Anders Brahme was moderator of a discussion about accelerators within healthcare. Symposium IV discussed 'Radiological benefit-risk-cost' relations with Lars-Eric Larsson as moderator. Ulf Rudhe and Bert Sarby were responsible for symposium VI, which presented dynamic radionuclide studies.

13.26. **Problems of Science and Religion**

The day before the World Council of Churches conference at the MIT (see next section), a discussion was held at the American Academy of Arts and Sciences about Problems of Science and Religion. The reason I was invited to take part was probably because Professor of Nuclear Technology at MIT, *David Rose*, knew me from before and because I was Chair of ICRP. 17 people took part in the meeting. Professor of Chemistry *John Turkevich* at Princeton University held the introductory address. I can quote a few statements from my minutes which highlight the problems that were perceived as key for American scientists:

> *John Turkevich*: Science does not just have minuses. One plus is that it provides technology which makes it possible to spread knowledge of wrongs in the world and thereby awaken our conscience whereas before, the wrongs had taken place on the quiet.

Turkevich: The feeling of belonging to 'a chosen people' and that the person is key to God is dangerous. If there are humanoids in other places in space, this is a sign that the person is insignificant, not indispensable to God.

Gordon Edwards (physicist from Canada): There is nothing to say that the development of man is necessarily positive. Many signs indicate that it is insane. Think of nuclear weapons.

Turkevich: I was one of those who developed the bomb, first for the British, then in the Manhattan project. It was an honest attempt to beat the Germans to it because we thought they might get there first. But we lost control and had no possibility of influencing the development or Truman. It was a shame to drop the bomb in Japan; so many innocent people were killed.

Edwards: Perhaps we ought to stop a while and learn to live with the scientific knowledge that society has collected rather than continuing with the current knowledge explosion.

G. R. V. Mmari (Dean of the Faculty for Social Sciences in Tanzania): Countries in my part of the world have many religions, mysteries and taboos which influence the general opinion, and people are often very poor. They say 'we'll go into the village before we go to the moon'. Science brings its advantages: longer life, healthier children, greater freedom and more food. Technology brings many gadgets that are economically out of reach, so in practice the technology concerns more necessary things.

13.27. **The World Council of Churches in Boston (MIT)**

The World Council of Churches arranged an international conference on Faith, Science and the Future at the Massachusetts Institute of Technology (MIT) in Cambridge outside Boston on 12-24 July. This was the third time I had been invited to take part in an ecumenical conference although I am not religious. It was probably my Chairmanship of ICRP which led to them thinking that I could contribute an explanation of the ethics of radiation protection.

The scope of the conference was impressive, which is shown by the headings for the ten sessions:

1. The nature of Science and the Nature of Faith
2. Humanity, Nature and God
3. Science and Education
4. Theological and ethical issues in the biological manipulation of life
5. Technology, resources, environment and population
6. Energy for the future
7. Planning the industrial and urban environment of the future
8. Economics of a just, participatory and ecologically sustainable society
9. Science and technology, political power, and a more just world order
10. Towards a new Christian social ethic and new social policies for the churches.

It is worth noting that point 8 wisely enough talked about a 'sustainable society' and did not have the usual phrase 'sustainable development', which literally means that the development continues without limitations. The Swedish participants included Kerstin Anér whom I had the opportunity to talk to about the ethics of radiation protection.

13.28. **The Reactor Safety Commission travels to the USA**

In August 1979, the Reactor Safety Commission travelled to the USA with the following programme:

Monday 20 Aug. at 10.00:	At the Swedish Embassy with *Lars Gunnar Larsson* as host.
at 13.30:	Nuclear Regulatory Commission (NRC) Bethesda with *Bob Senseney* as host.

Tuesday 21 Aug. at 09.00:	President's Commission on the accident at Three Mile Island (the Kemeny Commission), Georgetown University. *Richard Thornsburgh*, Governor of Pennsylvania
at 10.30-16.30:	NRC, Bob Senseney
Wed. 22 Aug. at 09.00-18.00:	President's Commission, host: *Barbara Jorgensen*. With *Roger Mattson*, Director Div. of Systems Safety
at 09.30:	Lunch: Electric Power Research Institute, Nuclear Safety Analysis *Ed Zabrowsky*, Director NSAC and host Bob Ritzman, Deputy Director EPRI Washington Office.
Thu 23 Aug at 09.00-13.00:	President's Commission. Host Barbara Jorgensen. With Harold Denton, Director of NRC Office of Nuclear Regulation
at 17.00-19.00:	Reception at the Swedish Embassy.
Friday 24 Aug. at 07.00:	Depart with Shoreham Americana to Three Mile Island

At the Swedish Embassy we were taken care of by the scientific attaché, Lars-Gunnar Larsson. During the visit to the NRC we were surprised how strongly hierarchical the organisation was and that most people we spoke to had been employed for only a very short time. The visit to Three Mile Island did not tell us much more than we already knew but seeing the enormous cooling towers (the reactors were not water-cooled in the way we are used to) was impressive. The huge clouds above the TMI-1 tower for consisted of steam. We learned that those in favour of nuclear power prefer to show photographs taken from the sunny side so the clouds are white, which is to be expected from steam, while those opposed to nuclear power prefer photos to be from the shaded side so the clouds are dull dark grey and can be suspected to contain all sorts of toxins.

In Washington DC we had the opportunity to interview the well-known radiologist and biophysicist Jacob Fabrikant (1928-1993) about the problems with the publication of the next BEIR report, BEIR III. The interview will be discussed in the next chapter.

13.29. **Fälldin's second government**

At Swedish Parliament's election in September the non-socialist parties won once again, but this time the victory was very narrow – 175 seats against 174. A non-socialist tripartite government was formed once more with Torbjörn Fälldin as Prime Minister. Lawyer Carl Axel Petri became consultative Cabinet Minister, responsible for the energy issues among other things. Anders Dahlgren returned as Minister for Agriculture.

13.30. **Warning about Ytong**

During the autumn, the magazine *Vi Bilägare* ('We Car Owners') carried an article warning about 'the carcinogenic blue lightweight concrete' showing a large photo of Bengt Håkansson and Jorma Suomela, each holding a block of lightweight concrete, one suspicious with blue concrete and one non-hazardous with white concrete based on sand.

13.31. **Israeli nuclear weapons testing?**

On 22 September 1979, two rapid flashes of light were observed by means of an American Vela satellite in the southern part of the Indian Ocean. American sources, including the CIA, have said that they were probably to do with a weak nuclear charge explosion carried out by Israel, possibly with technical support from South Africa. The event is also discussed in the book called *Spying on the bomb* (Richelson, 2006) about the American attempts to keep up to date with other countries' nuclear weapons testing.

13.32. **More effective emergency preparedness**

The work with the Radiation Protection Institute's preparedness report was productive and the cooperation with the County Administrative Boards' Defence Directors had been excellent. The report was to come out in six volumes together with the first main report, which were jointly called 'More Effective Emergency Preparedness'. The main report was submitted to the Ministry for Agriculture in December 1979. That was a sensitive time. The decision on the committee had already been made in 1978 but it had been established on 26 April following the American reactor accident on Three Mile Island on 28 March. On 'Mad Wednesday', 4 April, the Social Democratic Party's board had changed its mind and declared that it now wanted a referendum on nuclear power. The referendum would be held on 23 March 1980. Whatever the Radiation Protection Institute did, it would be accused of either withholding information on the consequences of reactor accidents or adapting the information in time to influence the wording of the electoral matters. Unfortunately, the Institute had been asked to submit its report at the end of 1979 but in the report, Volume 1, which then came out, the Institute had not had time to fit in all impact descriptions that both the Radiation Protection Institute and the Swedish Defence Research Establishment, FOA, had worked on. The most sensitive volume, Volume 5, was not finished until February 1980 and this led to unwarranted suspicions regarding a deliberate delay.

The summary of Volume 5, under the heading 'Why describe the consequences now?' began with the following text:

> The impact description in this volume has two objectives. Firstly, the Radiation Protection Institute has previously criticised the Urban Siting Report and the Energy Commission for failing to adequately emphasise the consequences of radioactive ground covering from a major accident. In the summary of Volume 1, the Institute said that the characteristics of a very substantial reactor accident which emits considerable quantities of radioactive substances into the surroundings were primarily the risks of cancer, the risks of hereditary injury and the possibility of radioactive contamination of very large areas of land for many decades. These consequences can be alleviated only marginally by greater preparedness. If nuclear power is approved, the possibility of the said injury risks also has to be accepted. The Institute wants to use this volume to help to highlight these risks of injury. They must be seen against the background of the likelihood of very substantial accidents occurring. The Institute has no expertise to be able to assess the estimated technical likelihood, but would like to point to the major principal difficulties that are associated with estimates of very small probabilities.
>
> Secondly, in volumes 1 and 2, the Institute has reported the way in which more effective emergency preparedness could alleviate the impacts of any reactor accidents. This emergency preparedness can primarily alleviate the acute radiation injuries. A brief description of the effect of the emergency preparedness measures was given in Volume 1. This volume aims to emphasise in greater detail what can be gained from more effective emergency preparedness.

One reason why we at the Radiation Protection Institute wanted to give impact descriptions of very substantial accidents was that we* did not think it was possible to estimate very small probabilities (see also Section 22.19) and gave our reasons in Chapter 10 of Volume 5. The likelihood of an individual event such as a reactor accident is dependent on the assumptions that can be made. These assumptions

* 'We' in this context should be interpreted as the Radiation Protection Institute people who were immediately responsible for the report, i.e., Gunnar Bengtsson, Ulf Bäverstam, Kay Edvarson, Bo Lindell, John-Christer Lindhé and Jan Olof Snihs.

in turn depend on the knowledge and experience of the person making the estimate. There is therefore no objective probability in this case.

Our decision to give scenarios for the impacts of very substantial accidents aroused strong criticism. Many technicians maintained that such extensive accidents were beyond reasonable limits. Professor of Reactor Technology at KTH, *Kurt Becker*, was categorically of the opinion that the worst accidents could not occur. He wrote the following in his statement about the report:

> The Swedish Radiation Protection Institute’s report is therefore only of value as an academic calculation exercise and is unusable as a basis for planning disaster preparedness and for assessing what could occur around our nuclear power plants in the event of a disaster. The report can actually be seen as a safety risk since it facilitates a discussion of impossible accidents rather than a factual assessment and analysis of what can realistically be expected in the event of a reactor disaster.

However, the Radiation Protection Institute’s assessment was shared by the Reactor Safety Commission, which submitted its report, ‘Safe Nuclear Power?’, in December. We gave the idea of the impact in a drastic example of extensive ground contamination, which was then realised with the Chernobyl disaster six year later. There is hopefully a lesser likelihood of this happening to Swedish nuclear power plants, but this quiet desire is based on belief rather than knowledge.

One problem that worried us somewhat was the allocation of responsibility. Here, there were two worlds. One was the emergency preparedness planning, which was implicit. The other was the situation that could arise if an ambitious but unprepared Cabinet Minister were to choose to intervene in a disaster situation. Rolf Sievert had realised the risk and, at the time of the substantial radioactive fallout from the Soviet superbombs in 1960 and 1961, had assured himself that the government would not make a surprising move because he had enforced a preparedness plan where the leadership, formally but not in practice, was allocated to the Ministry of the Interior.

13.33. **Safe nuclear power?**

On 19 December, the Reactor Safety Commission submitted its report, ‘Safe nuclear power?’, to Cabinet Minister Carl Axel Petri. The report contained an in-depth analysis of the TMI accident. The consequences (in addition to the political and economic) were summarised as follows:

> The reactor housing remained undamaged despite explosive hydrogen fuels. The emissions of radioactive substances were insignificant and limited to radioactive noble gases. These leaked out from relief systems outside the housing. It should be noted in particular that substances that could have caused ground coatings, such as radioactive iodine and caesium, were effectively retained, dissolved in the large quantities of water that existed within the buildings. It is estimated that the emissions that did take place could lead to a few extra cases of cancer.

The most important of the many recommendations contained in the report concerned the introduction of consequence-reducing systems. One action would be to prevent a heavy overpressure in the reactor housing with the risk of damage to this and radioactive substances leaking into the surroundings. The solution could be to introduce a pressure relief valve linked till a large filter chamber which would withhold the radioactive substances. The filter chamber could, as suggested by Studsvik scientist Kjell

Johansson, consist of a very large 10,000 m^3 filter chamber filled with crushed stone.* Such safety systems, later called 'FILTRA', were required in a government decision in 1981. A pressure relief filter device was introduced for Barsebäck in 1985 and for the other nuclear power plants in 1988.

The expensive devices were justified in 'Safe nuclear power?':

> It is natural to assess a safety measure with regard to expenses and anticipated safety effect. ... When making a decision, assessments are often based on the statistical 'expectation' which is the product of probability and scope of the accident's consequences. [The filter devices] would not be reasonable based on just one such assessment.
>
> However, regarding events that have a very low probability but very substantial consequences, it is misleading to use the expectation of damage ...as the sole basis for the assessment. In such cases, it is considered reasonable to pay particular attention to the magnitude of the impact.
>
> The most serious, conceivable, very unlikely accidents in the context of nuclear power could have very substantial consequences in the form of cases of cancer and radioactive contamination of large areas of land. Particularly for the two nuclear power plants on the west coast and primarily for the Barsebäck Nuclear Power Plant, a long-standing radioactive ground covering would be the dominant element of the impact.
>
> One additional point of view is the uncertainty regarding the numerical values attributed to the likelihood when the latter is deemed to be very low. In this type of case, for the error analysis and when calculating the probability, it is difficult to imagine the exact course of events of very substantial accidents since it is assumed that the safety systems are not functioning as intended. This uncertainty must also be factored in.
>
> The Committee thinks that the uncertainty in the probability numbers and the conceivable scope of very substantial accidents are completely adequate grounds to continue investing heavily in emission-limiting measures and an outline of the effectiveness of existing measures.

13.34. **A prayer for afflictions**

Many people were afraid of radiation. Newspapers and TV fuelled the fear by exaggerating the risks. This convinced to some readers and viewers that they were at serious, major risk from the normal operation of nuclear power plants and that the authorities were attempting to keep this risk secret. It created the usual information dilemma. If we from the Radiation Protection Institute attempted to give a fair picture, we automatically became 'counterparties'. In cases where we attempted to warn people about risks which most people did not believe in, such as the risk from radon in our homes or the risk of cancer from sunbathing, we had difficulty making ourselves heard.

After mentioning in a reply to a contribution by the literature critic *Maria Bergom-Larsson* in *Dagens Nyheter* how difficult it was to demonstrate a higher prevalence of cancer through epidemiological surveys. I received a brown envelope by post showing bright antinuclear power symbols. In the envelope was my contribution, a clipping with the following written above it in big red letters:

> If God is fair and good, Bo Lindell *et consortes* MUST be hit by incurable, PAINFUL cancer! We want it!
>
> Christian nuclear power opponents in Stockholm

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* On reading the manuscript, Arne Hedgran considered a reference to an American report by an author named Benjamin lacking, although the latter was not mentioned in the Reactor Safety Committee's report. However, on 20 October 1980, a DOE conference was held in San Diego on nuclear air cleaning. The title of a paper there by Walling, Benjamin and Cybulskis (Walling, 1980) was *Design criteria and concepts for vented containment systems*, so Benjamin's proposal for reactor housings with valves may very well have been discussed by the Committee. The Committee's most active advocate of the method was Professor Torbjörn Westermark, who was mainly referring to Kjell Johansson.

I noted that bloodthirstiness was not exactly worthy of the Christian faith but was sad to think that many people were clearly affected by such concern and indignation that they lost both judgement and humanity.

Another example of how far frightened people can be prepared to go is the telephone conversations that Gunnar Bengtsson and I received on 1 May 1979 when a female voice very abruptly said: 'In Jesus' name you've had it now!' Gunnar may have been less well prepared than I was since he had the call traced and then sent the subscriber an admonishing letter in which he wrote: 'I do not think it is good Christian conduct to make such calls. If someone is angry with or upset at someone you should talk about the matter and try to understand and forgive one another'.

I was less optimistic than Gunnar. The person who had rung had been psychologically unbalanced and may have been convinced that a curse in the name of Jesus would have an effect. In the conceptual world of that confused person, the curse was tantamount to attempted murder. If she had had a real weapon available to her she may have used it.

14. THE YEAR 1980

14.1. **George Wu**

Bearing in mind that China represents a considerable share of the Earth's population, David Sowby as Secretary of ICRP felt a responsibility to try to establish a contact. He has described how he succeeded with this in his (as yet unpublished) memoirs, *Man Ages*. I quote:

> For some time I'd felt that ICRP was poorly represented in the Far East. True, we had a couple of members from Japan, but the vast map of China, with its millions of people, was a reproach, inasmuch as we had no contacts with them, and they were, after all, a nuclear power. And so, around 1980, I was pleased to hear that a Chinese radiologist was visiting the Royal Marsden Hospital, and I made a special effort to meet him. This meeting turned out to be a turning point for ICRP and for me personally. George Wu was an exceedingly interesting person. He was born of Chinese parents in Mauritius, but was taken back to China at an early age. As a young doctor he was studying in Europe at the beginning of the Second World War, and managed to escape to England in 1940. He trained in radiology at the Marsden, living all the while in extreme poverty. He used to go to the local fishmonger to beg for scraps and for fish heads, which were normally thrown out, but which George, with his knowledge of Chinese cooking, knew how to make into nourishing soup. During his five-year stay in London he became more English than the English themselves and learnt to speak the language fluently. At the end of the war he returned to China, where he was welcomed as one of the few qualified radiotherapists in the country. However, he wasn't allowed out of China until twenty-five years later, when he was sent abroad to buy equipment for his radiotherapy department. He told me that he and a famous Chinese ballet dancer were the only people permitted to travel abroad freely. A couple of years later I had the great fortune to sit beside that dancer on a plane trip to China. I've forgotten her name, but she was a very impressive lady.

George Wu was greatly esteemed in China because he had returned there of his own accord following his education in England. He was said to be good friends with Zhou Enlai.

14.2. **The IRPA Congress in Israel**

In March 1980, IRPA held its 5th Congress, this time in Jerusalem. Dr. Aharon Eisenberg was 'Secretary General' of the Congress and has been kind enough to provide the following information. The Congress' motto was 'Radiation protection – a systematic approach to safety'. Chair of the Congress was *Tuvia Schlesinger*. The Programme Committee was led by Pamela Bryant and included André Bouville, John Horan, *Serge Prêtre*, Tuvia Schlesinger and David Sowby. Lauriston Taylor held the Sievert Lecture, which was entitled 'Some non-scientific influences on radiation protection and standards'. Dan Beninson gave a presentation entitled 'Justification and optimization in radiation protection'. Proceedings were published in two volumes after the Congress.

14.3. **GEILO in January**

In January, the Nordic Society for Radiation Protection held a subject meeting regarding radon in Geilo and Gun Astri Swedjemark was obviously there (as was I).

14.4. **Kyoto-Hiroshima in January**

Lars-Erik Holm, Karl Johan Johansson, Bo Lindell, Göran Lundell, Jan Olof Snihs and Gunnar Walinder (whom the magazines called *Swedish Scientists*) took part in a joint symposium with the Japan Late Effects Group on 14-15 January at Kyoto University Radiation Biology Centre (Director: Dr. Tsutomu Sugahara).

Kyoto was the capital city of Japan and the seat of the imperial family from 794-1868. In 1603-1867 the Emperor and Shogun (the head of the military government) were in different places, the Emperor in Kyoto and the Shogun in Edo (Tokyo). Kyoto had very nearly been the victim of the first atomic bomb instead of Hiroshima but for the fact that Minister of War *Henry Stimson* (1867-1950) had intervened against General *Leslie Groves'* original plans (see p. 192 of 'The Sword of Damocles').

On Wednesday 16 January we went by 'Hikari No. 1' from Kyoto Station to Hiroshima where we stayed at the Hiroshima Grand Hotel. After lunch at the hotel we visited the Hiroshima Peace Museum where we took part in a reception after meeting the press. We returned to Tokyo the next morning by 'Hikari No. 4' and flew home from Narita in the evening.

The Japanese journalists were anxious to be able to document how disturbed we were by what the museum showed about the atomic bomb. It was not difficult to be greatly disturbed – it was not as though we were ignorant of what had happened either.

14.5. **The Nuclear Gang**

'The Nuclear Gang' was the name of an American documentary film which the People's Campaign Against Nuclear Power wanted to have broadcast in Sweden. Head of TV1 *Sam Nilsson* refused to broadcast it. Then a large number of colleagues protested so TV2's head of factual information *Ingemar Bygdestam* wanted to purchase the film to broadcast it on TV2. However, this was stopped by head of TV2, *Oloph Hansson*. The film concerns soldiers who were ordered to remain near the atomic bomb testing site in Nevada. One of them in particular, *Paul Jacobs*, got cancer and died on 3 January 1978 at the age of 57. The film is about his twilight period when he was convinced that it was the radiation that had given him cancer. I answered the question from *Expressen* as to whether Jacobs had been right, and was quoted as saying:

> It is very difficult to believe that claim. Examinations of the survivors from Hiroshima show that even in that instance there is difficulty in establishing the increase in the number of cases of cancer that may be due to radiation. I therefore find it difficult to believe that it is possible to produce a more reliable response in the Nevada desert.

I referred to another American report (the Mancuso report) which maintained that it was possible to show greater risks of cancer among those employed at the Hanford plant. This had aroused a storm of scepticism from international experts. I continued:

The authorities then set up the BEIR Committee* which examined the reports that has been submitted in all different contexts in the USA. In May 1979, the Chair of the Committee, Professor Ted Radford, said that the Hanford report had been studied and no support was found for the risk of cancer.

14.6. **BEIR III**

The publication of BEIR III (see 13:27) had been delayed owing to disagreement between the two leading scientists, the Chair Ted Radford and Harald Rossi. Most of the Committee members thought the dose-response relationship was probably linear-quadratic, i.e., linear at low doses of radiation but with an additional quadratic component at higher doses. Radford thought the connection was purely linear so that the risk values could be interpolated between zero and the high doses where observations had been made. Rossi did not think anything could be said about the dose-response relationship at low doses for low LET radiation such as gamma radiation. No-one wanted to give way.

When the Reactor Safety Committee visited the USA in August 1979, we had the opportunity to interview the radiologist and biophysicist Jacob Fabrikant whom had been on the BEIR Committee. I reproduce my notes from the occasion:

> In the early 1970s there were three dominant scientific assessments of risks of late injury from low doses of radiation reports from ICRP, UNSCEAR and the American Academy of Science's Committee on the Biological Effects of Ionising Radiation (BEIR).
>
> In 1977 ICRP and UNSCEAR published new risk estimates. These have been criticised by people who think that papers by Mancuso and Stewart, Kneale and Bross point out the possibility that the risk per unit dose may have increased at low doses. According to the critics, rather than being a straight line, should be possible for the dose-response curve to be convex.
>
> We have therefore been waiting with interest for a new report from the National Academy of Sciences through the BEIR Committee. Such a report had been ordered by the EPA† and was estimated to [be] ready by April 1979. It was called BEIR III because a second BEIR report had been issued before.
>
> Advance copies of BEIR III were given to the EPA and NRC‡ in April (who made around 50 copies). The Academy of Science arranged a press conference which was referred to in the press. The Chair of BEIR III, Professor Radford, presented the report. It contained risk estimates using the linearity assumption. Radford had been quoted as saying that the Stewart group's assumptions that there was a risk increase (per unit radiation dose) at low doses of radiation were considered to be unfounded. At the press conference it was stated that a minority of the Committee, led by Professor Harald Rossi of Columbia University (NY) would make a separate statement where it was thought that the majority could have overestimated the risk at low doses of radiation.
>
> An embarrassing situation then arose when it was shown that Rossi's 'minority' did in fact include a majority of the Committee. It then became necessary to edit what was largely a finished report. Fabrikant, who was a member of the Committee and was neutral in the conflict that has arisen between the strong and pugnacious Radford and Rossi, was asked by Academy of Sciences to lead an editorial group for this assignment. The work was almost done but since Fabrikant was to travel to Europe in September, the final the report could not be ready until the start of October. Neither Radford nor Rossi got to take part in the editing.
>
> Fabrikant confirmed that the new report did not go against what ICRP and UNSCEAR had said. A linear dose-response relationship was assumed for densely-

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* BEIR stands for Biological Effects of Ionising Radiation.

† The US Environmental Protection Agency.

‡ The US Nuclear Regulatory Commission.

> ionising (‘high LET’) radiation (e.g., alpha rays) where the risk of cancer was concerned, and for all radiation where hereditary injury was concerned. For sparsely--ionising (‘low LET’) radiation such as gamma radiation, it is thought that the dose-response curve is confined between the extremes, a straight line and a quadratic curve, i.e., that a combination with a linear term is fairly plausible.
>
> This gives risk estimates that do not deviate greatly from those of ICRP and UNSCEAR. They do not believe in a convex curve, but there may be moderate dose-rate effects. If you calculate using a linear + quadratic curve, the risk factor (the risk per unit dose) at low doses of radiation is slightly less than it is at a completely linear dose-response relationship, perhaps 1/3 or 1/2.
>
> Fabrikant thought that the new reworking of the report would be acceptable to everyone but Radford and Rossi. Radford is probably unable to accept anything other than a purely linear extrapolation, and Rossi thinks that nobody knows the shape of the curve for low doses of gamma radiation.
>
> This means there are sensations to be expected in BEIR III. However, one new phenomenon is that emphasis will be placed on not just presenting the number of deaths from cancer but also the total the incidence of cancer that radiation can cause. The morbidity risk is of course greater than the mortality risk and the difference is particularly substantial in the case of skin cancer and thyroid cancer. The Committee is expected to discuss the psychological suffering to which even curable cancer can lead.
>
> However, the most important information was that BEIR III is not expected to support assumptions on the part of Stewart and others of a higher risk per unit dose at low doses of radiation. The means that it is possible to use largely the same risk numbers that were used by the Energy Commission, for example.

The final, revised BEIR III report became available in August 1980.

14.7. **East German activity control**

Twenty years would pass before the macabre activities that had gone on in East Germany became generally known. The secret police in the *Ministerium für Staatssicherheit* (Ministry for State Security), Stasi, had used radioactive substances in their hunt for awkward citizens. What happened could have been taken from a James Bond film. But it was also a logical and coherent development in the methods of those in power to maintain their grip on an oppressed population. The rumours of what happened had circulated but were so unbelievable that they never had the publicity they deserved. Following a trip, a Swedish businessman feared that he might have been exposed to radioactive substances, but no-one truly believed him. The thing he was worried about was thought to be too unreasonable.

Not until January 2001 did the internationally well-known radiophysicist Klaus Becker report what had been known following the fall of Stasi and the German reunification in 1990. It was a commission of inquiry, the Gauck Commission, which unearthed facts from Stasi’s archive and made it possible for Becker to understand what had happened.

More than a thousand people had been marked with radioactive substances so they could be traced by the secret police. Documents, notes, ball point pens and other objects had also been marked. Stasi’s agents were supplied with a special measurement instrument, a type of Geiger-Müller counter which they carried under one armpit so they could trace the marked people and objects. Rather than having a pattering loudspeaker, the instruments were supplied with a silent vibrator which the agent carried under the other armpit.

One regularly-used radionuclide was scandium-46 which has an 84-days half-life. Stasi had a 56-page radiation protection letter containing recommendations for the agents. It assured them of the same level of radiation protection as other radiation workers. Such protection was not enjoyed by the people who were marked, but Becker said that there was nothing to indicate that anyone was seriously injured.

Other Bond film-type instruments included an air gun that could shoot a radioactive silver thread into a car tyre at a distance of 25 metres to enable Stasi to track the car. Becker’s account was publicised on the BBC News and in *New Scientist* on 4th and 6th January 2001 respectively.

14.8. **Polish snow collection from Mount Everest**

The Polish UNSCEAR delegate, Professor Jaworowski, who appeared to love exotic assignments, sent me a large photograph in February showing him and three other Alpine-ready Poles on the way to Mount Everest. The card came from the Polish 'Alpine Association' and the Central Laboratory for Radiological Protection in Warsaw. On the card was written 'We collected snow samples for global contamination studies from the top'. Jaworowski himself had written a new year's greeting to me and Snihs.

14.9. **ICRP in Brighton**

ICRP and its Committees met at the Bedford Hotel in Brighton on 17-26 March. Dan Beninson's wife, Ambretta, had a heart muscle inflammation and was admitted to a hospital. The hospital was on the outskirts of the community. I accompanied Dan on a long walk to visit Ambretta. He was very worried. 'You and I philosophise about the risks from small doses of radiation in large populations,' he said, 'but Ambretta's now ill and suddenly everything else lacks significance.'

When I came home it was Easter and I went wolf tracking at our holiday home in Västerdalarna. The world is a strange place.

14.10. **Taylor's colossal book**

In the spring, I collected from the post office the largest book I had ever set eyes on. It was in quarto format, i.e., the American equivalent of A4. It was ten centimetres thick and weighed five and a half kilos. It was Lauriston Taylor's mammoth work about the history of the NCRP and the ICRP called *Organization for Radiation Protection: The Operations of the ICRP and NCRP, 1928-1974.* The work had been paid for by the National Library of Medicine under the National Institute of Health. The book is a conscientious and valuable collection of records, correspondence and publications but makes for fairly impersonal and dry reading. It is a pity that Taylor's dry, drastic humour was not allowed to show through on more occasions than it was.

However, Taylor's book is a goldmine of information about the early radiation protection activity, in places such as Norway in the 1920s for example. The development of quantities and units for dosimetry is of particular interest.

14.11. **Referendum on nuclear power**

The advisory referendum on nuclear power took place on 23 March 1980. With the general worry that had arisen following the Harrisburg accident, no alternative was left open for the continued expansion of nuclear power, but then no alternative required an immediate stoppage. There were three alternatives for the referendum. The most negative, line 3, which was advocated by the Centre Party and Left Party Communists, was worded as follows:

> NO to the continued expansion of nuclear power. Decommission the six reactors that are currently operating* within no more than 10 years. An economising plan to make us less dependent on oil to be implemented on the basis of continued, intensified energy saving: heavily increased investment in renewable energy sources. Subject the reactors in operation to strict safety requirements. Never commission reactors that have not been charged. Do not allow uranium to be mined in our country. If ongoing or impending safety analyses so dictate, this proposal obviously means that there must be immediate closure. The work against the spreading of nuclear weapons and against atomic weapons

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* Oskarshamn 1 and 2, Barsebäck 1 and 2 and Ringhals 1 and 2.

> must be intensified. No reprocessing is permitted and the export of reactors and reactor technology is to cease. Employment will be increased through alternative energy - production, more efficient energy use and greater refinement of raw materials.

Both of the other alternatives, lines 1 and 2, had exactly the same wording on the front page of the voting slip, i.e.:

> Nuclear power to be decommissioned at the rate that is possible with regard to the need for electricity to maintain employment and welfare. In order to reduce the dependency on oil and in anticipation of renewable energy sources becoming available, use no more than the 12 nuclear power reactors that are in operation today, complete or under construction. There must be no further nuclear power expansion. Safety points of view are crucial to the order in which the reactors are decommissioned.

Line 1, which was supported by the (conservative) Moderates, was the least critical alternative regarding nuclear power. Line 2, put forward by the Social Democrats and the (liberal) People's Party, was slightly more cautious because an additional text was written on the rear side of the voting slip, which read:

> The saving of energy is being strongly promoted and further stimulated. The weakest groups in society are being protected. Measures are being taken to control electricity consumption to prevent direct electric heating in new permanent developments. Research and development into renewable energy sources is being accelerated under the leadership of society. Environmental and safety-improving measures are taking place at the nuclear power plants. A special safety study is taking place for each reactor. To provide the citizens with an insight, a safety committee with local connections is being established for each nuclear power plant. Electricity production using oil and coal-fired power plants is to be avoided. Society will have the main responsibility for the production and distribution of electric power. Nuclear power plants and other future plants for the production of electric power of significance shall be owned by the State and municipality. Surplus profits from water power production will be suppressed through taxation.

The referendum resulted in line 2 getting 39.1 % of the votes, line 3 getting 38.7 % and line 1 getting 18.9 %. Since the referendum was advisory the result was not binding, but Swedish Parliament was influenced by it in June when it adopted a social democratic bill that the twelve reactors that were in operation, under construction or being planned would be permitted during its technical lifetime. According to the decision, the nuclear energy epoch would be over in the year 2010. The reactors would be decommissioned in the order determined by safety considerations. So, the year 2010 was not a primary result of the referendum but was decided by the Swedish Parliament.

14.12. **The Radiation Protection Institute gets a Director General**

A letter signed by Thorbjörn Fälldin and Anders Dahlgren came from the Ministry for Agriculture in which Bo Lindell was now appointed as Director General and head of the Swedish Radiation Protection Institute (SSI).

14.13. **Visitors in Stockholm**

Bouville, O'Riordan and Rowe took part in a meeting in Stockholm on 9-12 June 1980 about the problem with radon.

14.14. **The Swedish Radiation Protection Institute's emergency preparedness**

The Radiation Protection Institute had a guideline if enquiries were made about accidents. In case of an alarm to the 'acute group' of the Preparedness Board against Nuclear Accidents, there were twenty or so contact persons. The majority, and all of the first ten, were from the Swedish Radiation Protection Institute staff (the first five were Lindell, Lindhé, Bengtsson, Edvarson and Godås). Those who followed after the first ten were:

Christer Viktorsson	Ragnar Boge
Arne Hedgran	Sören Norrby
Sam Ekholm	Jan Olof Snihs
Nils Gyldén	Mikael Jensen
Erik Jansson	Gundula Aalto
Göran Lundell	Karin Lindell
Olov Lönnqvist	Kerstin Lundmark
Bertil Mandahl	Nils Hagberg
Erik Thyberg	Göran Samuelson
Bernhard Tribukait	

The contact persons for responses to the mass media are also interesting (Sven Löfveberg was no longer there):

Bo Lindell
Mikael Jensen (temporary head of information)
Gunnar Bengtsson
Jan Olof Snihs
Gun Astri Swedjemark
Sten-Erik Olsson
Carl-Gösta Hesser
Lennart Holmberg
Lennart Lindborg
Lars Persson

14.15. **Laser radiation**

The word *laser* is made up of the initial letters of the English phrase 'light amplification by stimulated emission of radiation'. To make possible such a light amplification, a medium with suitable energy levels is required. As in the ruby laser both a broad higher level with a very short lifetime (e.g., 10^{-15} seconds) and a sharp lower level with a longer lifetime (e.g., 10^{-3} seconds). Energy is conveyed through an intensive flash of light ('optical pumping') which easily excites the molecules to the higher state. They then transform rapidly into the lower, sharp state. When they then spontaneously return to the basic state, light quanta are emitted which have the right energy to stimulate emission from the same level from other molecules. Arranging mirrors which reflect emitted photons leads to the amplification of the emitted light which becomes coherent and can form a very parallel beam, the laser beam. The laser light can come in pulses or be emitted continuously, depending on the type of pumping.

The ruby laser provides radiation with a wavelength of 694 nm. Gas lasers usually use an electric discharge for the pumping. They emit continuous radiation with wavelengths between 300 and 700 nm, depending on the gas. Laser beams are used in many fields such as for measurements, in material treatment, healthcare and information processing, and especially in military applications.

14.16. **The Radiation Protection Institute's provisions regarding lasers**

On 13 June, the Radiation Protection Institute issued provisions regarding lasers (SSI FS 1980:2). The lasers were divided into different classes with different requirements regarding supervision and protection measures. Laser class 1 covered lasers that emit the lowest level of energy. Laser class 4 covered lasers with the highest energy.

14.17. **UNSCEAR's 29th session in Vienna**

UNSCEAR met in Vienna on 1-12 September for its 29th session. Professor Stieve was Chair with the Polish representative, Professor Jaworowski, as Deputy Chair and Dan Beninson was rapporteur. I was the Swedish representative with Gunnar Walinder as deputy and Kay Edvarson, K-G. Lüning and Jan Olof Snihs as advisers.

The work was a direct continuation of the work that began at the 27th session. It would end up in the extensive 1982 report.

Dan Beninson and I stayed at the same hotel, the Astoria, next to Kärntner Strasse and we therefore kept each other company during our free hours. Since I was now Chair of ICRP and Dan Deputy Chair, we had much to discuss regarding the Commission's policy. We strolled along Kärntner Strasse and Graben and did a bit of window shopping. On Graben we went into the bookshops and on Kärntner Strasse we were interested in the electronics shops and their range of pocket calculators. At the corner of Kärntner Strasse and one of the turnings from Neuer Markt was one of these big stores with a range of porcelain, vases and all sorts of articles that were difficult to sell, which made you wonder how it stayed afloat. Its window display facing onto Kärntner Strasse had an enormous jackdaw which made you wonder about the mental health of potential buyers. We got into the habit of stopping and paying homage to the big bird every time we passed the shop, which probably made passers-by wonder about the state of our mental health as well. The places where we ate dinner included Gösser Bierklinik on the other side of Ringen where you could get a hefty desert in the shape of a Salzburger Nockerl for 58 schillings, a desert which later also tempted Gunnar Bengtsson.

Dan had a big social circle in Vienna. It also included Swedes such as the IAEA employee medical physicist Lars Johansson and his family whom we were lucky enough to benefit from meeting.

14.18. **The Iran-Iraq war**

In September 1980, Iraqi troops crossed the border into Iran and the Iran-Iraq war was started, which went on until 1988. The Iraqis wanted to use the confusion they thought prevailed following the Islamic revolution when the Shah was overthrown. One factor to cause the war was the dispute regarding the borderline at Shatt al-Arab where the Euphrates and the Tigris flow into the Persian Gulf. However, there were many other reasons, such as the disagreement between Arabs and Persians and between Sunni and Shia Muslims. Big powers like the USA and the Soviet Union were officially neutral but supported primarily, but not only, Iraq, particularly in supplying weapons. The majority of the Arab States also supported Iraq since they were worried about the development of the revolution in Iran. To prevent the conflict from spreading, the UN's Security Council adopted a ceasefire resolution and military retreat in July 1987. Both countries accepted the resolution in July 1988. Oil production fell because of the Iranian revolution and because of the long war which increased the price of crude oil, and the opposition to nuclear power began to wane.

14.19. **Forsmark 1**

Sweden's seventh big reactor block, Forsmark 1, was commissioned in December 1980.

14.20. **The IAEA group's final editing of Basic Safety Standards**

On 1-12 December, the expert group which was to draw up the 1980 Basic Safety Standards (IAEA Safety Series No. 9) met in Vienna for the last time. This time, Dan Beninson also took part instead of

Abel González who had represented Argentina at the first two meetings. I mentioned the content of the reports in Section 12.23.

Dan and I followed the battle for prestige between the Chair, Henri Jammet, and the Belgian delegate Professor Lafontaine with interest. There was no doubt that Lafontaine had set his mind on irritating Jammet and did so artfully by interrupting speakers and giving long speeches himself which Jammet unsuccessfully attempted to stop. On one occasion, Lafontaine burst out with feigned anger: ‘I've had enough! I'm leaving the meeting!’ and went towards the door. Jammet, who was easily provoked, was furious and shouted: ‘Good! Go! At least we can have some peace and quiet!’, whereupon Lafontaine paused and answered: ‘Aha! The chair wants me to go – so I'll stay!’, and returned to his place at the table.

15. THE YEAR 1981

15.1. **Bariloche in January**

A new task group, common to ICRP and ICRU, had been formed with Harald Rossi as Chair. In addition to Rossi, its members were Beninson, Sinclair and Wyckoff and me, i.e., the same members that were in the 1974 group, except that Sinclair had replaced Dunster. The subject of the group's work was 'The quality factor in radiation protection'.

The group met in January 1981 in Bariloche, the Argentinian Atomic Energy Commission's research centre in Patagonia. We stayed at the Interlaken Hotel in central Bariloche with Dan Beninson as host and, as in 1974, took trips out into the surroundings with Dan. The result of the task group's efforts was published on 4 April 1986 as ICRU Report 40. From it I quote:

> In 1980, the International Commission on Radiological Protection (ICRP) and the International Commission on Radiation Units and Measurements (ICRU) established a Joint Task Group on Radiation Protection Quantities. The immediate reasons for this step were relatively recent radiobiological findings which indicated that protection recommendations for some high-LET radiations* might not offer the same margin of safety as those for low-LET radiations.
>
> This could be accommodated simply by a change in the numerical values for the quality factor (Q) which, in the present system, defines the dose equivalent† (H), given the absorbed dose (D), by the relation
>
> $$H = Q\,D\,N$$
>
> where N = 1. However, it was deemed advisable to reconsider in detail the methods by which differences in radiation quality can be accounted for in systems of radiation protection. This led, necessarily, to a broader inquiry into basic approaches to radiation protection, an examination of the quantities that are required in their formulation, and a review of pertinent biological data. Although this Report touches on all of these issues, it is primarily focused on the problem of radiation quality and its quantitative treatment in radiation protection. The advice presented is devoted to this subject.

15.2. **ICRP in China and Japan**

The ICRP Main Commission was to meet in Tokyo in March but was invited to visit China on the way there to take part in discussions about the ICRP recommendations. China was new to most of us and therefore made a strong impression. It may therefore be worthwhile giving a slightly more detailed description, but remember this was China nearly thirty years ago. It has developed enormously since then. The initiative for the visit to China had come from David Sowby and George Wu. David writes the following about this:

> I had a good number of chats with George Wu during my first visit when I told him I was sure ICRP would welcome a Chinese representative. The result of it all was that

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* LET = Linear Energy Transfer

† Now the 'equivalent dose'.

> George proposed that members of ICRP should visit China en route to the meeting in Tokyo which had already been planned and hold discussions with Chinese radiation protection scientists. Eight members, some of them accompanied by their wives, actually travelled to Beijing in February 1981. A group of us from Europe flew firstly to Hong Kong where we were met by George who had gone there especially to meet us and escort us to Beijing. His nephew ran a Chinese chamber of commerce in Hong Kong; he invited us all to dinner at a restaurant in Hong Kong. We stayed in Kowloon on the mainland on the other side of the bay and island and were picked up by the nephew's cars, a Rolls Royce and another expensive car, maybe a Daimler.
>
> ...
>
> We stopped before an obscure entrance to a restaurant where the owner was waiting for us. He led us through a fairly tough, smoke-filled premises where the guests looked at us with curiosity. The owner led us into a private dining room at the back, resplendently furnished with expensive Chinese furniture, including a large, round table dressed with flowers, beautiful porcelain and glass. There we enjoyed (an appropriate word for such a distinguished social affair) a magnificent twelve-dish banquet, the greatest accolade a Chinese host can give his guests.

Marrit accompanied me on the trip. We had financed it by selling a small 'Döderhultarn' wooden sculpture of a man which I had inherited; an old sign of my kinship (Döderhultarn was my paternal grandfather's cousin) and from the time when he sold his wood carvings for 25 *öre* each. We had travelled via Delhi and Bangkok and were pretty tired after the journey.

Harald Rossi in Argentina, outside Bariloche in the Andes, at a meeting in 1981
of a joint ICRP-ICRU Task Group.
Photo: Bo Lindell.

Dan Beninson and Harald Rossi in Bariloche, Argentina, 1981.
Photo: Bo Lindell.

The next day, a Sunday, we continued by train from Hong Kong to Guangzhou, the city of four million people that we were used to calling Canton. There we were received by a delegation from the local department of the Chinese Society of Medicine. They would accompany us to the airport for our continued journey to Beijing, but first they wanted to invite us to lunch at the railway station, which we accepted for the sake of politeness, despite having just eaten a good lunch on the train.

From Guangzhou we flew to Beijing where we were met by a new delegation which accompanied us to the hotel. David, who was accompanied by his wife Sheila, writes:

> We finally arrived at our accommodation, a renovated Russian building surrounded by high fencing and guarded by armed soldiers. The first thing we had to do was register in reception. I placed my hand on the marble counter and almost got frostbit it was so cold. The hotel's banking arrangements were very interesting. We were obliged to buy special Chinese money for tourists, different from the notes that the Chinese themselves used. These affairs were seen to at the hotel – there did not appear to be a bank where they could be done. We bargained with the porter who rummaged around after the notes in a cardboard box which stood on the counter. There was no safe as far as I could see. Luckily, the rest of the hotel was nice and warm, including the bedrooms. After having

done a bit of elementary plumbing on the constantly-running toilet and crushed a few dozen cockroaches that were also running round, we managed to get to sleep. The next morning we had a surprising view when we looked out of the window. It was snowing and hundreds of cyclists were gliding silently along the road.

George Wu had invited us to give presentations about various aspects of ICRP's activity. When we arrived at the venue we found it was very big and overfilled with expectant Chinese. It was very cold and George showed us into a small room with a stove so we could warm ourselves up before going into the cold. Bill Pochin became impatient and looked at the clock. 'This is improper,' he muttered. 'It's past the time we were meant to start and we're keeping hundreds of listeners waiting.' But George Wu evidently thought that waiting was part of the game. David tells us his impressions of the cold:

> It was a freezing cold morning when we arrived at the Chinese Society of Medicine's venue. I had expected to see maybe a dozen scientists and was surprised that hundreds had already taken their places and were sitting waiting for us. The temperature in the hall was a few degrees above freezing and all of the audience wore outdoor coats, scarves and hats. Later, when I looked out at them from the podium and could see the ends of the arms of their cardigans, I noticed they were wearing layers of cardigans beneath their coats.

Every presentation took twice as long as usual because it had to be translated into Chinese sentence by sentence. That was the only time I have given a presentation with my overcoat on. Henri Jammet had prepared himself and showed transparencies with Chinese text as a translation of what he was saying.

We were impressed with our Chinese colleagues' knowledge of ICRP and of what happened in the western world. They had the latest documents and they had had them translated. We were asked many intelligent questions which showed that the asker had looked into the problems thoroughly. They not only understood what was recommended but also why.

We obviously got to visit the Wall, although it was windy and very cold. Dan Beninson and I had obtained warm fur hats but our clothing was generally not suitable for the trip. I went down with a heavy cold, as did many others. The Wall was icy and slippery and February was evidently not an appropriate time to visit. After the visit it was a relief to be able to seek shelter in the corrugated steel building which functioned as a railway station waiting room and warm ourselves up a bit, courtesy of a tent stove. David's account of this is as follows:

> Despite everything, we were glad to leave the Wall and get back to the shelter of the waiting room at Badaling railway station. By contrast the room seemed so nice and warm, and when we looked at the thermometer which was on the wall, we realised how cold it was outside because in the waiting room it was zero degrees Celsius. But Bo Lindell remembers that it was not cold enough for the Chinese. A couple of men came in and evidently thought it was too warm inside because they opened two large gates at the gable end of the building to allow the biting wind to rush in and cheer us up.

On the last day of February we flew from Beijing via Shanghai to Tokyo where we stayed at the Shimbashi Dai-Ichi Hotel (the flagship hotel).

Professor Takahashi was assisted by a number of young colleagues from his hospital. They showed him considerable respect and appeared to think we were white barbarians who went beyond the limits of decency in being familiar t with their revered boss. But the adventure was now over and we were able to concentrate on ICRP's tasks.

On 2 March, Professor and Mrs. Takahashi invited the ICRP group to dinner at the exclusive restaurant, *Happo-en*. There were thirty of us in total and the feast must have cost our host at least ten thousand dollars. We sat on the floor as the Japanese do, which proved problematic for Charlie Meinhold's large circumference.

15.3. **The NCRP's annual meeting in Washington DC**

The theme of the NCRP's annual meeting, which was held in Washington 8-9 April 1981, was 'Critical Issues in Setting Radiation Dose Limits', and I took part as Chair of the ICRP. There I also had the occasion to listen to the fifth Lauriston S. Taylor Lecture, which was given by the Professor of Genetics *James F. Crow* on the subject: *How well can we assess genetic risk? Not very.* The Taylor Lectures were introduced in 1977 with an unconventional lecture by Herbert Parker with the title: *The squares of the natural numbers in radiation protection.*

15.4. **Cooperation between the Radiation Protection Institute and the Nuclear Power Inspectorate**

On 22 April, a meeting was held at the Nuclear Power Inspectorate (SKi) about demarcation issues between the Radiation Protection Institute (SSI) and the Nuclear Power Inspectorate. Jan Olof Snihs and Erik Jansson began with information about the work done by the Atomic Legislation Committee (see also Section 18.12). Lars Nordström had been Chair of the Nuclear Power Inspectorate since 1979 and was also on the Swedish Radiation Protection Institute's board. He had a better understanding of the Swedish Radiation Protection Institute's activity than Gösta Netzén had had. There were two items on the agenda: Identifying the 'grey areas' and Continuing work to clarify responsibilities and forms of cooperation. And that was when the cooperation between the two the authorities started to improve.

15.5. **The 'wonderful night'**

In May (the 'wonderful night'), the (labour) Social Democrats reached agreement with the (agrarian) Centre Party and the (liberal) People's Party regarding a reformation of the government income tax to lessen the marginal effect. This led to the (conservative) Moderates leaving the non-socialist government, which was replaced by a non-socialist two-party government where Fälldin became Prime Minister for the third time. This time, *Ingemar Eliasson* became Minister for Energy. The government was short-lived, however.

15.6. **Israel bombs Iraqi research reactor**

On 7 June 1981, Israeli aircraft attacked the Tuwaitha nuclear physics research station near Bagdad and destroyed the Tammuz-1 ('Osirak') research reactor. A few people died as a result of the attack, one of whom was a French engineer. Israel's motive was to prevent Iraq from starting to develop nuclear weapons and they wanted to minimise the number of casualties by taking the opportunity to bomb the reactor before the fuel was introduced and activated. The attack aroused great indignation in the surrounding world and was condemned by the UN Security Council. See also Sections 17.4 and 17.13 for details of the inquiry set up by the UN in 1983.

15.7. **UNSCEAR'S 30th session in Vienna**

UNSCEAR met on 6-10 July in Vienna for its 30th session. Now, the Chair was Professor Jaworowski, Deputy Chair Dan Beninson and rapporteur Professor T. Kumatori from Japan. I was still the Swedish representative with Gunnar Walinder as deputy and Kay Edvarson, K-G. Lüning and Jan Olof Snihs as advisers. This was the penultimate meeting of the work cycle used at the time and the report was expected to be ready the next year.

15.8. **Forsmark 2 and Ringhals 3**

In July, the eighth big reactor block, Forsmark 2, was commissioned. On 9 September, Ringhals 3 was also put to commercial use, the ninth nuclear power reactor. However, on 20 October the reactor was stopped for a long-term survey and problems with the steam generators to be actioned. The start of Ringhals 4 was postponed in anticipation of the result (see Section 16.7).

15.9. **Radioactive rock in Malung**

When one fine summer's day a lay-geologist by the name of *Olle Forsman* was walking around in the woods outside Malung with his Geiger-Müller counter and the instrument made a surprising sound at Lisshåberget south-west of the community, Forsman contacted the LKAB's chief geologist *Lars Göran Olsson*, who confirmed that the rock did emit gamma rays but that it was too small an area to be of commercial interest.

The find came as a surprise to the municipality of Malung. Since there was a lack of expertise in radiation, precautionary measures were taken for safety's sake. According to *Dagens Nyheter*'s Örebro editors, the municipality

> issued recommendations not to drink water from the area for the time being. A moose pass which is within this area of a few hectares was also moved.
>
> However, Malung would take no pleasure if Lisshåberget were shown to contain large uranium deposits.
>
> Crisis-ridden Malung needs new employment opportunities. However, according to a decision by Swedish Parliament, no new uranium deposits were to even be examined in the future. This means that Malung has an additional problem to contend with. How will this radiation be dealt with in the future?

The newspaper had probably got Swedish Parliament's decision wrong, but Malung's municipal - politicians were definitely worried. They contacted the Radiation Protection Institute. It so happened that Jan Olof Snihs was on holiday in his home area by Rättvik and that I was at our holiday home by Rothån south of Lisskogsåsen, not many km from Lisshåberget.* Jan Olof and I agreed to meet a representative of Malung's healthcare board (that was still its title) at Lisshåberget. Olle Forsman also came along to show where he had found the radiation.

The visit led to large articles in *DN*, *Dala-Demokraten* and *Falu-Kuriren*, among others, as was often the case with pseudo-events. *Dala-Demokraten* wrote:

> **Uranium in Malung**
> **NOT DANGEROUS!**
>
> The experts have now measured the radioactive radiation at Lisshåberget, west of Malung, and they say with no hesitation:
>
> 'The radiation is not a hazard. People can feel free to spend as much time here as they like.
>
> The experts are Bo Lindell and Jan Olof Snihs from the Radiation Protection Institute.
>
> 'The radiation values are around 10 times the normal value where
> they are at their greatest,' they say, 'and they occur within a very small area.'
>
> As well as taking the measurements, they also took with them some ground and water samples from the area.

And *Falu-Kuriren* wrote:

> **Radiation protectionists picked blueberries at the 'uranium site'**

* 'Liss' means 'small' and 'hå' means 'small creek' or extension of flowing water.

> The best proof that there was no danger was that the wives and children of the Radiation Protection Institute's personnel were able to pick blueberries in the immediate vicinity of the 'uranium deposit'.

We were glad that we had been able to take action against the worry, but complained that the newspapers were still writing 'radioactive' radiation instead of ionising radiation. The radiation is not radioactive - it just comes from radioactive substances.

15.10. **Grythyttan**

In summer 1981 I was invited to take part in a workshop for the assessment of chemical health risks. The invitation came from *Torbjörn Malmfors*, medical doctor and Assistant professor, who was working for the consultation company Malmfors Consulting AB and an enthusiast when it came to risk research (see Section 22.20, for example). In running a commercial activity, Torbjörn sometimes encountered scepticism in the academic world, which was unfair but understandable. The task group was to meet at *Grythyttans Gästgivaregård* which was becoming well-known thanks to its eccentric restaurateur *Carl Jan Granqvist* who won the *Nya Wermlandstidningen* culture prize in 1979.

In the invitation, Torbjörn and his assistants, Assistant professors *Bo Lambert* and *Robert Olin*, wrote:

> What should we do about the problems created concerning chemical health risks in our society? Daily scares highlight first one and then another chemical substance as hazardous to the health. The warnings are undoubtedly justified in some cases, but the health risks are clearly exaggerated in others. When experts express themselves they are sometimes difficult to understand and they make great reservations about the scientific basis, whereas other parties involved convey what they have experienced and what they believe. The views usually differ and create difficulty and confusion for the public.
>
> We would now like to gather 30 or so people with varying knowledge and experience and in senior positions within different areas of society such as politics, public authority, research and science – medicine, natural science, humanities, law and economics, industry and enterprise to discuss the problems concerning chemical health risks in our society.

I no longer remember who took part but the list of 37 invitees was impressive. And the concept of 'risk' in its general sense, i.e., not just radiation risk, started to grow into a separate branch of science, 'riskology'. Torbjörn Malmfors had written that the 'perception of risk is influenced by many factors such as free will, type of risk, individual or group'.

An initial stage had thus been taken towards the activity that, in Sweden, ended up being discussed primarily within the group of interested parties who called themselves 'The Society for Risk Sciences' (Section 22.20).

15.11. **Symposium in Madrid regarding ICRP's recommendations**

IAEA, ILO and WHO along with ICRP arranged a symposium in Madrid for 18-24 October regarding the application of the Commission's dose limitation system. IAEA, ILO, OECD/NEA and WHO had recently revised their Basic Safety Standards which were now based on ICRP's latest recommendations. This meant that the international significance of the Commission had increased considerably.

The dining habits of the Spaniards were a problem for Dan Beninson and me when we wanted to eat dinner together. No Spanish restaurant appeared willing to take any diners until late in the evening. Luckily there were Japanese restaurants which were used to serving at an earlier time.

15.12. **U 137**

In the very early hours of 28 October, the Soviet submarine U 137 went aground in Gåsöfjärden in Blekinge within a military protection area. This caused a great deal of fuss. Soviet authorities maintained that the submarine was there due to a navigation error, but the Swedish Defence thought this was unlikely. Personnel from the Swedish Defence Research Establishment (FOA) under the leadership of physicist Lars-Erik DeGeer took radiation measurements in a specially-equipped boat next to the submarine and were able to show gamma radiation from uranium-238, which led them to believe that the submarine was carrying nuclear weapons. A formal protest was submitted in which the government concluded that the Soviet Union had intentionally invaded Swedish waters to perform unlawful activity. On 6 November, the submarine was pulled from here it had run aground and was escorted out of Swedish waters to be handed to the Soviet Navy. What happened the day before this was so special that I wrote a summary down on the same day, 5 November. I reproduce an unabbreviated and linguistically-unedited version here:

> In the morning, chaired an expert discussion on the risks of cancer from UV radiation with reference to the Swedish Radiation Protection Institute's intention to issue provisions for solariums. For 'cosmetic use' they want to approve only fluorescent lamp solariums which, consisting of UVA and UVB radiation, are most like the sun and have very little of the UVB radiation that is suspected of causing cancer. Old quartz lamps have a different spectral division and will not be permitted.
>
> My spotlight was lit while the meeting was on but since I said that I did not want to be disturbed I did not care about it. Margareta [Rydell] then came in with a note which said that the Minister of Agriculture was on the telephone. I left the meeting and took the call. He said:
>
> 'I must meet you but no-one must know about it. Can you come to my home or shall I pick you up by car?'
>
> 'I'd prefer the latter, thank you,' was my reply.
>
> 'But not from the Institute so people can see we are meeting.'
>
> 'How about the entrance to *Radiumhemmet*?'
>
> '11.30?'
>
> '11.30.'
>
> I returned to the meeting and said that I was temporarily unavailable. When I left the building it was the usual lunchtime and everyone thought I had gone to lunch. Anders Dahlgren came in an unmarked company car. I got into the back seat. He moved up to make room for me and said 'Hello!' We shook hands. I suggested the car drive past *Eugeniahemmet* so we were not seen by those who were walking out to lunch. Dahlgren asked where we could travel to. I suggested *Hagaterminalen*. We drove down and parked behind the Court of Justice. The chauffeur left the car.
>
> 'As you may realise, it's about the submarine. It was carrying nuclear weapons.'
>
> 'I guessed as much.'
>
> 'A meeting of the Foreign Affairs Advisory Council* starts in an hour's time. I'm going there. But first of all I wanted to inform you. In the Supreme Commander's view, there is no reason to take any preparedness measures in respect of a radiation risk, to evacuate the surrounding area.'
>
> 'I share that view. A nuclear weapon is not dangerous until it is used. If someone wanted to use a nuclear weapon against Sweden he wouldn't need to transport it here. There are many that can be fired from a distance.'
>
> 'I wanted to inform you. After the Foreign Affairs Advisory Council's meeting, the government is holding a press conference. We'll release the information. The Swedish Defence Research Establishment's experts have told the Supreme Commander that there are almost certainly nuclear weapons in the submarine. It would not be good if

* The Foreign Affairs Council (Utrikesnämnden) was established by Parliament in 1921 in order to organise consultations between the government and the parliament and to provide an opportunity for the Opposition to influence important decisions concerning foreign policy.

you as head of radiation protection found it out through the mass media and were unprepared. Do you feel uncomfortable about it?

'Of course I feel uncomfortable about the thought of the Russians making their way into the Swedish archipelago with nuclear weapons, bearing in mind what that can mean in terms of the risk of war. Not from the radiation protection point of view. But they may ask whether the Swedish Radiation Protection Institute's preparedness centre should be on alert.'

'If anyone asks, you can say that the government completely agrees with the Supreme Commander's view that there is no reason to take any preparedness measures and that the government will take full responsibility for it. But be prepared to receive questions and telephone calls.'

'In that case I have a problem. I'm in a Spri conference* at the Mornington Hotel between three and five and will be giving a presentation on radiation protection against x rays. If I withdraw from that, everyone will wonder why.'

'Yes, you must go there. Publication will be after three, maybe after five. It would be very unfortunate if something came out before then. That is why I have to act so dramatically. The Chancellery is monitored by all of the world's press. I was forced to sneak out via a back door. If it came out that I was meeting you, everyone would draw the conclusion as to why.'

'Isn't it strange using such an old submarine for nuclear weapons and bringing nuclear weapons into the Swedish archipelago if it's a question of spying? Could there possibly be a completely different reason for it?'

'Like what?

'It might be an unrealistic, science fiction-like thought, but imagine it's not a nuclear weapon in the actual sense but a nuclear charge mine. Imagine if the task were to lay nuclear charge mines in strategic straits around Swedish Naval bases with the option of triggering them by radio if necessary.'

'That's not a nice thought. I will actually discuss it in the afternoon.'

'If it is actually a possibility, wouldn't that be reason enough to insist on searching the submarine?'

'The government wants to get rid of the boat from Swedish territory as soon as possible.'

A few questions later, Dahlgren wondered whether anything further was worrying me.

'Not about the submarine, but in sitting here one to one with you I'd prefer to take the opportunity of saying that I'm deeply concerned about what would happen with the Radiation Protection Institute if an expert were not to succeed me next year.'

'Do you have anything to suggest?'

'The most obvious choice would be my deputy, Gunnar Bengtsson, to get the job. He has the competence to be a Professor. He's applying for a Professorship in Gothenburg and may well get it. If so, that's both he and I leaving the Institute in one go, which would be disaster bearing in mind the specialist knowledge of the leadership and the Institute's policy if it is headed by someone who does not have specialist knowledge.

'Can I appoint Bengtsson without any special processes or procedures?'

'I'd have thought so.'

Dahlgren picked up a piece of paper and wrote BENGTSSON in capital letters.

'Anything else?'

'It doesn't feel quite right to be sitting having another meeting with no-one at the Institute knowing what's happening. I'd like to tell at least one reliable person – Kay Edvarson, who's from the Swedish Defence Research Establishment and is very reliable and sensible and familiar with our preparedness issues.'

'You trust him completely?'

---

* Spri was the name of the Swedish Institute for Health Services Development which was formed in 1968 and closed down in 1999.

'Yes.'

'Alright. Tell him.'

Dahlgren waved to the chauffeur and we drove past the main entrance of KS where I got out and walked back to the Institute. The time was 12.00. The Foreign Affairs Advisory Council's meeting at the castle began at half past twelve. I rang Kay who was in his room at Kräftriket.*

'Can you come here? I have to tell you something very important.'

We agreed one o'clock. I returned to the ultraviolet radiation meeting to lead the discussion until one o'clock. There were three Norwegian participants – Finn Devik, Helge Aamlid and Gunnar Saxeböl. I excused myself, saying that I could not accompany them to lunch at one o'clock because I had to go to the Spri meeting.

Kay had arrived. I informed him and asked about the possibility of nuclear charge mines.

'It's perfectly possible of course, but unlikely that the Russians would take the risk of the mines being discovered.'

'Unless they're counting on them being used pretty quickly.'

'It's a scary thought but not out of the question. It could coincide with their measures for peace marches and nuclear weapon-free zones to divert attention.'

Kay promised to monitor the radio and, as soon as the government had publicly announced the discovery of nuclear weapons, to inform John-Christer Lindhé and Lena Lindell† so that they would not be surprised by sudden questions from the mass media. He would then assess whether any action would be necessary by the Radiation Protection Institute and contact me at the Mornington if necessary.

And so I took the bus and tube back to the Mornington. *Aftonbladet* and *Expressen* ran big headlines about the release of the submarine, printed before anything had become properly known, a gamble on what was probably a guess. I wondered what the readers would say when the information had been made public. Would they be scared or furious? Was something really going on which would soon lead to war? War with Sweden involved, occupied? What would things be like for these youths and Stockholm wives out shopping in a few months' time? What would things be like for me and my nearest and dearest?

I gave my presentation, the same one that I had given in Uppsala a few weeks previously when it had been a successful and provoked an interesting discussion in which I had clearly done well, given all the appreciation I was shown afterwards. Now, the presentation was perhaps acceptable but there was no discussion. Had I been thinking too much about something else to be able to hold the audience's attention?

I sneaked out a few times and rang 0710 – *TT-Nytt*. Rang home and told Marrit that I might be late but could not explain why until later. Rang Kay. Everything under control. My last call to 0710 at quarter past five brought the news. The government had made public the discovery of nuclear weapons on the submarine. I rang Marrit and told her what my problems were and asked her to refer any telephone calls to my room at the Radiation Protection Institute.

And so I travelled there and bought some sandwiches from KS' bar. Borrowed a radio, ate sandwiches and listened for the telephone. Preparedness on the backburner but not altogether without flame.

Dahlgren had asked how quickly we could get staff to the Swedish Radiation Protection Institute's contact centre. I said that, under current circumstances, maybe within half an hour. Like many other people I had a pager at home. Nils Gylldén was one of the people being interviewed on the radio. People thought nuclear weapons were

* The Radiation Protection Institute had temporary premises at the Veterinary College's previous premises at Brunnsviken north of Roslagstull, an area which was called Kräftriket.

† The same surname but no relation to me.

> in torpedoes. No-one discussed the idea of a mine. I wrote these pages while I was listening.

15.13. **The Congress of Radiology in Brussels**

The 15th international Congress of Radiology was held in Brussels. It was well-attended. There was now a tendency to present innovations using overview presentations and classes rather than speakers. Bill Pochin was awarded the Swedish Academy's gold medal, which was now struck in gilded silver for the first time – the gold had been too expensive. Ambretta and Dan Beninson dined with me outdoors, despite it being November, together with Lauriston Taylor and his wife and Harold Wyckoff.

15.14. **ICRP in Eastbourne**

The ICRP Main Commission and its four Committees met at the Cavendish Hotel in Eastbourne on 30 November-9 December 1981. The series of meetings in Brighton was over, the participants had become tired of the Bedford Hotel and London still had no suitable places to offer. We therefore met at the Cavendish* in Eastbourne, a seaside resort on the English Channel approximately half the size of Brighton if it is possible to define residents in a tourist spot.

For the meeting I had written a 'Chair's introductory speech' on ten or so pages. I quote the first few sections, followed by extracts from the content. The speech gives an idea of the situation at the start of 1980s:

> The first meeting of the Commission with all of its four Committees at the start of a new working period is particularly important. That is the time when the work for the new period is planned and initiated. That is the time when new members of the 'ICRP family' are exposed to this work for the first time. The Commission's by-laws and the Committee's practice create a turnover of approximately one quarter of its members every four years. As a consequence, the Commission is happy to welcome seventeen new participants in the work that is now beginning.
>
> Three and a half years ago at a corresponding meeting which was held in Stockholm – which was actually the Commission's fiftieth anniversary since its formation in 1928, the meeting began with a series of classes where the fundamental concepts and the Commission's policy were clarified to the new members. It is interesting to note that the Commission no longer considers this necessary; concepts and ideas which were considered unusual and debatable in 1978 have now been generally accepted. When IAEA, ILO and WHO together with ICRP arranged a symposium in Madrid regarding the application of ICRP's dose limitation system a month ago, it was obvious that expressions such as effective dose equivalent, collective dose, dose commitment and optimisation of radiation protection were being used without much hesitation. This would not have been the case four years ago.
>
> This year, the Commission's members have had many opportunities to be in contact with radiation protection colleagues in a good number of countries. It is encouraging to see a great uniformity in the fundamental attitude between countries with widely-differing economic, social, political and administrative structures. We must realise that this fundamental attitude is usually said to be based on ICRP's recommendations. It places a considerable burden of responsibility on the Commission to develop and formulate well-founded, prudent advice. The circumstances – and hopefully also to some extent dependable work – have put the Commission in a position where much

* Henry Cavendish (1731-1810) was a prominent British private scientist and experimenter. In 1784 he showed that water was not an element but consisted of hydrogen and oxygen. In 1798 he determined Newton's gravitational constant. Not just the hotel but also a well-known research laboratory in Cambridge has been named after him. At the Cavendish Laboratory, famous scientists like Maxwell and Rutherford have made their significant discoveries.

greater importance and weight are attached to each statement than we would give to it ourselves.

My introductory speech then discussed a number of remaining questions. I list them here to give an idea of what was thought to be of particular interest in 1981:

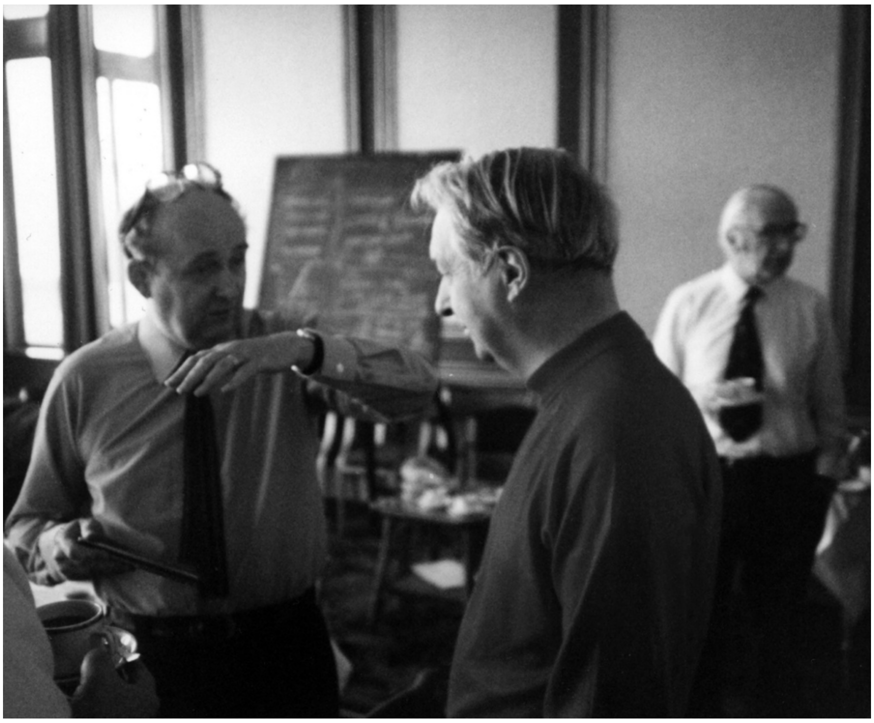
1. The ICRP recommendations cannot supersede national regulations.
2. The ICRP recommendations are theoretical; practical guidance is needed.
3. Effective dose was created for dose limitation purposes but is also used to optimise radiation protection.

[This can be questioned but may be acceptable bearing in mind the uncertainty of the risk estimate.]

4. The organ weighting factors do not take into account all components of the detriment.
5. Does the current dose limit permit too high a lifetime dose?
6. The new ALI values* refer sometimes to stochastic and sometimes to non-stochastic dose limits.
7. Would a cautious annual dose limit of, say 10 mSv for workers, corresponding to 1 mSv for the public, not make the non-stochastic dose limit unnecessary?
8. The use of the quality factor Q must be based on the assumption of proportionality between dose and effect.
9. How should para. 107 of Publication 26 be interpreted?

[Paragraph 107 said that the secondary limit for external irradiation should be applied to the dose equivalent index. The paragraph should be seen as an instruction for the calibration of measurement instruments.]

10. Why must the new ALI values also be applied when it is possible to work with lower exposure using the old system?
11. How should measurement results for long effective half-life be interpreted?



Bo Lindell putting forward an idea to John Dunster. In the background, 'Bill' Pochin.

* Annual Limit of Intake.

12. If a worker is exposed to plutonium at an ALI over 40 years and then continues to work where there is only external radiation but still at

the annual dose limit he will receive annual doses that exceed the limit. How can this be permitted?

[It is the committed dose that is counted.]

13. The genetic detriment should be better quantified.

14. The detriment from exposure of the embryo and foetus.

15. Acute radiation injuries.

16. Are ‘ALARA’ and radiation protection optimisation the same thing?

17. Optimisation is an abstract concept which is not applicable in practice.

[The radiation protectionist or radiologist can scarcely be expected to optimise the protection in his day-to-day work by using a pocket calculator before every decision. But he does need to keep the concept in mind. The fact that protection optimisation is not just an abstract idea is shown by an increasing number of reports.]

18. People often confuse cost-effectiveness with optimisation.

19. People often confuse the value of ‘alpha’* with the actual cost to eliminate a unit collective dose.

20**.** National authorities state no value for ‘alpha’; how in that case are you meant to be able to optimise?

21. Can ICRP not recommend a value for ‘alpha’?

22. Should one and the same value for ‘alpha’ be used for all purposes, irrespective of which group is exposed, the period of exposure and the size of the dose?

23. The application of the dose limitation system to naturally-occurring sources of radiation.

I commented on each point in my introductory speech. In the above list of questions I have inserted a brief version of the explanations for some of the questions.

15.15. **OKG aktuellt**

The December 1981 issue of OKG’s *OKG aktuellt* contained interviews with Hans Löwbeer (who had become Chair of a parliamentary Committee for the Decommissioning of Nuclear Power), the head of Asea-Atom Lars Halle, Gösta Bohman, Nils Rydell and Bo Lindell. Lindell is asked whether nuclear power is safe and proper for our country, and says:

> It’s a tricky question. With a nuclear power plant that’s in suitable place and functioning well, the actual power plant is definitely more environmentally-friendly than other forms of power plant, there’s no doubt about that. Technical solutions can be found for the issue of waste, while the mining and slag aspects have yet to be investigated. We can’t get away from the problems with uranium mining and with regard to accidents, we rely largely on preventative measures so there is a great deal of safety involved. But the remaining question is the unsolvable problem of a very major accident. It is not possible to estimate the likelihood of such an accident, or forget about the idea of it happening. However, broadly speaking, it’s difficult to see any other solution which could be an awful lot better.
>
> ...
>
> It’s difficult for me to think it credible that Sweden should stay away from nuclear power if its development out there in the world is for peaceful purposes. We are also holding a very craven discussion about the breeder reactors. If these are not thought to be on the horizon, that makes the whole of the nuclear power discussion a trifle debatable. If France cancels its breeder reactor experiments while the international concern is increasing, there are no compelling reasons for Sweden to change its mind

* ‘Alpha’ designates the highest justifiable cost to pay to eliminate a unit collective dose.

with regard to nuclear power. But if the breeder reactor is seen to have a future and is a radical solution for the electricity supply, that may make it worthwhile to rethink.

16. THE YEAR 1982

16.1. **The magnetic field camera: MRI**

The magnetic field camera is the latest method to be used for tomography, i.e., the creation of images of a slice of a body being examined. Unlike computed tomography (CT) and the methods for emission tomography (SPECT and PET), neither x rays nor radioactive substances is used for the magnetic field camera. The correct name is *magnetic resonance tomography* or MRI (*magnetic resonance imaging*). It has nothing to do with x rays or any other kind of ionising radiation.

The magnetic field camera is based on the physical concept *nuclear magnetic resonance* (NMR). This phenomenon was discovered in 1945 by the American scientists *Felix Bloch* (1905-1983) and *Edward Purcell* (1912-1997) who shared the 1952 Nobel Prize for Physics for the discovery.

Electric charge movements in the atomic nuclei generate magnetic dipole moments which mean that the nuclei behave like compass needles when they enter a magnetic field. This applies to atomic nuclei with an odd number of nucleons (protons and neutrons); where there is an even number, the effect is neutralised for each proton-neutron pairing. The dipole moment of the atom is related to the spin of the nucleus, which is subject to the laws of quantum mechanics and can assume only specific values. The permitted orientation of the magnetic moments corresponds to different energy levels. Two different orientations occur for hydrogen nuclei in a magnetic field: parallel or antiparallel to the direction of the field.

What is known as the *Zeeman effect* consists in a magnetic field broadening or splitting the spectral lines that are characteristic of an atom or a molecule. The nuclear spin can be made to change its energy level in the magnetic field if you expose the nucleus to radio waves with a resonance frequency corresponding to the level difference. The change in the orientation of the nuclear spin generates a short-term radiofrequency signal, which can be observed in a receiver. When analysed, the signal strength is registered as a function of the radiofrequency used, which gives you an NMR spectrum which shows the different resonance frequencies. The time it takes for the radio signal to decay is called the *relaxation time*.

After a few years, it was found that the resonance frequencies were affected not only by the magnetic field strength but also by the chemical environment of the atomic nucleus, which opened up new possibilities for analysis methods. However, the NMR method had low sensitivity, which limited its use. A major step in the development was taken in 1966 when the Swiss chemist *Richard Ernst* (born in 1933) together with the American *W. A. Anderson* discovered that the sensitivity could be drastically increased if the sample were exposed to short, intensive radiofrequency pulses rather than gradually varying the frequency. You then get a response signal that can be registered as a function of the time. It contains all resonance frequencies and must therefore be subjected to *Fourier analysis*. This is based on the fact that an apparently complicated time pattern of a signal can be shown to be made up of a number of harmonics (sine curves) with different frequencies. The analysis of the complicated harmonic ends up in a spectrum of the frequencies involved. Ernst was rewarded with the Nobel Prize for Chemistry in 1991.

The possibility of using nuclear magnetic resonance within medicine had already been proposed in around 1960 by *Erik Odeblad* (born in 1922) and colleagues. Odeblad, who was Professor in Medical Technology in Umeå, used nuclear magnetic resonance to analyse biological preparations and in 1955 also showed that the relaxation time was characteristic of different tissues. In 1971 an important discovery was made by *Raymond Damadian* who showed that the NMR signal from tumour cells in rats decayed more slowly than the signals from healthy cells.

The first tomographic images using NMR were created in 1973 by *Paul Lauterbar*, who allowed the magnetic field strength to be different in different parts of the depicted volume. The frequency of the resonance signal thereby determined the position of the affected cells. The strength of the signal was a measure of the nuclear spin density in the object. A combination of these details made it possible to create an image.

Over the next few years, a number of attempts at tomographic depiction were made using NMR methods. *Peter Mansfield* and his group at the University of Nottingham in England in particular developed the methods for practical use. Damadian also demonstrated methods. In 1982, the methods had become fairly widespread and ended up being an extremely valuable tool for diagnosing mainly diseases of the brain and the spinal cord. In the mid-1980s the word ‘nuclear’ was removed because of the desire to avoid frightening associations with radioactivity and nuclear weapons, so ‘MR’ or ‘MRI’ only (for ‘magnetic resonance imaging’) started to be used on a worldwide basis. If you want to emphasise that it is a tomography, you use ‘MRT’.

In Sweden, magnetic field cameras were brought into the x-ray department at *Akademiska sjukhuset* in Uppsala in 1984 and into the psychiatric departments at *S:t Görans sjukhus*. The Association of County Councils then introduced a moratorium for further installations until the activity in Uppsala had been assessed. The activity continued in 1986 with installations at the General Hospital in Lund, *Karolinska sjukhuset* in Stockholm and the Regional Hospital in Umeå. In October 1994 there were 45 MR devices in Sweden.

The MR image is affected by the chemical structure of the tissue, unlike the image in a transmission computed tomography (CT) which is determined solely by the permeability of the tissue for the x rays. The MR technique can build on direct depiction through two-dimensional Fourier transformation which directly gives the spin density distribution in the object. It can also build on projection reconstruction with image construction algorithms similar to those drawn up for CT and PET.

The magnetic field camera is often thought to be completely free from risks since it has no ionising radiation. The magnetic field does not lead to any risks as far as we know, but the ambition to work with increasingly stronger magnetic fields (including to increase the signal to noise ratio) also involves the use of higher radiofrequencies. In extreme cases, this can lead to harmful, high-frequency heating.

Paul Lauterbar and Peter Mansfield were rewarded with the 2003 Nobel Prize for Medicine. Raymond Damadian felt ignored and protested with full-page announcements in the Swedish daily press.

16.2. **Hans Blix succeeds Sigvard Eklund as DG of IAEA**

Sigvard Eklund had left his job as Director General of IAEA in 1981 at the age of 70. He stayed in Vienna where he had been given both an emeritus room and a Swedish Secretary at IAEA. Eklund was succeeded by the 53 year-old lawyer Hans Blix whose achievements had included Foreign Affairs Council adviser, Secretary of State at the Ministry for Foreign Affairs and Swedish Foreign Minister. It was unique and an honour for Sweden that Eklund, after twenty years’ service as Director General of IAEA, was replaced by another Swede.

16.3. **Concern regarding the appointment of the head of the Radiation Protection Institute**

On 12 January, a *Svenska Dagbladet* article said that concern had arisen that the appointment of someone to succeed Bo Lindell could be a political appointment to satisfy the nuclear power opposition in Sweden. It also said:

> In a letter to [Minister for Agriculture] Dahlgren, with former GP Carl-Johan Clemedson as first name on the list, 25 Professors and scientists within radiation

> protection research say that they are looking very seriously at the complicated radiation protection issues that a head of the Radiation Protection Institute must deal with.
>
> ...
>
> The letter to the Minister of Agriculture emphasises that the Swedish Radiation Protection Institute has a top international reputation. The Institute has acted in an objective, scientifically-substantiated way in the radiation and nuclear power debates and has gained the trust of the Swedish people.
>
> The 25 undersigned say it is essential to retain this international reputation and national trust when a successor is appointed. This can only be the case if the successor has the same qualifications as Sievert and Lindell, objective know-how documented by academic education and long-term professional activity within radiation physics.
>
> ...
>
> The scientists and even Lindell himself want the successor to be appointed from among his closest colleagues. One of these is Deputy Director General Gunnar Bengtsson.

16.4. **UNSCEAR's 31st session in Vienna**

UNSCEAR met in Vienna from 15-26 March. The Chair once again was Professor Jaworowski, Deputy Chair Dan Beninson and rapporteur Professor T. Kumatori from Japan. I was the Swedish representative with Gunnar Walinder as deputy and Kay Edvarson, K-G. Lüning and Jan Olof Snihs as advisers. The meeting concluded the work with the 1982 report.

When I asked the Ministry for Foreign Affairs for experts for this meeting I was asked to give a 'more detailed rationale and to unconditionally consider the scope of Swedish participation'. The following can be quoted from my response to the Ministry for Foreign Affairs:

> The situation is that the UNSCEAR delegation necessarily consists of the representative (whose expenses are paid by the UN) and said person's deputy, and that it is appropriate for these to be supported by expertise to the extent that Sweden considers suitable. The experts must be selected in respect of the expertise that is necessary, not with regard to where they happen to be employed.
>
> One reason why the Radiation Protection Institute occupies an increasingly dominant position as regards the expertise within UNSCEAR's field is because the State has decided to concentrate expertise at the Institute and close down activities that have been run elsewhere, e.g., within the Swedish Defence Research Establishment . It is worth adding that Walinder originally came from the Swedish Defence Research Establishment but has now been transferred to Stockholm University simultaneously with the Radiation Protection Institute being asked to pay for a significant share of his research. The radiobiology committee has also recently proposed that the Radiation Protection Institute should have an even more dominant role regarding control of the radiobiological research, which is something that the Institute has had certain doubts about.
>
> The aforesaid ought to show that it is exceedingly in appropriate to change the composition of the Swedish delegations in the middle of a report production period and particularly so before the concluding meeting when all experts are heavily engaged with work assignments they already have.
>
> I propose that the delegation remain unchanged before the 31st session so that the work is not disrupted. At the 32nd session, when the direction of the activity for the next period is to be discussed, it may be sufficient for the representative and his deputy to take part without any other expertise. For the 33rd session and following sessions over the next production period, we should consider which level of ambition Sweden can afford and which experts will take part. Whoever is then appointed as experts should remain as experts throughout the period.

The 1982 UNSCEAR report contained a completely new presentation of the radiation doses from natural radiation. When previous reports stated that the annual 'natural radiation dose' was 100 mrad per year in round figures, this referred to the *absorbed dosed* in organs and gonads and bone marrow, which corresponds to 1 milligray (mGy) at the time of changing over to the new SI unit. Since the absorbed dose of alpha rays from the radon and its daughter products in the lungs was really insignificant, it was possible to simplify the situation by assuming that the dose from natural radiation was caused principally by beta and gamma radiation so that, roughly calculated, you could say that the annual natural dose equivalent was 1 millisievert. This would have been convenient when people wanted to make comparisons with the radiation doses from radioactive environmental contaminations, e.g., from the powerful nuclear weapons testing between 1960 and 1961 and from emissions from nuclear reactors.

However, ICRP Publication 26 from 1977 changed the situation. ICRP offered a new dose unit, the effective dose equivalent (later the *effective dose*) which took into account the radiation doses in different organs of the body and the radiation sensitivity of the organ with regard to the risk of cancer. Now, the radiation dose in the lungs from the alpha-emitting radon daughters suddenly increased in significance. The annual absorbed dose had previously been stated as an apparently insignificant 30 mrad, but to calculate the effective dose you first had to multiply by the radiation weighting factor 20 with regard to the alpha rays and then by the organ weighting factor 0.12 for the lungs. If you took into account the radiation from all alpha emitters of natural origin, the annual effective dose became approximately 1 mSv in addition to the millisievert that had previously been counted on as the annual radiation dose. Double the amount! And for some countries, including Sweden, more than that: the Radiation Protection Institute counted on 4 mSv as the annual natural effective radiation dose.

This way of calculating the natural radiation dose was embraced by UNSCEAR in its 1982 report; radon did not really come into the limelight until then.

16.5. **The Falklands War**

Argentina invaded The Falkland Islands on 2 April 1982 and the Falklands War, which was lost by Argentina, began. This also had a number of consequences for the radiation protection cooperation between Argentina and Britain, but the British had a pragmatic and lenient attitude which did not prevent Dan Beninson from visiting Britain, for example.

16.6. **The Ringhals steam generators**

Ringhals 3 had come into commercial operation on 9 September 1981 but had problems with the steam generators, which led to a long-term stoppage on 20 October for investigation and measures. The start of Ringhals 4 was postponed while they were waiting for information from this investigation. The steam generators were shaken by vibrations due to unsuitable flow conditions.

MS *Sigyn* came to Ringhals for the first time in 1982 and was met by demonstrations. Dan Beninson was visiting Stockholm in late April/early May. He was obviously interested in the steam generator problem and, after visiting *Vattenfall,* we were given permission to visit the Älvkarleby Laboratory together. I drove Dan there and we visited the laboratory on 2 May and discussed the problem. Dan then visited us at the Radiation Protection Institute on 4 May before travelling home to Argentina the following day.

Ringhals 4 was allowed to start and the nuclear reaction was working on 19 May. The power grid was phased in on 23 June. The steam generators at Ringhals 3 and 4 were modified in 1983. Ringhals 4 came into commercial operation on 21 November. The four aggregates were driven at full power in January 1984. Ringhals was thereby Sweden's biggest power plant with an output of 3 380 MW.

16.7. **The Rasmussen report**

In the 1970s, Norman C. Rasmussen at the Massachusetts Institute of Technology (MIT) did a study for the US Atomic Energy Commission. It was called *The Reactor Safety Study* but was better known as 'The Rasmussen report'. It cost four million dollars and took three years to carry out. Its conclusion was that the odds against the worst type of reactor accident were astronomical: 10 million to 1, i.e., a probability of 1 in 10 million.

The report estimated that such an accident could lead to 3,000 early deaths and 14 billion dollars' worth of property damage because of radioactive contamination. It was also thought that 1 500 people could be affected by cancer after the accident. In my view, the report was a textbook example of the misuse of the concept of probability.

Professors Arne Hedgran and Kurt Becker convened a seminar at KTH on 5 May 1982 with N. Rasmussen and S. Levine as lecturers.

16.8. **The National Board for Spent Nuclear Fuel**

The National Board for Spent Nuclear Fuel (SKN) was now discussing risk concepts and the perception of risk on the basis of a foundation document written by *Sven Ove Hansson*. The National Board for Spent Nuclear Fuel was set up in 1981 with the task of monitoring the purposefulness and efficiency of the work with the nuclear waste. The Board existed for around ten years. Swedish Parliament decided to close down the SKN on 1 July 1992 when its tasks were taken over by the Nuclear Power Inspectorate. This put KASAM (the Swedish National Council for Nuclear Waste), the scientific council which had been linked to the SKN since 1985, in a more independent position, associated with the then Ministry of the Environment and Energy so that it was not linked to an authority. See Section 19.6.

16.9. **The irradiation of foods**

Arne Engström, the then Director General of the National Food Agency, rang me in March and said that he intended to propose me as investigator of the irradiation of foods. He was annoyed and said: 'It's bad practice to call ionising radiation, the thing that's causing people's worry, radioactive radiation. They believe the irradiated foods become radioactive!'

On 29 April 1982, the government authorised the head of the Ministry for Agriculture to appoint a special investigator to investigate matters concerning the irradiation of foods. With the support of this authorisation, I was appointed as special investigator from 15 June. I was given two knowledgeable Secretaries, Professor *Marie-Louise Danielsson-Tham* and Departmental Director *Christer Hoe* to assist me. A number of experts were provided, the following being of primary note: Professors *Carl Erik Danielson* (1921-1992), Lars Ehrenberg (1921-2005) and *Lars-Erik Tammelin* (1923-1991). Marie-Louise and Christer collected material and checked facts but I insisted on writing the report myself; it entertained me.

16.10. **Haga Court of Justice**

On 11 June, Haga Court of Justice was inaugurated as an extra premises for the Radiation Protection Institute, to be more precise for the work with nuclear power radiation protection which was initially headed by Jan Olof Snihs and then by Jack Valentin (when Jan Olof became Deputy DG).

16.11. **Palme Prime Minister once again**

The Social Democrats won the Swedish election in 1982 and formed a government with Olof Palme as Prime Minister. Birgitta Dahl now became Minister for Energy.

16.12. **The Radiation Protection Institute on sunlamps**

The Swedish Radiation Protection Institute issued provisions regarding sunlamps (SSI FS 1982:1). The concept of sunlamps also included solariums. Further provisions followed in 1998.

16.13. **Kosmos 1402**

The Soviet satellite Kosmos 1402 could conceivably come down over Sweden but luckily did not. The Swedish Radiation Protection Institute's Haga Court of Justice preparedness was activated. As the number implies, there have been many Kosmos satellites.

16.14. **Lindell retires and is succeeded by Gunnar Bengtsson**

I had informed our Ministry that I did not wish to extend my assignment as Director General of the Radiation Protection Institute and thus retired. As per my wish, I was succeeded by Gunnar Bengtsson. The Radiation Protection Institute's shortage of premises had temporarily been solved because, as a consequence of an initiative by Lars Persson, we were allowed to use the Haga Court of Justice where the Nuclear Regulatory Commission was moved to and where I was given a big emeritus room just to the right of the entrance. In the building was a big central computer, a VAX, but I was also given a personal computer which initially had a hard disk of 5 MB, an impressive thing at the time.

As a retiree I was given two (unpaid) assignments. I would be adviser to the Director General on policy matters and I was expected to write Annex C (the grounds for assessing the significance of radiation effects) in the impending new ICRP recommendations. I remained Chair of ICRP and Swedish representative at UNSCEAR for a few years. The calculations for ICRP required a whole load of computer calculations so I was full to the back teeth with work.

16.15. **The ICRP Main Commission in Geneva**

The ICRP MC met at WHO's headquarters in Geneva on 1-5 November.

17. THE YEAR 1983

Since my retirement in 1982, I have not had the same insight into the Radiation Protection Institute's activities as before, but during the 1980s I was still active within ICRP and UNSCEAR and had an emeritus room at the Radiation Protection Institute until the start of the 2000s. This obviously has an influence on the following portrayal.

17.1. The Radiation Protection Institute in the Haga Court of Justice

The growth of the Radiation Protection Institute created problems in terms of space. Many options to move to or utilise other premises were looked into. In the end, it was Lars Persson who found that the nearby Haga Court of Justice was empty and could accommodate the personnel working with the nuclear power problems. The Institute used the former Court of Justice until the early 1990s when an extension of Sievert's high voltage hall was completed and additional space became available in the previous workshop.

17.2. BALK goes on a trip

As investigator into the irradiation of foods I took a trip to Europe from 24-28 January with my Secretary and experts (the 'BALK-1' Committee). We firstly flew to Amsterdam and then to Frankfurt, then drove to Karlsruhe. In the University town of Wageningen we visited a pilot irradiation plant and were shown around by *Dr. J. Cornelis* whom I knew from meetings with the CRPPH at the NEA in Paris. We also visited an irradiation plant, *Gammaster*, in the nearby industrial town of Ede. Cornelis was positive towards the irradiation of foods, but we found that only 'cost-intensive' products such as chickens, frogs' legs and strawberries had been irradiated. We discussed the technology in Karlsruhe. Christer Hoel was an efficient tour guide.

17.3. The Harrisburg meeting with very concerned people

The reactor accident at the Three Mile Island nuclear power plant outside Harrisburg, Pennsylvania on 28 March 1979 (see Section 13.14) had political and economic consequences all over the world, including a referendum on nuclear power in Sweden. Locally, there were obviously considerable economic consequences for the owners of the power plant. In the legal proceedings, a Public Health Fund was created which would be used in the interests of the surrounding population. An Expert Advisory Board was formed and connected to the fund. During the proceedings, Karl Morgan had been given the task of appointing these experts, and he had selected a group of people who were openly critical of nuclear power.

The advisers, who as far as I understood in practice also had executive powers, had decided to use means from the fund to arrange a Public Forum on nuclear power. It would meet on 2-30 March on the Penn State University campus in Middletown close to Three Mile Island. According to the programme, lectures would be held within six sessions. Karl Morgan had invited lecturers and I had been asked to speak about dose limits in radiological work.

I accepted Karl's invitation out of curiosity but the thought of finding myself in an environment that was exclusively hostile to nuclear power worried me. It turned out that the environment was indeed, owing to Morgan's selection, largely against nuclear power, but there were also a few lecturers with a good reputation as scientists with good judgement such as radiation biologist *Arthur Upton* from New York University and risk scientist *Roger Kasperson* from Clark University.

The programme was intended to give laypeople an insight into the problems at Three Mile Island. The layperson's points of view were also discussed at a special meeting where the neighbouring public had the opportunity to voice their concerns. The meeting depressed me greatly. The many radiation measurements that had been carried out after the accident by scientists from a large number of scientific institutions had clearly shown that the reactor accident had not caused any worrying doses of radiation in the surrounding area. Yet there were locals who had come to the meeting not just worried but panic-stricken. They did not have sufficient education to assess the risks and were assuming that every case of illness or death after the accident had been caused by radiation.

At the next lunch I sat next to one of the members of the Advisory Board, Edward ('Ted') Radford from the University of Pittsburgh. I discussed the matter with him.

'I was shocked at the deep distress, even panic, that the locals testified to. I couldn't put them right - they wouldn't have believed me. But those of you who are members of the Advisory Board also kept quiet. Didn't you have a responsibility to explain that things were certainly not as dangerous as they thought?' I asked.

'Yes,' answered Radford, 'but the important thing is for us to have their trust. We'd lose that if we said it was less dangerous. We can state things as they really are in a few years' time when they really trust us.'

I was stunned. I had recently met people who were extremely scared and who were plagued by their fear. And here was their adviser not wanting to put them right!'

During free periods I walked through the town down to the river and looked for the power plant's cooling tower. I asked some of the locals if they were afraid of the power plant but found no-one who seemed concerned. Maybe it was a selection of extremely scared people who had taken the trouble to visit our Public Forum?

17.4. **The UN group on Iraq and Israel in Vienna**

The Israeli bombing of the Tammuz-1 research reactor in June 1981 had caused the UN's General Assembly in November 1982 with 119 votes for and 2 against (Israel and the USA) to establish an expert group on 'the consequences of Israel's armed attack on Iraqi nuclear installations'. I had been appointed as one of the experts. The group's first meeting was held in Vienna on 18-22 April 1983 (a second meeting was held in New York in the same year (see Section 17.13). The people who took part were:

Akinwande Akinyemi of Nigeria
Bo Lindell of Sweden
Milan Osredkar of Yugoslavia
Kalyan Valdya of India
Nikolai Titkov of the Soviet Union
Charles Van Doren of the USA

17.5. **IAEA for a syllabus**

From 18-23 April I was in Vienna as consultant for IAEA to draw up a syllabus for a Basic Training Course on radiation protection and a draft of a policy document on radiation protection training.*

* Syllabus was originally a list of 80 'aberrations' (including naturalism and socialism) which were appended to Pius IX's circular *Quanta cura* in 1864.

17.6. The Vatican's meeting regarding the optimisation of radiation protection

When IAEA in Vienna was to formulate its Basic Safety Standards, one of the Italian experts, Dr. Lidia Failla, observed that ICRP's recommendation for the optimisation of radiation protection using a cost-benefit analysis involved the pricing of doses of radiation and thereby, implicitly, putting a value on a human life. Dr. Failla, who was deeply religious, became concerned and approached the Vatican's representative in Vienna, who protested. It all led to the Vatican convening an expert group to meet in the Pontifical Academy of Sciences' building within the walls of the Vatican City.

Those who took part were:

Carlos Chagas of Brazil
Gilbert Beebe of the USA
Dan Beninson of Argentina
Merril Eisenbud of the USA
Lidia Failla of Italy
Wolfgang Jacobi of Germany
Raymond Latarjet of France
Jérôme Lejeune of France
Bo Lindell of the UK
Carlo Polvani of Italy
Giovanni Silini of Austria
F. H. Sobels of the Netherlands
David Sowby of the UK

The list said that I was coming from the UK because I was there as Chair of ICRP whose Secretariat was in the UK in the same way that the Italian Giovanni Silini was classed as being Austrian because he was the new Secretary of UNSCEAR.

We stayed at the nearby Hotel Michelangelo and were picked up by bus every morning. Dan's curiosity observed that it was not the stately Swiss Guard who were responsible for the safety but men in civilian clothes who used their mobile telephones to exchange efficient views as to who looked suspicious. We walked past powerful radio stations which spread the catholic message all over the world.

The meeting took place in the Vatican City Park in the beautiful Casina Pio IV building which appeared to be the home of the papal Academy of Sciences under the leadership of Professor Chagas. I was struck by the contrast between a Swedish priest offering coffee and the quantities of wine that were served to us during the coffee breaks. The week-long meeting resulted in a six-page report, *Biological Implications of Optimisation in Radiation Protection*, which was published in 1985 or, to use the correct expression for the environment, MCMLXXXV.

Dan Beninson and Pope John Paul II, 1983.

After consulting one of the Vatican's ethics experts, the following text was written which pacified Dr. Failla:

> The method usually employed [for optimisation of radiation protection], on a case by case basis, is to choose the protection option (among those that ensure that individual doses are below the dose limit) that gives the minimum value of the sum of the cost of protection and the product of the expected collective radiation dose and a factor expressed in resource units per unit of collective dose. This factor is the maximum amount allocated by society to avoid a unit of collective dose, and its magnitude determines the attainable level of radiation protection. It has nothing to do with valuation of human lives but is a device for conserving lives. It must be stressed that the net result of protection optimisation is to reduce exposure *below* the dose limits. It is the responsibility of the protection authorities to seek society's acceptance of a level of radiation protection which is the highest possible without conflict with other legitimate needs and duties of society.

One of the group's conclusions read:

> [The group] recognises also that a remarkably efficient system of dose and risk limitation has been evolved in the field of radiation protection. It suggests that a similar method could be applied to the control of other toxic and mutagenic agents endangering man and his environment.

We also received a healthy measure of cultural history. We were channelled the back way into St. Peter's Basilica and were shown the ongoing excavations in the search for the apostle Paul's grave beneath the church. We also got to see a booklet of the same dimensions that our own would have. There, the Pope acknowledged that Galileo had been wronged by the church. We were in an historic environment.

17.7. **The accident in Constituyentes**

A radiation accident with a fatal outcome took place in Constituyentes in Argentina. A summary is given in the 1988 UNSCEAR report:

> An accidental prompt critical excursion occurred during a configuration change in a critical assembly, resulting in the death of an operator, who was only 3-4 metres away. The dose to the victim was estimated to be 5-20 Gy from gamma rays and 14-17 Gy from neutrons.

17.8. **The scattering of cobalt from Ciudad Juarez**

An event which extensively disseminated cobalt-60 occurred in Ciudad Juarez in Mexico, although no-one died. A summary is given in the 1988 UNSCEAR report:

> An improperly disposed of cobalt-60 source found its way into a scrap metal shipment, contaminating the delivery truck, the roadsides and the processed steel into which the scrap was incorporated. Some 300-500 individuals were exposed, ten to doses of 1-3 Gy. There were no deaths.

17.9. **The IAEA waste meeting in Seattle**

A conference on radioactive waste was held in Seattle on 15-21 May. Dan Beninson and I took part with a paper proposing the principle for the limitation of future doses of radiation, a principle which was later also used by ICRP. Perhaps not surprisingly, I was Chair and Dan Deputy Chair.

Ambretta Beninson took part as a scientist, her last work trip as she had just four months left to live. Ragnar Boge took part in the meeting, the Norwegian with a good international reputation who had become a radiation protectionist for Sweden. Another participant was Abel González who had become quite an important person. We had many interesting discussions.

I walked around in Seattle and paid a special visit to the harbour in the hope of finding a good fish restaurant. Instead, I found a good non-fish, a killer whale in a large pool. It was sociable and swam up to the edge of the pool and looked at me. My scientific training told me that I was just imagining that it liked me, but it let me pat it on the head and I felt a sort of bond, a feeling that Dan would have laughed at.

17.10. The Nordic Society for Radiation Protection's meeting in Hanstholm

At the end of May 1983, the Nordic Society for Radiation Protection held a meeting at Hotel Hanstholm on Jylland's north-west coast. I came by car from Stockholm and took the ferry from Gothenburg to Frederikshavn and then drove to Hanstholm at the same time as Gunnar Walinder. As well as the Nordic colleagues there were also other participants, among them Bill Pochin with whom I walked along the beach past old German defence bunkers.

I gave a presentation which also interested Bill. I attempted to explain the policy behind the optimisation of radiation protection. I showed a picture of a ball which rolled down a hill. The hill represented the cost of the radiation protection and the distance was the collective radiation dose. At a certain distance was a wall across the hill. The wall represented a limit value for the radiation dose.

Of course, the ball rolled down the hill until it was stopped by the wall, the limit value. This meant that if one took no further measures, the limit value would determine the size of the radiation dose. However, we had higher ambitions. I showed another hill which sloped in the other direction and made it difficult for the ball to reach the wall. The hill represented a value of the cost of the damage that would be caused by the radiation dose. We did of course want to take into account the damage and reduce it to as little as was reasonably possible.

Now that the ball was rolling, its path was the sum of the two hills, i.e., a U-shaped hill where the ball stayed where the hill total was at its lowest. That point was where there was a balance between a change to the cost of the injury and a change to the cost of protection. The problem was that one became obliged to put a price on the radiation dose and thereby, implicitly, a 'value' on a human life. This was the problem I had been discussing in the Pontifical Academy of Sciences a few weeks previously (see Section 17.6).

If we postulated a linear, no-threshold relationship (later referred to as LNT) between radiation dose and probability of serious injury, the injury value could be calculated as $\alpha \cdot S$ if S were the collective radiation dose, i.e., the product of the number of irradiated people and their average dose.

Some rules could be established, such as

Lack of linearity. The British NRPB wanted to add a β term which would depend on the number of people and the highest individual radiation doses. Dan Beninson and I thought that such a term reflected subjective risk perceptions which did indeed exist but which were not functions of the size of the radiation doses and which therefore ought to be dealt with by measures outside the system.

Distance. Dan and I thought that injury ought to be taken into account irrespective of the distance – in other words, 'a life is a life'. If this were not done, further on in the future one would have to expect a 'backlash' of deliberate emissions over long distances or a 'sweep it under the carpet' policy. The value of α for doses of radiation outsider the contaminating country ought to be at least that which is used within the country.

Time. It ought to be wrong to discount future injury expenses. On the other hand, very far into the future, doses of radiation are irrelevant to the protection optimisation if the protection measures are ineffective in the long term.

However, the most important significance of the LNT assumption was that it made it possible to treat every activity separately, irrespective of other small additions to the total radiation dose.

17.11. **The irradiation of foods**

According to a press release from the Ministry of Agriculture on 14 June, the investigation report called 'The irradiation of foods' (SOU 1983:26) was submitted on that date. We had concluded that the irradiation of foods made the foods neither radioactive nor dangerously toxic. The chemical substances formed at the time of the irradiation are also not unique – they are the same substances that are formed when frying food, for example. There was therefore no reason to avoid irradiating foods due to any risks, even if it was impossible in many similar cases to say that irradiated food was completely without risk. On the other hand, there were other reasons to be sceptical. With the help of irradiation one might preserve foods that could otherwise have been dangerous due to lack of food hygiene in the producing countries. In such cases, rather than banning the irradiation we thought it better to take intervention against the poor hygiene so that the irradiation was not needed.

The report was received in a positive light. Most enthusiastic was the reviewer (*Kurt Östlund*) in *Livsmedelsteknik*. I cannot refrain from that conveying the praise that was heaped on us:

> It's just as well to say it from the start: This is no usual report. The usual thing is to approach SOU-marked volumes with a certain reluctance. You dutifully attempt to skim the most important section to form a rough idea, checking that you haven't missed anything important. You're unable to sacrifice more than a half an hour for a report. After all, you need that same evening to clear an additional part of the flotsam that today's information wave has brought ashore. Not this evening. SOU 1983:26 can compete with *Watership Down* – or why not *Lord of the Flies* – when it comes to captivating the reader.
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> \- - -
>
> SOU 1983:26 is not just a report. It is a considered, very well-written document with unusual pedagogic qualities. You get the impression that the Committee has set out to present this complex problem in such a way that the reader will have learned enough to refrain from asking the meaningless question 'So, has it now been shown that radiation treatment is not dangerous?' I believe success has prevailed.

17.12. **UNSCEAR's 32nd session in Vienna**

UNSCEAR met in Vienna on 20-24 June for its 32nd session. Dan Beninson was the now Chair with Professor Kumatori from Japan as Deputy Chair and A. Hidayatalla as rapporteur. Since it was a planning meeting rather than am ordinary work meeting, the Swedish delegation was reduced to me and my deputy, Gunnar Walinder. In our report from the meeting we initially discussed UNSCEAR's position:

> UNSCEAR reports directly to the UN's General Assembly. However, the Committee's Secretariat is administered by UNEP in Nairobi, despite the Secretariat being located in Vienna and the Committee now always meeting in Vienna. In our opinion, administration through UNEP means bureaucratic sluggishness which has sometimes made the activity difficult. UNEP's responsibility for the Secretariat has sometimes also been misunderstood and led people to believe that UNSCEAR works for UNEP rather than for the General Assembly, which is an unfortunate misunderstanding.
>
> Since the scope of the atmospheric [nuclear] test explosions has lessened, UNSCEAR has been less politically significant. The Committee has been very important in establishing a generally-accepted view of radiation levels and biological impacts of radiation. Over the past few years the Committee has made great efforts to achieve a corresponding uniformity in the perception of radiation levels and radiation risks from the other sources of radiation which worry the public all over the world. This has meant that people have started to forget the Committee's connection to the UN's General Assembly.

> In our opinion it would be unfortunate if the Committee's political significance were to be underrated. The Committee is a scientific committee with very little political bent. Through the routine that the Committee developed to deal with and assess scientific issues and the good reputation that the Committee enjoys in scientific circles, it has, less paradoxically than it may seem, perhaps primarily been of importance in defining a facts base and scientific interpretation which are acceptable to all parties and which have clarified the political discussion. In other words, the Committee is invaluable in new crisis situations where there could be political disagreement regarding the interpretation of facts. In such a situation, it would not be possible to rapidly create a scientific committee for the necessary assessments; a newly-created committee would neither receive the same trust nor have the same routine to achieve a uniform assessment as that of UNSCEAR.

We said that another Swede, Lars-Erik De Geer from the Swedish Defence Research Establishment, had been consultant for UNSCEAR regarding radioactive fallout and the handling of military nuclear fuel. We again voiced our concern regarding UNEP's passivity when it came to support for UNSCEAR's Secretariat and the Secretary, Dr. Silini. We also expressed concern about the Ministry's handling of the UNSCEAR issues:

> In all previous years, participation in the UNSCEAR work has followed a direct decision from the Ministry for Foreign Affairs. It has therefore been to our surprise to notice that this year, *the Ministry for Industry* has issued the notification (17/05/1983) regarding Sweden's participation in UNSCEAR's 32nd session. We are concerned that this is once again because UNSCEAR happens to be meeting in Vienna and is therefore in some way linked with other Swedish interests in Vienna, such as IAEA. However, there is no such link; UNSCEAR is the *General Assembly's* Committee as well as being a Scientific Committee. UNSCEAR's programme certainly does appear to include a review of the radiation doses from the nuclear power industry, but it would be very unfortunate if this were confused with inputs that concern international cooperation or policy within the nuclear power field. We therefore do not understand the Ministry for Industry's involvement in the matter. The Ministry for Foreign Affairs gave us our original assignment and we therefore submit our meeting report to the Ministry for Foreign Affairs, not to the Ministry for Industry as requested in the Ministry's letter of 17/05/1983. If another Ministry is affected in addition to the Ministry for Foreign Affairs, it ought primarily to be the Ministry for Agriculture under which the radiation protection matters and the Radiation Protection Institute come.

17.13. **The UN group on Iraq and Israel in New York**

The second and last meeting of the expert group on Israel's bombing of an Iraqi research reactor was held on 11-15 July. The venue was now the UN headquarters in New York. The six members of the group had each been appointed to deal with separate sub-problems. I now also had the opportunity to get to know them better.

Akinwande Akinyemi was DG of the Nigerian Institute for International Affairs. The group elected him as Chair. His task was to write about political aspects that did not concern nuclear matters.

Milan Osredkar, Professor of Physics and Nuclear Technology at the Stefan Institute at Ljubljana University, was in my view the only 'ordinary' colleague in the group, a pleasant, knowledgeable man who sent me New Year's greetings for several years afterwards. His task was to deal with the technical matters.

Nikolai Titkov came from the Soviet Union's Federal Committee on Atomic Energy Issues. He was to deal with the political aspects of the reactor bombing.

Kalyan Vaidya was now a consultant in New York but had previously been ambassador and leader of the Indian delegation for the conference on international economic cooperation in Paris from 1976-1977. He was to write about economic consequences of the bombing.

Charles Van Doren had been Deputy Director for non-proliferation treaty (NPT) matters at the USA's Arms Control and Disarmament Agency. He was still occupied with NPT matters in Washington DC. His task was to deal with legal matters.

As for me, I was expected to write about the health aspects of the bombing.

My impression of my colleagues was that, with the exception of Osredkar, they were divas and that they envisioned their primary task as being to prevent the bombing leading to international unease.

The bombed reactor, Tammuz-1, was a 40 MW pool reactor while Tammuz-2 was a significantly smaller reactor. Tammuz-1 was sometimes referred to as 'OsIraq' because a similar reactor in France was called 'Osiris'. Since various sources differ as regards which name (Tammuz-1 or Tammuz-2) was relevant to the larger reactor, calling it OsIraq will lessen the uncertainty. The reactors were not charged with nuclear fuel; the fuel lay outside and had, as it turned out, never been irradiated. The bombing could therefore not lead to any significant radiation injuries. The reactors had been inspected under IAEA's safeguards programme and would not have been able to produce plutonium without tangible changes. The bombing was perceived by IAEA as a mistrust of the organisation's safeguards system. Two days after the airstrike, Director General of IAEA Sigvard Eklund told his board:

> We should remind ourselves that the Agency's safeguards system is a basic element of the Non-Proliferation Treaty (NPT). During my long time here, I do not think we have been faced with a more serious question than the implications of the Israeli air attack on the Iraqi research reactors. The Agency has inspected them and has not found evidence of any activity not in accordance with the Non-Proliferation Treaty. A non-NPT country has evidently not felt assured by our findings and about our ability to continue to discharge our safeguarding responsibilities effectively. In the interest of its national security it has felt motivated to take military action unilaterally. From a point of principle, one can only conclude that it is the Agency's safeguards regime which has been attacked. Where will this lead us in the future?

In response to Eklund's address the board condemned the attack and expressed continued trust in IAEA's safeguards system.

My assignment to write in the report about the health injuries had been simplified by the lack of radioactive substances other than (the undamaged) fuel elements. However, a few people had evidently been killed, one of whom was a French engineer. Exact details were difficult to come by and the Iraqis who came to the expert group did not shed much light; they seemed afraid of Saddam Hussein.

The lack of radiation injuries meant that I had to content myself with mentioning what could have happened had the damaged reactor been in operation. But it was not easy. I wrote:

> It should be pointed out that the crucial impact on a number of parameters that would affect the result means that every estimate of the health effects of military attacker on reactors are very hypothetical. For this report, it may be enough to say that the health consequences can be substantial and that long-term contamination of land with radioactive substances can create a severe problem.

It was clear that the airstrike had killed some people but that there would be no radiation injuries. Israel's attack was condemned since, by all accounts, over and above the deaths, it had destroyed only one valuable research reactor. However, we asked ourselves whether Saddam Hussein had actually thought he could have produced nuclear weapons and that no-one had dared disclose the truth to him.

17.14. **Report on the new Radiation Protection Act**

With reference to a proposal from the National Radiation Protection Institute, on 25 August the government authorised Minister for Agriculture Svante Lundkvist to invite a special investigator to review the radiation protection legislation. The Judge of Appeal (and later Chief Judge) Bengt Eliasson (1932-1996) was then appointed to be investigator. Deputy chief physician Eric Jannerfeldt, Departmental Director of the Radiation Protection Institute Enn Kivisäkk, Head of Division Lennart

Rinder, ombudsman Bo Tengberg, ombudsman Erik Wångby, and Judge of Appeal Rutger Öijerholm were appointed as experts. Head of Division at the Radiation Protection Institute Lars Persson was also appointed to be expert and Judge of Appeal Mats Jender to be the investigator's secretary. The committee assumed the name *Committee for the review of the radiation protection legislation*. It submitted its report, *New Radiation Protection Act*, in 1985 (see also Section 22.2).

17.15. **Olof Hörmander succeeds Lars Nordström as head of the Nuclear Power Inspectorate**

I had been asked by the Ministry for Industry whether I might recommend anyone to become the new head of the Nuclear Power Inspectorate once Lars Nordström had retired. I proposed Lars Högberg who had been Chief Engineer at the Swedish Defence Research Establishment but was now head of the main unit for investigations at the Nuclear Power Inspectorate. Lars had made valued contributions as Secretary of the Energy and Environment Committee and for the Reactor Safety Commission. However, the Ministry appeared to think he was too young or unproven and instead appointed Research Director of the Johnson Group Olof Hörmander, who was well qualified in administrative terms. But Lars Högberg ended up taking over from him anyway, in 1989.

17.16. **Ambretta Beninson dies**

One late day September as I was sitting cleaning lingonberries at our summer cottage in Västerdalarna the telephone rang. It was David Sowby with a sad message. Ambretta Beninson had died. In addition to the grief at the loss of a good friend, we discussed what the death would mean for Dan. He was a pretty impractical person so how would he manage? I personally was very depressed by the message and could not sit indoors any longer. I walked over the ants into the forest and tried to pay my respects in memory of Ambretta.

17.17. **EEC radon meeting in Anacapri**

On 3-5 October 1983, the EEC arranged a radon problems conference in Anacapri. I took part and travelled to Naples by train and continued from there by boat to Capri. It was a short walk from the railway station down to the harbour. My American colleagues John and Naomi Harley, who also took part in the conference, later said that they had lost a suitcase while walking. They had asked an obliging man at the railway station to help them to carry the heavy case down to the harbour. He walked quickly in front of them down the hill, faster and faster. And faster - until he disappeared behind the corner of a house and with him the suitcase.

Also on the boat were André Bouville and his beautiful, intelligent wife. They were also saddened when I told them that Ambretta Beninson had died. From the boat we saw the road from the harbour up to Anacapri on the almost six-hundred-metre-high Monte Solaro. The roadway appeared to be firmly fixed to the steep rock face like a long balcony and I asked myself whether it really could carry motor vehicles. Thankfully it did.

The hotel was not far from Axel Munthe's Villa San Michele. The guests included several Swedish colleagues, primarily Gun Astri Svedjemark who welcomed the fact that the problem with radon was starting to arouse international attention. Naomi Harley was perhaps the leading American radon scientist at the time. She and John were also quite dismayed when I told them of Ambretta's death. Would Dan get over the loss?

I experienced several other risks in addition to the journey along the rock face. The programme included a trip to the top of Monte Solaro. We were taken there by cable car over the vineyards where sharp stakes produced uncomfortable feelings when viewed from above by those who could imagine being impaled if they fell. Right up on the flat mountain top I experienced the biggest number of snakes I had ever seen. On the way back down the mountain the snakes appeared regularly. I thought about the difference in the risk environment compared with my safe homeland and considered how different perceptions of risk could influence one's view of radiation protection.

17.18. **The ICRP Main Commission in Washington DC**

The ICRP Main Commission met in the big Pan American Health Organisation building in Washington DC on 10-14 October. I was nervous before the meeting with Dan Beninson, the first meeting since Ambretta's death. I had managed to get undressed and was sitting in my pyjamas on the bed in my hotel room when Dan rang the door. It was a sad meeting. Dan said that the letter I had written to him after Ambretta's death had touched him more than I might have intended. He now wanted me to get dressed and accompany him to the hotel bar for a cup of coffee, his life drink. While walking along the hotel corridor he turned around the DO NOT DISTURB notices that had been posted on some of the doors so that the text instead read PLEASE MAKE UP ROOM. It was a manifestation of defiance and desperation. Dan was sometimes a big child.

At the ICRP meeting I hired a car and David Sowby, Dan and I went on short trips during our free time, including to the Luray Caverns, an impressive, colourful grotto complex. When David had left Washington, Dan and I went on a drive to Annapolis. There was a great deal of grief because of Ambretta and it affected the whole of our trip. What was actually an uninteresting account of our visit, written that same evening, does reflect a certain ambience, though, which might be worth recounting:

> When David had left, Dan and I drove the rental car to Annapolis, which was a day trip. ... We found Main Street and book shops that were open even though it was Sunday. ... We wandered down Maryland Avenue out towards the US Naval Academy and found time to browse a poorly-arranged museum just before it closed. Before this we had visited State House and found that Annapolis had been the capital city of the United States from 26 November 1783 until 13 August 1784 and so was once the site of the Congress. We found the site of the Michelson-Morley experiment, visited the church at the Naval Academy and wondered back towards the water. ... Asked where the city's best fish restaurant was, were pointed in the direction of Green Street, tried a vending machine, asked again, got new directions, looked but did not find anything good. Ate at a restaurant at Market Space on Main Street, not that good. Dan in a reasonable mood despite having lost Ambretta.

17.19. **ICRP/ICRU at the Cosmos Club**

The joint ICRP/ICRU 'Quality factor in radiation protection' task group met on 17-19 October, this time at the Cosmos Club in Washington DC (see Section 15.1 for the group's assignments).

17.20. **Jack Valentin comes to the Radiation Protection Institute**

Jack Valentin was recruited to the Radiation Protection Institute by Gunnar Bengtsson in spring 1983 and Jack started his assignment in the autumn. This is what he said to me about it:

> As far as I understand it, before my time there were three heads of division, for administration, research and supervision. The head of supervision was in charge of non-ionising radiation, personal dosimetry, x rays and the Nuclear Physics Department where, according to what I've been told, the latter also included nuclear power, which must have become an enormous cuckoo in the nest of course. Gunnar succeeded in obtaining permission from the government (oh, the good old times!) to divide the supervision into nuclear energy supervision and general supervision (with the latter-mentioned four units where Nuclear Physics was now a more modest group), to which I was recruited in spring 1983 and started in early autumn of the same year. At the same time, C. G. Junback was recruited as head of administration. C. G. could be rather coarse if necessary... and surely he did some good while he was at the Radiation Protection

Institute, but there was more than one person who probably also thought how nice and relatively quiet it was when he moved on to new hunting grounds.

Jack Valentin, newly employed at the Swedish Radiation Protection Institute in 1983. Photo: Bo Lindell.

Under me were mainly the head of x rays, the knowledgeable, loyal and really nice Sten ‘Grappo’ Grapengiesser who would have liked my job but did everything to help me get on top of the job, form contacts, etc. Nuclear Physics was led by the very clever and helpful Ingemar Malmström who, after a while, was succeeded by the even cleverer and even more helpful Gunilla Hellström, Non-Ionising Radiation was led by Enn Kivisäkk who was a driven man of action but not necessarily a supportive rock for the head of division to lean on, and Personal Dosimetry was led by Albert Kiibus, a paragon of loyalty and an enterprising prankster but not exactly prone to sophisticated argumentation when it came to the essence of radiation protection. In 1988 we heads of division were made heads of department, a way for Gunnar to increase our pay and keep up with the Joneses at the Nuclear Power Inspectorate, but it was no organisational change in itself.

See also the organisational chart in Section 18.14.

17.21. **The ISR's Executive Committee in Chicago**

In November, the Executive Committee of the International Society of Radiology (ISR) met in Chicago at the same time as the huge American Congress of Radiology. As departing Chair of ICRP in 1985, I was obliged to discuss the Commission's work with the Executive Committee. When I arrived I saw one of ICRP members, Professor Takahashi, on the bus from the airport, but I did not see my friend Curt Lagergren who was meant to take part in the Congress. In Sweden, his taxi had flipped over at the motorway exit towards Arlanda Airport; he was unconscious for a while and missed the plane but flew to Chicago later. I stayed at the University Club of Chicago and visited Lauriston Taylor at his hotel to get advice. His amiable wife, Robena, was an excellent watercolour artist.

17.22. **The OECD/NEA in Paris**

The OECD/NEA's Radiation Protection Committee, CRPPH, met in Paris on 15-17 November. I stayed at the *Hotel ETAP Saint-Honoré*. The Committee reviewed my report on collective doses and decided it should be published as an NEA consultation report. It was published in 1984 under the title *Concepts of Collective Dose in Radiation Protection*.

17.23. **Ringhals 4**

Sweden's tenth full-size nuclear power reactor, Ringhals 4, was brought into commercial operation on 21 November once the damaged steam generators for Ringhals 3 and 4 had been modified.

17.24. **Consultant for IAEA**

From 30 November - 1 December I was consultant for IAEA in Vienna 'to discuss preparation of review of Radiological highlights throughout the world during 1983', i.e., to help to write their annual safety review.

17.25. **With Takahashi for funding for ICRP from Sasakawa**

I was invited to Japan to give a presentation at a radiology conference but the main purpose of my visit as Chair of ICRP was to attempt, along with the Japanese ICRP member Professor Shinji Takahashi, to make contact with the notorious industry magnate Ryoichi Sasakawa to cajole some money for ICRP's activity. In the previous year, Sasakawa had set up the annual Sasakawa Prize for important achievements within environmental care. The prize total was 200,000 dollars so Sasakawa had plenty of money but he was difficult to reach. I made notes about what happened.

Monday 5 December 1983

> Went with Takahashi and Dr. Koga to visit *Professor Kentaro Tagaki* who is a member of The House of Councillors and has advised Takahashi regarding the Sasakawa affair. Tagaki is an older, wise man who has been Professor of Pathology. He advises against meeting Sasakawa face to face.
>
> Ate lunch with Takahashi and Koga and *Professor Masao Kaneko*, head of radiology at Hamamatsu University and Deputy Chairman of the conference's Programme Committee, a talkative and extrovert person. The quieter *Hideto Kamagawa*, a thin man, Director of the Atomic Power Department, Chubu Electric Power Co. and a small, animated *Hisashi Kaneda*, head of radiation protection at the same company, were also there.
>
> *Ms. Tomoko Kusama* (K'sama), very small and in her 40s, guided me to Shinkansen in Tokyo.

Tuesday 6 December

> Visited the Nuclear Safety Bureau within the Science and Technology Agency with Takahashi (and the guide). First met *Gen-Nosuke Satoh*, head of the Radiation Protection Division, and we then both met with the Nuclear Safety Bureau's Director General *Eiick Tsuji*. Satoh had been the contact person between Takahashi/Koga and Tsuji. Tsuji had worked on the former Director of the Japan Shipbuilding Industry Foundation, who had been prepared to present ICRP's case to Sasakawa, but who had suddenly died. Tsuji then had to go back to the beginning with acting Director *Masaaki Usuki* who was not familiar with the case. We spoke to Tsuji for half an hour and he was positive towards the matter and wanted to continue working on Usuki. It was not yet the right time to talk to Sasakawa who was a strange man who found it easy to make decisions – if he were negative at an early stage, the whole matter was dropped.
>
> We travelled from there with Satoh and two of his colleagues to the Japan Shipbuilding Industry Foundation where we were received by *Takeju Ogata*, head of International Affairs Division. We were shown into the powerful Usuki's meeting room and, after waiting a while, Usuki himself came along, courteous but slightly sceptical. Why don't all countries pay for ICRP if all countries use ICRP? he asked. Why can't WHO or IAEA provide for ICRP's expenses? Etcetera.
>
> Takahashi spoke warmly of ICRP, and the discussion, to which Usuki had initially said he could not allot more than a short time, lasted for one and a half hours (from half past four until six). 95 per cent of it was conducted in Japanese. We then expressed mutual appreciation. Takahashi was very pleased.

ICRP eventually received money from Sasakawa, without terms or conditions. I had told Takahashi that I was thinking of leaving ICRP. I remember his reaction, which moved me so much that I made a note:

> Professor Takahashi spoke slowly and seriously. His voice was gentle and friendly.
>
> 'It's sad that you're leaving ICRP,' he said. 'You have the capacity to listen and understand other people's points of view and to be calm and friendly. It is an unusual trait but one which we appreciate, we, who for linguistic reasons or because we belong to another culture, have difficulty making ourselves heard. We feel that you make an effort and try to take things into account. That is unusual.'
>
> 'Doctor Beninson also has that ability,' I said. 'He's also a friendly man and he listens.'
>
> 'Yes,' said Takahashi, 'that's true.'
>
> He laid his hand on my arm and looked at me in a friendly but melancholic way.
>
> 'It's sad that you're leaving ICRP,' he repeated gently, slowly shaking his head.
>
> A month later I received a telex from David Sowby about an ICRP affair with reference to Takahashi. He called him only Shinji in the telex and a shiver went through my body. That informality was fully in line with our western social habits but grated on my ears like a sacral dissonance, a blasphemy, a wolf whistle during a tea ceremony. Shinji Takahashi, the gentle man who had met the Emperor and who was president of Japan's largest cancer clinic, *Takahashi-sama sensei*, revered and respected. I detested the idea of calling him Shinji. Such chumminess might perhaps also be seen as a sign of appreciation – but not in the eyes of the Japanese.

17.26. **IAEA on doses of radiation from an international perspective**

In December 1983 I chaired a meeting regarding an 'international alpha' i.e., an attempt to achieve international agreement regarding a value for how much in the context of radiation protection it could be reasonable to pay per man-sievert if collective doses of radiation were reduced. We failed to reach any such agreement but did succeed in agreeing on a minimum value for doses of radiation to be reduced to outside one's own country. It was a great step forwards. The result was published in 1985 in IAEA's

Safety Series no. 67.* The intention was to prevent any country from placing low emphasis on doses of radiation outside its own country's limits to transfer the larger share of the collective dose to other countries, through emissions taking place from tall chimneys, for example.

I stayed at the Astoria Hotel and was for a few days after the meeting returned to being consultant for IAEA to continue to help write their annual safety review.

17.27. **Fuzzy sets**

In the 1980s a new concept was spread, namely the theory of fuzzy sets. A scientist who published a large number of reports on how the concept could be applied, among other things in safety analyses at nuclear power plants, was the Japanese *Yasushi Nishiwaki*. Nishiwaki was an eccentric professor who achieved the feat of being an official at IAEA in Vienna while having a professorship at home in Japan. He had been noticed by Karl Morgan when IRPA was being formed and was a member of its board for a long time. I recounted his activities in connection with the examination of the *Fukuryu Maru* ('Lucky Dragon'), the fishing vessel that was contaminated with radioactivity, in 'The Labours of Hercules'.

So, what is a 'fuzzy set' and how can it be used? Well, there are numerous occasions when we use adjectives or measurement words which do not have a scientific precision. How should they be handled in calculations where we are used to having exact values for the constituent parameter? When we need to state a person's height in a calculation we can either imagine a given person with a well-defined height or a person of average height. In both cases we can add in a numerical value. But how do we deal with a 'tall' person? The adjective 'tall' is not associated with a specific measurement value and we cannot simply write 'tall' in our formulae. 'Tall' is a fuzzy set. We can carry out a study where we ask how tall a man needs to be in order to be referred to as 'tall', i.e., to be included in the 'fuzzy set' labelled 'tall'. The study will show that it is not a matter of a 'clear' value but that the responses (in Sweden) are distributed over a very low frequency for the values around 160 cm while almost everyone would call a man of 190 cm in length tall.

> I concocted a program for identifying mushrooms based on fuzzy sets. When using an ordinary examination table to try to find a mushroom which you have picked, you often find a hierarchical order; you are expected to answer 'yes' or 'no' to a number questions. If you answer wrongly you are out of the game. Instead, I created a table where every row represented a type of fungus and the columns represented 30 or so characteristics. Each characteristic was indicated by a digit corresponding to a colour or a measurement, for example. When I wanted to determine what a picked mushroom was, I encountered a number of questions where I had to state as many of the 30 characteristics as possible using the same numbers. I could then get the computer to compare my search line with each and every one of the many hundreds of lines in the table If it found a table line that was identical to the search line, the search was almost over. But the system picked up points even if a characteristic was not completely the same on the search line and one of the lines in the table. I could, for example, gain points, although fewer, if I had answered 'red' where a table line said 'orange', or if I answered '8 cm' where the table line said '10-12 cm'. I was rarely completely rejected but obtained more points for the table lines where I was close to 'result' for the characteristics. I was working with fuzzy sets. The computer listed the species that collected the most points and gave a warning if the fungus was poisonous.

* Assigning a Value to Transboundary Radiation Exposures (IAEA, 1985).

18. THE YEAR 1984

18.1. The arrival of computers

In the Haga Court of Justice where I sat with the Swedish Radiation Protection Institute's nuclear power inspectors we had terminals to a central computer, a VAX. We could perform calculations and see the result on the screen but if we wanted a printout, that was on large, fan fold paper with perforated margins. Many of us had experienced programmable pocket calculators such as different Sharp models. At the time they were thought to be so valuable that I was prompted to keep my pocket calculator at the Radiation Protection Institute chained to a radiator. 'Microcomputers', as personal computers were then called, were still primitive and had no monitor; you used your TV for that purpose. Data was stored on tapes and storage was an erratic procedure.

There was great progress at the start of the 1980s when it was possible to replace the tape recorder with diskettes which could be inserted into special disk drives. There were two types of diskette, a smaller 'hard' and a larger 'floppy' disk. There was great progress at the Haga Court of Justice when I was given a free-standing personal computer with a permanent internal hard drive which held a full 5 megabytes (MB) of information. You may compare this with the computer with which I am writing the present text. Its hard drive holds 300,000 MB and the storage space increases considerably for each new model.

The emergence of personal computers meant a drastic change to work procedures. Not only could you use the computer keyboard to write texts that could be read on the monitor, stored on the hard drive, printed out using a personal or a central printer and archived on diskettes, you could also 'word process the text', i.e., undo keystrokes, delete or move bits, change the typography and insert diagrams and images. It also became possible to search for words in the text, which was a fantastic help. At one time there were special computers for word processing, i.e., dedicated word processors (which the Secretary of UNSCEAR used for a long time), but soon the ordinary personal computer had taken on the task at the same time as being able to perform calculations, store databases and entertain the user in various ways. The arduous tasks of the clerk were at an end. Women (since it had been women) now no longer sat typing from dictation or manuscripts. The various administrative officers, initially mainly men, no longer wrote drafts to be copy-typed - they wrote things themselves on their computers. Mainly because they thought it was fun. A real revolution.

In March 1984 I completed an internal information letter 'Computer ABC', to assist my colleagues, which now makes for an amusing read about the old times. Things developed in a flash.

18.2. Sievert's papers and the national archive

After Sievert had died we faced a practical problem when it came to the papers he had left behind – letters, reports, instrument drawings and much more. I had received a letter from university libraries in Japan and the USA enquiring about Sievert's letters and primarily his construction diagrams for different types of measurement instrument. They wondered whether we could share these historically-valuable documents. In response I had said that we intended to submit the most important material to the national archive, the securest storage place we could think of for the future.

Sievert had left behind large quantities of paper. They were temporarily stored in the high voltage hall; temporarily since no-one had time to spend sorting out the most important documents.

It was not until the 1980s that anything happened. I had retired in 1982 and been succeeded by Gunnar Bengtsson. Like me, Gunnar realised that the piles of documents contained documents that were of value, but he was also aghast at the Radiation Protection Institute's archiving system, or rather lack of archiving system, so he employed an archiving expert, *Helena Welin-Berger*, on 1 January 1983 to sort out the Institute's archiving procedures and system, and it then seemed natural to also tackle Sievert's mountains of papers. Gunnar asked me and Bengt Håkansson, who had been Sievert's colleagues for so many years, to help roughly sort through the documents.

And so, one day in 1984 I stood with Helena and Bengt before a good number of cubic metres of documents. We were to decide what was valuable enough to be archived and what could be discarded. Most of the papers fell into the latter category for the simple reason that Sievert had been in the habit of taking many copies of each document, sometimes up to 50 or 100 copies. I took the opportunity of saving for myself copies of documents that I thought would be of interest in any historical description. I also kept some material which I thought was of interest in the cultural historical sense but which Helena did not think were worth saving. We still ended up throwing away cubic metres of paper. The document which concerned the Radiation Protection Institute's and the former Radiation Protection Board's and the Institute of Radiophysics' exercising of public authority went into the Institute's own archive. Some documents were sent to the Swedish Defence Research Establishment and a series of reprints was submitted to the Academy of Sciences. The ones that concerned Sievert more personally, scientific correspondence, instrument drawings, etc., things which Gunnar and I thought were particularly valuable, were sent to the National Archive for secure storage. However, the Institute of Radiophysics' archives do contain some diaries, lectures, drawings, Sievert's draft of address to the UN, notebooks, invitations, etc.

In March 1985, Helena got a job at the National Archive. Immediately afterwards, news came to the Radiation Protection Institute that Sievert's documents had disappeared. When Helena checked to see what was happening, she found that this was correct. What in our eyes had been the valuable documents had been thrown away. One rumour said that a summer temp had seen mountains of paper and thought it was rubbish. All of the material had been destroyed, possibly burned.

This *faux pas* is perhaps best described with quotes from three relevant documents. The first is Gunnar Bengtsson's letter to the National Archive on 10 May 1984:

> On this day, the National Radiation Protection Institute has submitted to the National Archive a gift in the form of the sections of documents left behind by Professor Rolf Sievert which are not stored in the Swedish Radiation Protection Institute's archive.
> Gunnar Bengtsson
> Director General

Head of Section Ingemar Carlsson at the National Archive expressed thanks for the gift in a letter of 18 May which was worded as follows (case no. 907/J1):

> The National Archive has received PROFESSOR ROLF SIEVERT'S personal ARCHIVE (6 transport carts) as a gift by delivery from the National Radiation Protection Institute, which is hereby recognised by the Archive.
>
> At the same time, the National Archive would like to extend its thanks for entrusting [us with] the storage of this evidently valuable and interesting research archive for future research.

However, the National Archive's records overview contains the following information:

> Sievert, Rolf, Professor of radiophysics, Stockholm (1896—1966)
> ---
> His archive was submitted as a gift in 1984 by the National Radiation Protection Institute on 6 transport carts. It disappeared from the NA's warehouse through circumstances which were never clarified before they had been packed up and have never been recovered.
> ---

For a good number of years I was plagued by the fear that Sievert's widow, Astrid, would find out about the *faux pas*. She was very particular about Rolf's memory being respected and would have taken great offence had she found out what had happened. I was glad that I had saved some material by setting copies aside. For the time being.

18.3. **The radiation accident in Mohammedia**

A radiation accident involving several deaths occurred in Mohammedia in Morocco. The following summary is given in the 1988 UNSCEAR report:

> A source of iridium-192 used to make radiographs of welds at a construction site became detached from the take-up line to its shielded container. The source dropped to the ground and was noticed by a passer-by, who took it home. Eight persons, an entire family, died from the radiation overexposure with doses of 8-25 Gy.

18.4. **IRPA in Berlin**

IRPA held its 6th international Congress in Berlin on 7-11 May, organised by the German member society of IRPA, the *Fachverband für Strahlenschutz*, and with the subject of 'Radiation - risk - protection'. On arrival, I had a bit of trouble finding Dan Beninson in the big city; we were to appear at the plenary meeting alongside Jammet, Pochin, Silini and Sinclair.

More than 1000 persons attended the congress. Sir Edward Pochin gave the Sievert-lecture, entitled 'Sieverts and Safety'.

18.5. **ICRP in Stockholm**

ICRP and its Committees met at the Birger Jarl Hotel on 14-24 May. I discussed the choice of Committee Chair from 1985 with Dan, John Dunster and Charlie Meinhold (Warren Sinclair was not yet a member of the Main Commission). I had explained that I wanted to leave the Commission to offer room for new abilities. One condition was that Dan would succeed me as Chair. John had drawn up a list of ten possible combinations. Two of them included Gunnar Bengtsson as conceivable Chair of Committee 2, but John's first choice for Committee Chairs were Warren Sinclair, Charlie Meinhold, Julian Liniecki and himself for Committees 1-4 respectively. He suggested Henri Jammet as Deputy Chair. We agreed to put forward his proposal to the Commission when it was time to decide on the new composition of the Main Commission.

On 16 May, everyone was invited to dinner as guests of the government in Rosenbad. Astrid Sievert was also invited, which moved her so much that she wrote to me that it was not even in her power to say thank you. Gunnar Bengtsson presented himself to her as one of the grandchildren of Rolf Sievert's generation. On 22 May, Marrit and I had the Main Commission at home for a simple meal. On another day, host Curt Lagergren had arranged a dinner for the Commission at the Swedish Medical Association's premises on Villagatan. Professor Takahashi had his daughter as companion. Dr. Michael Thorne was also there, who took part in the meeting so that he could later go on to succeed David Sowby as Scientific Secretary of ICRP.

18.6. **The RAPAT idea**

At the ICRP meeting in Stockholm, the two Chinese Committee members Wu Dechang and Wei Lüxin contacted me, Dan Beninson and David Sowby and wondered if we were willing to travel to China again to give lectures about ICRP (we were Chair, Deputy Chair and Secretary of the Commission at the time).

In response we said that it could well be conceivable but that we saw no way of being able to finance the trip. The Chinese were prepared to pay the expenses within China, but not for the trip there.

Because time was passing and we had not heard anything further, we thought the matter had been forgotten about and once the summer was over we no longer though the trip to China would be on. However, at the end of September we suddenly received an invitation from the Chinese Medical Association to come to China from 19 November – 2 December. However, the matter of the travel expense had yet to be solved.

However, in the meantime, Abel González had made it clear that IAEA could pay our travel expenses if the Chinese requested this. The difficulty was that the Chinese Medical Association was not an organisation that was in contact with IAEA, so it was necessary for someone in China to agree to contact IAEA through the usual channel, the Ministry for Nuclear Energy.

On 5 October I wrote on behalf of ICRP to the Chinese Medical Association, saying that my two ICRP colleagues and I were willing to come in principle, but that we had not succeeded in solving the travel expense problem. I added that contact with IAEA could perhaps solve the problem if we could travel as consultants for IAEA.

The weeks went by without anything happening, but it turned out that Dr. Wei came to Vienna for a meeting so direct contact could be arranged between him and González. Wei contacted the Chinese IAEA Embassy with which González had direct contact in this connection. It turned out that the Ministry for Nuclear Energy had now been informed.

This led to González being able to submit a proposal on 24 October to Director General of IAEA Hans Blix through the head of the IAEA Department of Nuclear Energy and Safety, Professor Konstantinov, that Beninson, Lindell and Sowby travel to China as consultants for IAEA.

On 24 October (speedy handling!), Konstantinov sent me an invitation, saying that China had requested a 'RAPAT' visit by us three. After having consulted my colleagues, I responded to this letter on 1 November. However, what was 'RAPAT'?

Dan Beninson and I happened to be in Vienna when González acted; we took part in a panel of experts for the International Maritime Organisation (IMO) regarding the interpretation of the London Convention on Ocean Dumping*. González then told us about IAEA's latest idea, called 'RAPAT' (stands for Radiation Protection Advisory Team). The proposal for RAPAT had been put forward by the former head of Argentina's Atomic Energy Commission, Admiral Castro Madero and the head of the Canadian Atomic Energy Control Board, *J. H. Jennekens*.

Castro Madero and Jennekens had highlighted the need for inputs from consultants where the total radiation protection situation in a country was to be reviewed, sources of radiation were to be charted, the organisation looked at, etc. Everything at a high level so that the consultants could finally give advice on how the country could best obtain assistance from IAEA.

Since Hans Blix had approved the RAPAT idea it was given very high priority. Preparations for the trip, travel routes, tickets, etc. were handled at a previously-unseen speed; more was carried out in a few days than what would normally have taken months at the otherwise not particularly efficient IAEA.

And so the question of the travel expense was solved, but new problems may have been created instead. The invitation from the Chinese Medical Association had concerned a number of presentations at seminars in Beijing (Peking) and Shanghai, but the RAPAT assignment would give us other tasks altogether. Would the original hosts be offended? Would we really have the time and resources to carry out the RAPAT assignment for us to be satisfied with our input?

I shall talk more about the visit to China below (see Section 18.19).

18.7. UNSCEAR's 33rd session in Vienna

UNSCEAR met in Vienna on 25-29 June for its 33rd session. Dan Beninson was Chair with Professor Kumatori as Deputy Chair and A. Hidayatalla as rapporteur.

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* The first Convention (1972) on terms for dumping waste at sea was *Oslokonventionen* [the Oslo Convention], although this applied only to the Atlantic and the Arctic Ocean. It was followed by the *London Convention*, which covered all oceans and was written in London in 1972 to become valid in 1975.

When I had proposed the composition of the Swedish delegation to the Ministry of Foreign Affairs I had reminded people that the Committee would now be starting a new production period. I wrote:

> The 32nd session was a planning meeting which established the plans for drawing up a new extensive report for the UN's General Assembly. UNSCEAR's task is to compile facts about levels of radiation and effects of radiation and to report its conclusions. Up until now, this has taken place in eight extensive reports (1958, 1962, 1964, 1966, 1969, 1972, 1977 and 1982). While the first the report (1958) was approx. 230 pages, the last three reports have covered approx. 700 pages each [all in closely-printed, two-column A4 format]. A summary of these is what is presented to the General Assembly.
>
> The work with each of the last two reports has lasted 5 years since the publication of the previous report. This would indicate a new report for 1987*, which is probably a realistic estimate; the report that is now planned will by all accounts be just as extensive as the three latest.

I had retired from my job as head of the Radiation Protection Institute but was still Sweden's UNSCEAR representative. However, I had notified the Ministry for Foreign Affairs that I ought to step down as representative following the current production period and proposed that I should be succeeded by the person who succeeded me as DG of the Swedish Radiation Protection Institute, Gunnar Bengtsson. Bengtsson had declared that, due to urgent work assignments, he still did not want to be part of the Swedish delegation, but I had proposed that he ought to be given the opportunity of being involved in the delegation at the end of the current period in order to gain experience of the work before starting as representative, which he would do at the 37th session.

For the 33rd session, the Ministry for Foreign Affairs had approved a relatively large Swedish delegation. As before, Gunnar Walinder was the representative's deputy and, as before, the Ministry for Foreign Affairs also paid for the participation of Kay Edvarson, K.-G. Lüning and Jan Olof Snihs. But in addition, at cost to the Radiation Protection Institute, Assistant professor Lars-Erik Holm, *Karolinska sjukhuset* (the Karolinska University Hospital), Professor Sören Mattsson at Gothenburg University and head of division Jack Valentin of the Swedish Radiation Protection Institute, also took part for the first time.

The Committee continued its work to the same work procedure as before. When the entire Committee meets without the formalities of the introductory and concluding plenary meetings it usually calls itself the 'task group', despite the fact that the whole of the Committee meets up. The task group meetings usually take no more than one day. Most of the time, the Committee met as three sub-groups – a biological and a physics 'sub-group' and a genetic 'sub-sub-group', the latter-mentioned a spin-off from the biological sub-group.

I was chosen to be Chair of the physics sub-group, a task that was usually given to Beninson but that he could not undertake because he was now Chair of the entire Committee. Chair of the biological sub-group was the American representative, radiologist Bob Moseley, and Chair of the genetic sub-sub-group was the Indian representative, K. Sundaram.

The following can be quoted from the report Walinder and I wrote for the Ministry for Foreign Affairs about the meeting:

> It may be worth mentioning that the 1982 UNSCEAR report did not contain a section about the risks of cancer to humans. The reason was that the estimate of the doses of radiation to the population in Hiroshima and Nagasaki following the 1945 bombs had recently been revised and that the new results had not yet been verified. The observance of the incidence of cancer among the survivors in the two Japanese cities is one of the most important sources of our knowledge of the risk of cancer from ionising radiation.†

* The report was published in 1988.

† See also the ICRP meeting with its Committees in Como in Chapter 21.

> At the meeting, the Committee finalised a work document on the dose-response relationship for radiation-induced cancer. However, over the next two years the currently-ongoing studies of doses of radiation and the incidence of cancer in Hiroshima and Nagasaki are expected to make such important contributions to our knowledge of the connection between doses of radiation and the incidence of cancer that additions will be necessary.
>
> The consultant (Lars-Erik DeGeer of the Swedish Defence Research Establishment), who had written the work document on the nuclear charge explosions and the military nuclear fuel cycle for the Secretariat, had difficulty obtaining material to highlight the later activity. For example, the French representative was willing to provide an account of the French circumstances but only if other nuclear weapon powers were prepared to provide the corresponding information. The Committee may have to be content with a short report in this regard, based on the military use of uranium and plutonium production which can be inferred by measuring the quantity of krypton-85 in the atmosphere.

Frau Holzer, who had a weakness for titles, looked up to Lars-Erik DeGeer as a baron; even ‘Professor’ was an asset in that respect. For Dan Beninson, who had none of these assets, she showed deep respect and affection because of his dominant personality. She cared about her favourites and was anxious when we had booked rooms at a hotel which was not worthy enough in her view. When she found out that Abel González (like Jan Olof Snihs) was staying at the Hotel Wandl near Graben, her despondent words to Dan were: ‘Dr. Beninson, do you really think you should mix with people who stay at the Hotel *Wandl*!?’

18.8. **Infrared radiation**

Infrared radiation (IR radiation) is the same as heat radiation, an electromagnetic radiation with wavelengths of between 0.75 µm and 1 mm that is warming but invisible to people. It is emitted when the atoms in a body vibrate from heat and therefore increase with the temperature. In terms of energy, the radiation from the sun is half made up of heat radiation and a normal light bulb emits 95 % heat radiation rather than visible light.

18.9. **Infrared radiation and cataracts**

A doctoral thesis by ophthalmologist *Eva Lydahl* showed the connection between heat radiation and cataracts. Lydahl and physicist *Anders Glansholm* had been able to demonstrate that glass workers who were exposed to heat radiation ran a greater risk of cataracts in the eye that was exposed the most. The observation aroused international interest. Glansholm had come to the Radiation Protection Institute from *Sahlgrenska Sjukhuset* (the Sahlgrenska University Hospital) in 1979 via *Karolinska institutet* (the Karolinska Medical University) where he worked with Björn Tengroth. Initially he worked on standards, but from 1981 he went into the section for non-ionising radiation.

18.10. **Radiation from computer VDU monitors**

A 20-page information leaflet on radiation from computer screens was issued by the Radiation Protection Institute in September 1984 from which the following can be quoted:

> The usual computer monitor (video display unit) has been developed directly from TV technology. Older computer monitors are very like ordinary TV screens. Modern designs have to some extent broken away from TV technology as regards the number of lines per picture and the number of pictures per second. However, the basic principle is still the same in most cases.
>
> A TV picture is made up by an electron beam whose current can be varied sweeping in a cathode ray tube over a screen which emits light in proportion to the current. The

> beam sweeps horizontal from left to right in 64 microseconds. At the same time there is a slower, vertical sweep which takes 20,000 microseconds. A complete 625-line TV picture is formed during two such periods.
>
> ...
>
> The electron beam is usually deflected by magnetic means. There are two coil systems around the neck of the cathode ray tube. In the coils, currents are driven which vary over time with a frequency (for normal TV) of 50 Hz for vertical deflection and approximately 16 kHz for horizontal deflection. Computer screens use frequencies in the region of 50-120 Hz and 15-60 kHz respectively. The current in the deflection coils can amount to no more than a few amperes. The external magnetic fields are generated largely by these currents. You also get a certain contribution to the magnetic fields from the high voltage transformer. There is no easy way to shield against the external magnetic fields. Metal cases do provide partial shielding.*
>
> ...
>
> The currents and voltages that occur in the electronic circuits of a computer screen can also generate fields outside the device. These fields contain sections that have different frequencies. The highest frequencies can be up towards 1000 MHz. These fields are very weak and cannot be measured using radiation protection instruments. They are of no significance from the hygiene point of view but they can cause radiofrequency interference and create problems with data security.
>
> ...
>
> The voltage that is necessary to obtain a bright picture for black and white or monochrome cathode ray tubes amounts to 8,000 – 20,000 V and for colour cathode ray tubes it is 20,000 – 28,000 V. ... The high positive voltage on [the thin metal coating over the light-generating layer of the screen] gives rise to an electrostatic field in front of the cathode ray tube. A negatively-charged particle in the air will therefore move itself towards the screen. In the same way, positively-charged particles move in the opposite direction towards surfaces which have a lower voltage than the screen, such as the face of the operator. Such particles are always in the air, in the form of dust for example. ... It is very easy to shield against the electrostatic field using an electrically-conductive layer on or outside the glass of the screen. ...
>
> When the electron beam hits the screen, both visible light and x rays are formed. ... The x rays from the computer screen are strongly absorbed by glass, for example. This is the explanation as to why you cannot measure any radiation outside the device despite x rays being generated inside the cathode ray tube.

The Swedish Radiation Protection Institute's scientists had measured the strength of the magnetic fields around computer screens. Flow densities of 1 μT (microtesla) were measured for the 50-Hz field. Higher-frequency fields had lower flow densities but higher induction of around 50 mT/s. The risks that had been feared from computer screens had primarily concerned foetal injury, mainly due to observations following the exposure of chicken eggs.

18.11. **Approval of KBS-3 [Nuclear Fuel Safety 3]**

'Nuclear Fuel Safety 3' (abbreviation KBS-3 from the Swedish) was approved in 1984 as a conceivable method for final disposal. Until now, the spent nuclear fuel had been stored in a central interim storage installation for spent reactor fuel at Oskarshamn ('CLAB', see Section 19.16). KBS 3 was the final proposal from the Swedish Nuclear Fuel and Waste Management Company (Svensk

* 'Partial shielding' means that the screening is not complete because there always has to be enough holes to be able to see the screen. There actually appear to be few screens that have metal cases. Today (and largely as a result of the Swedish Radiation Protection Institute's measurements that were published in the 1980s), the manufacturers instead insert compensating coils that eliminate the magnetic field which does not end up in the cathode ray tube. Since the birth of TV, the art has been to get the magnetic fields in the right place. It is a matter of design and ambition. Nowadays, practically all screens are called 'low radiation emission'.

Kärnbränslehantering AB, SKB) regarding final disposal in accordance with the Nuclear Fuel Safety project which had started in 1976.

The KBS-3 proposal says that the spent nuclear fuel must be placed in a capsule made of cast iron (in the middle) and copper. The capsule must be embedded in in bentonite clay that is 500 metres deep in the Swedish bedrock. The bentonite is named after the place in which the first deposit was found, Fort Benton in Montana. It also occurs in Sweden. Its advantage is its fluid absorption capacity and the resulting swelling properties.

KBS-3 reckons that the use of four barriers can prevent the radioactive nuclear fuel from leaking out of its storage, i.e.:

1. The fuel itself, which consists mainly of uranium dioxide. The radioactive substances are in the uranium dioxide and remain there unless the fuel is dissolved.
2. The encapsulation of the fuel pellets in copper is assumed to be chemically stable and have a lifetime of 100,000 years.
3. The bentonite clay is packed around the copper capsule in the bedrock so it does not have room to swell if it absorbs fluid. Instead, it then becomes very compact and prevents leakage other than through diffusion.
4. The surrounding bedrock prevents further transport since most of the radionuclides are adsorbed by mineral surfaces.

The place of disposal has still not been selected at the time of writing this.

18.12. **The Act on Nuclear Activities**

The Act on Nuclear Activities (1984:3) became valid on 1 February and superseded the Atomic Energy Act from 1956.

18.13. **Ringhals**

On 23 January, all reactors in Ringhals came into operation. Ringhals was now Sweden's largest nuclear power plant with an electric output of 3380 MW

18.14. **The organisation of the Swedish Radiation Protection Institute**

When Jack Valentin and C. G. Junback had been employed, the Swedish Radiation Protection Institute's organisation was as follows:

BOARD			
Director General *Gunnar Bengtsson*	Secretariat *Lars Persson*	Preparedness Board against Nuclear Accidents	Research Board

MAIN UNIT FOR GENERAL SUPERVISION *Jack Valentin*	MAIN UNIT FOR NUCLEAR ENERGY *Jan Olof Snihs*	MAIN UNIT FOR RESEARCH AND DEVELOPMENT *Kay Edvarson*	MAIN UNIT FOR ADMINISTRATION *Carl Gunnar Junback*
Unit for x ray supervision *Sten Grapengiesser*	Secretariat *Leif Moberg*	Environmental Laboratories *Gun Astri Svedjemark*	Information Unit *Sven Löfveberg*
Nuclear Physics Unit Industry: *Torkel Bennerstedt* Medicine and Research: *Ingemar Malmström*	Unit for Plant Supervision *Åke Persson*	Dosimetry Laboratory *Lennart Lindberg*	Legal Unit *Carl-Gösta Hesser*
	Unit for Waste and Environment Supervision *Ragnar Boge*		Economic Unit *(Acting) Inger Svalstedt*
Unit for Non-Ionising Radiation *Enn Kivisäkk*	Preparedness Unit *John-Christer Lindhé*	Radiation medicine laboratory *Sten-Erik Olsson*	Personnel Unit *Svea Forss*
			Supply Services Unit *Inge Gustafsson*
Unit for Personal Dose Measurement *Albert Kiibus*	Unit for Specialist Supervision [mines, radon, etc.] *Hans Ehdwall*	Research Secretariat *Ulf Bäverstam*	Instrument workshop *Arvid Nyman*

18.15. **John Hursh**

In August we had John Hursh with wife and daughter as guests in our cottage outside Malung, their last visit to Sweden. Both Jan Olof Snihs and I would later visit them in Arizona where they had moved to as retirees. When John died in 2003 I wrote the following obituary:

> Radiochemist, Professor John B. Hursh, died on 19 March, two weeks before his 96th birthday, in Green Valley, Arizona. John became well-known among radiation protectionists in the 1950s when he was the first person to reliably estimate the natural quantity of radium in the human body. There were other scientists who stated much larger quantities, and this discrepancy was the basis for Rolf Sievert taking measurements of the body's gamma radiation to try to determine who was right. It was John.
>
> While active in the University of Rochester's Atomic Energy Project, John played a part in the Manhattan project. I visited him there for the first time in summer 1956 to discuss his measurements of a person's uptake of strontium-90 from the radioactive fallout from the nuclear weapons testing. This started a life-long friendship between us and our wives. During a sabbatical year from 1966-1967, John spent half his time in Stockholm where he examined the uptake of lead from the gastrointestinal tract at the Radiation Protection Institute along with Jan Olof Snihs and Jorma Suomela.
>
> John Hursh was a very knowledgeable but also very modest who loved walking in the mountains and making his own wine. When the winters in Rochester became too severe and the Hursh family's big villa became too laborious to keep up going, John and his wife Lydia moved to Green Valley, a retirement community in Arizona not far from Mexico. Both Jan Olof and I have visited him there. John and Lydia have been to Sweden and picked cloudberries and lingonberries in Västerdalarna every now and then.
>
> John had a long and eventful life so, as his daughters said when they wrote to me about his death, 'we cannot be too sad'. However, all of us who knew John will remember him with gratitude.

18.16. **The CRPPH about ICRP**

On 14 September I had received an invitation from the OECD to take part in a meeting of the CRPPH in Paris on 2-4 October. The meeting would be discussing the relations between the CRPPH and ICRP. I stayed at the *Hotel Nicolo* on *rue Nicolo*.

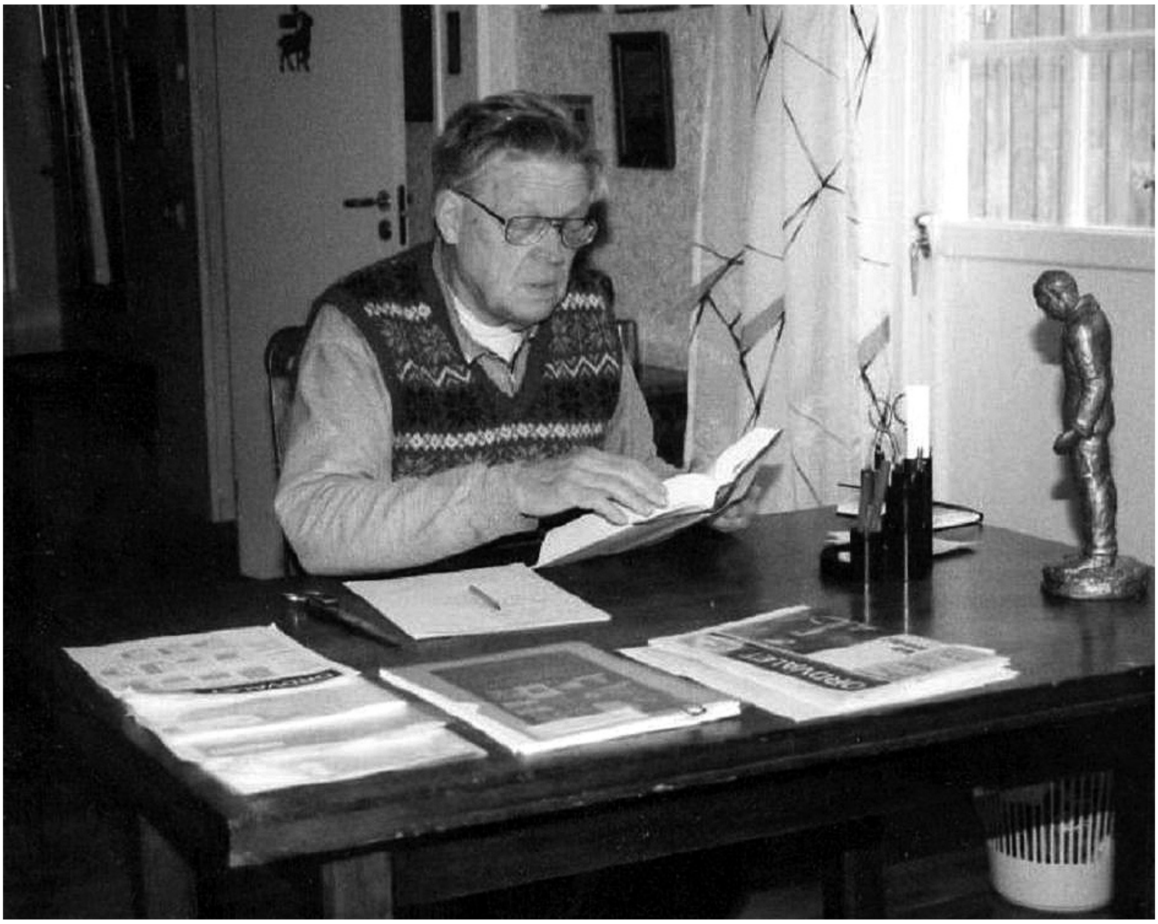
18.17. **The Nordic Society for Radiation Protection's 7th ordinary meeting in Copenhagen**

The Nordic Society for Radiation Protection held its 7th ordinary meeting at *Ingenjörshuset* in Copenhagen on 10-12 October with Per Grande as Chair and Bente Lewinsky as Secretary. Marrit accompanied me and we drove to Copenhagen. We met Kristian Koren and his good-humoured Danish wife Lilli but became anxious about Kristian's health. I had cooperated with him for more than thirty years and valued his composure and friendliness. Like Per, Kristian had been of great help in the Nordic cooperation, but age was now beginning to put obstacles in the way.

Robin Mole talked about the injuries if foetuses were irradiated, Mogens Faber about Thorotrast, Sven Löfveberg about 'Informing an individual person of the threat of a nuclear power accident', Jan Olof Snihs about 'Policy and bases of assessment for waste issues', Ragnar Boge about 'Nordic cooperation within the field of waste issues', Antti Vuorinen about 'Main principles regarding the re-organisation of the Finnish Institute for Radiation Protection (STL) into the Finnish Radiation and Nuclear Safety Authority (STUK)' and Gunnar Bengtsson about 'Time is money – in the cost-benefit analysis'.

18.18. **IMO meeting in Vienna**

A panel of experts for the International Maritime Organization (IMO) on the interpretation of the London Convention on Ocean Dumping met in Vienna at the end of October. The London Convention came out in 1972 as a treaty on the ocean dumping of waste. It became valid in 1975 and was an extension of the Oslo Convention which concerned only the Atlantic and the Arctic Ocean. As usual, the Swedish expert on the waste issues was Ragnar Boge.



Sven Löfveberg at his desk at home.

18.19. **RAPAT in China**

So, it was time for RAPAT's maiden voyage. The tickets to China lay waiting in Vienna. The intention was that we, i.e., Dan Beninson, David Sowby, Petar Strohal and I, would fly to Copenhagen from Vienna and from there go by SAS to Karachi in Pakistan and from there take a Chinese plane to Beijing. After a trip around China we would then fly home from Beijing on a Chinese aircraft to Moscow and from there with Austrian Airlines to Vienna. David Sowby was disappointed that only the distance to Karachi was business class. González was disappointed that David was disappointed – hadn't IAEA put its hand in its pocket and enabled us to travel after all? It eventually proved to be fairly smart to fly home via Moscow as it was probably the least tempting route.

Clothes were something of a problem. We knew from experience that it would be cold in Beijing, but what would it be like in Shanghai? I decided to be prepared for the cold and take a skiing hat and a warm winter coat, but I added a beret and a fold-up plastic raincoat in case the weather was warmer.

González had rung me in Stockholm before the trip and also left a message for me at the Astoria Hotel in Vienna. I was to meet Dan Beninson and David Sowby at the airport and from there take a taxi with them to González' villa for dinner. Both protested about not being able to go to their hotels first, but I bundled them into a car and off we went to González.

Morris Rosen (González' line manager at the time), his colleague Iansiti (head of the IAEA reactor safety section), and Castro Madero were all there with their wives. Also there was the Croat Petar Strohal who would accompany us as representative of the IAEA on the trip.

The next day we travelled to Vienna International Centre and the IAEA's premises where we were given further information by a couple of representatives of China's IAEA delegation. They told us that the visit would start with an introductory meeting in Beijing on Monday 19th November and then 20-22 November would be devoted to 'academic lectures'. Not until then would the RAPAT assignment start.

On Saturday 17 November we flew to Copenhagen to take the SAS plane to Karachi. We were dressed for winter since we would be arriving in Karachi at three in the morning and continuing on to cold Beijing after just one hour. However, we did think that an hour's margin between the planes was unnervingly short. This was verified when the plane made its way to the runway and there was a BANG! The plane just managed to stop before the end of the runway. A bird had been sucked into one of the jet engines. The plane had to turn back to the terminal to have its engine examined. Everything was shown to be OK, but we were one and a half hours late.

This of course meant that we missed the plane in Karachi and had no option but to wait 18 hours for the next plane. We had to walk around in the Karachi heat dressed for Beijing and rest for a few hours at an hotel. We were disturbed at the poverty and misery. Wherever we went we were accosted by beggars who waved their maimed arms or pointed to legs without feet. A crowd of children between five and ten years of age followed us, pulling at our clothes. I gave a small girl a note. She took it reverentially, placed it against her forehead and kissed it. The other children pulled at our clothes with even more gusto. Any person with normal morals would quickly become poor in that environment. This misery is still there even when we are not physically there to see it. Why don't we do more about it?

We landed at Beijing airport at around seven in the morning. A delegation of Chinese had patiently waited for us. Our ICRP colleagues Wei Lüxin and Wu Dechang were there. A towering, grey-haired, round-cheeked, friendly and reassuring man greeted us like old friends. It was of course Li Deping. There were plenty of others whom we were unable to identify at the time. The whole crowd accompanied us to Xiyuan Hotel on the outskirts of the city.

'You must be tired after the long journey,' said Wei Lüxin. 'Go up to your rooms and relax, take a hot bath and sleep for a while and we'll meet here at the reception in ten minutes!'

My description of the visit to China in a letter to John and Lydia Hursh may be worth reproducing since it was written immediately after the visit:

> The visit to China was interesting. It was not as cold as the time before but cold enough due to a lack of heat sources in the buildings. But the Chinese themselves are warm and friendly, although very demanding: 'Go up to your rooms and relax, take a hot bath and sleep for a while and we'll meet here at the reception in ten minutes!'
>
> There has been a tangible change since last time when it comes to the number of new buildings. Building work is going on everywhere. There are now also 'free markets' where the farmers sell some of their own products, and some farmers even have their own cars.
>
> Beijing is still a Chinese Washington with official buildings and plenty of space but little that resembles a normal city. A visit to the Mao mausoleum was very interesting. There are halls, one for each and every one of the revolution's prominent figures with photos and explanatory text (in Chinese) on the walls. You are struck by the lack of political slogans and by the apparently factual presentation. There are photographs that include Mao's wife or Chiang Kai-shek but, so it seems, with no critical comments.
>
> A similar experience awaits the visitors to the heat sources outside Xian where Chiang Kai-shek was captured in 1936 and forced to form a united front against the Japanese. The small building on the mountain slope where Chiang was living at the time still has his workroom and bedroom exactly as they were when he was there. Although Chiang has been the big enemy, the factual presentation and preservation of an historical site appear to be completely without emotion. Discussions even give you the feeling of 'fairness' rather than fanaticism. As regards Mao, several people said approximately the same thing. 'He made a big mistake, but so did we. He approved the cultural revolution.

It was a dreadful mistake. But we followed him because we thought he was superhuman. That was our mistake. He was a big human but a human. Anyway, we will never forget all the good he did'.

To come from Beijing to Tai-yuan and Xian was a great experience. Cities that the majority of Europeans and Americans have never heard spoken about. Each still has 2-3 million inhabitants and is more like 'cities' than Beijing*.

From the IAEA 'RAPAT' mission to China, 1984.
Three of the group members at the breakfast table: David Sowby, Dan Beninson, and the IAEA representative, Petar Strohal.
Photo: Bo Lindell.

In the area between Tai-yuan and Xian there are many of the installations for China's military nuclear weapons programme. The enrichment plant in Lanchou further west is also mentioned in ordinary travel brochures. But the big radiation protection research laboratory in Tai-yuan was mentioned only by the code name North China Radiation Laboratory. until a year ago. It was very competently organised with many knowledgeable scientists.

The terracotta army at Emperor Qin's† grave is worth a trip to China in itself. Up to 6,000-8,000 life-sized soldiers with horses, chariots and weapons, excavated and now protected by an enormous, hangar-like building. Fantastic!

We had a 28-hours train journey from Xian to Shanghai as a variation from the local trips around Tai-yuan and Xian on roads with thousands of cyclists, barrows and farm

* Remember this was written a quarter of a century ago!

† 'Qin' is pronounced 'chin', as in the resulting China.

trucks. We had been surprised to see so many mules but no horses; how are mules produced without horses?

Chinese trains are quite comfortable but the restaurant carriages are cold! The landscape along the Yangtze is almost European. Large areas of medium-sized fields and scarcely any people within sight. Plenty of wheat but no rice. No exotic China there.

The first place we visited was Suzhou* near Shanghai. 'In Heaven there is Paradise, on Earth there is Suzhou' (as the Chinese saying has it). There is another attractive city with numerous parks, canals and lakes, and flowers despite it being November. Our young Chinese companion attempted to read a text that was inscribed on an old noticeboard but was unsuccessful. One of our hosts, an older man with awe-inspiring dignity, took her hand and led it towards the noticeboard. He said, in English, that not all Chinese was written by young people. Try to read it vertically rather than horizontally! The girl blushed with embarrassment.

In Shanghai, our little group of four people (Dan Beninson, David Sowby, Petar Strohal and I) decided to take a look at the city for ourselves without a guide. This nearly caused the female guide a nervous breakdown as she was afraid that the foreign visitors would be run over by cyclists, get food poisoning, be mugged (by foreign seamen, she said cautiously) or purely and simply get lost for ever. If just one hair on our heads were put out of place, she said, her career would become non-existent and her future lost. We promised to be cautious, avoid muggers and bicycles, eat at respectable restaurants only and let her know as soon as we had arrived back to the hotel.

Regarding the hotel, it was luxurious, with TVs in the bedroom and communal room and three telephones, one of which was in the bathroom. Its luxury had been exceeded only by Guesthouse no. 1 in Xian, where Chou En-lai and President Pompidou (with wife) had stayed. The enormous bathroom in Guesthouse no. 1 had a toilet seat in front of which stood a magnificent stand to support the literature that those visiting the toilet may want to read while seated.

There was a definite difference between the ways in which people were dressed in Shanghai compared to Beijing. In the northern capital city, Mao-style clothes dominated but in Shanghai, western-style clothes were more common. People started spontaneous conversations to practise their English. In one warehouse, two students wanted advice on which bicycle was the best buy. By 'best', they said they meant ones that were in fashion in the west.

We returned to the hotel to find a worried guide waiting for us in tears. Her joy when she found us unscathed was indescribable.

These commentaries may make it sound as though our visit to China was one long sightseeing tour but we did actually do some good for our hosts. It did not take us long to realise that the radiation protection organisation was hampered because it came under a number of different Ministries and there were no lower-level lines of horizontal contact (where the work was carried out) between those who had different governing bodies. We also found that radiation protection, as in countries like France, was run, with few exceptions, by doctors when it came to the use of radiation within healthcare. The conditions were much better within the nuclear energy industry where the governing bodies were less fragmented.

We found the same result on a number of visits to different institutions. We were shown large albums of colour photographs of successful treatment of radiation injuries. The doctors in China were very skilful at this. They transplanted healthy skin onto the injured areas and were able to show superb results. Still, we criticised the measures by saying: 'Haven't you ever thought whether it mightn't be better to improve radiation protection so there are fewer injuries rather than to treat the injuries that are now arising?' The answer was no - that was someone else's responsibility.

Our report from this first RAPAT visit was constructively critical and was actually valued by the higher Chinese authorities.

* Suzhou is a university town 75 km west of Shanghai, famous for its many canals and beautiful gardens.

18.20. **Lauriston Taylor v Karl Morgan**

In a letter to me on 11 December, Lauriston, then 82 years old, told me about his expectations over the past few years. Among other things, he wrote:

> Over the past 2 ½ years I have supported the Ministry of Justice in averting attacks from Morgan and Gofman, both of whom are occupied with supporting all types of compensation claims against the government. Last year I was summoned to court and in and out of the court at the time of the meeting [of ICRP] in Stockholm and I am now once again in a similar situation for February and March 1985. I hope this is the last time I need to deal with these tasks because I find them extremely unsavoury.
>
> Last year, Morgan dragged Sternglass and Alice Stewart into his group for an 11 million-dollar compensation claim for injuries from a well-documented instance of exposure to approximately 2 ¼ rad [22.5 mSv]. He succeeded in counting it up to around 3,000 rad before they got onto him. It was a trial by jury which lasted around 2 ½ months and the jury's decision favoured the government after 3 ½ hours. The latest case was a 14 million-dollar case about four individuals where the highest dose spread over a period of approximately ten years was 10 rad. In one case, Morgan somehow succeeded in getting this up to more than 280,000 rad in the lungs of one of the individuals. This was a case which took 3 ½ months before one and the same judge who has written the most biting statements I have ever read, in which he blames Morgan and Gofman as well as two supporting witnesses, Gallagher and Carl Johnson.

19. THE YEAR 1985

19.1. **UNSCEAR consultation**

On 12 January I took part in a consultation meeting regarding the Evaluation of the detriment and perception of risk from ionising radiation at UNSCEAR's Secretariat in Vienna.

19.2. **The IMO in Vienna about the London Convention**

The IMO (International Maritime Organisation) held a new meeting in Vienna about the interpretation of the London Convention (see Section 18.17).

19.3. **ICRP/ICRU at the Cosmos Club in Washington DC**

The joint task group that ICRP and ICRU had set up in 1980 regarding the quality factor of radiation protection met at the Cosmos Club thanks to Harold Wyckoff's membership of the renowned club. Whatever the case, the Cosmos Club was a comfortable meeting place for efficient work.

19.4. **The ICRP MC in Paris in March – Member Emeritus**

ICRP met courtesy of Jammet at the *Institut Curie* on 25-29 March. In a later letter (in December) to Lars-Eric Larsson I wrote:

> I do not remember how much I told you the previous time I wrote to you about the upheavals following ICRP's meeting in Paris in March. There were some really major changes to all Committees and the Chairmen of all four Committees were also replaced.
>
> New to the Main Commission were Roger Berry, Li Deping (China), Paul Ramzaev, Giovanni Silini and Eizo Tajima (Japan). David [Sowby] was among the candidates but was not selected and was very disappointed, particularly with Dan and myself, thinking that we should have made more of an effort on his behalf. I think Sheila was the most disappointed.
>
> Instead, David became Secretary of Committee 3 and Julian Liniecki became Chair. Your old committee has now been changed beyond recognition and the only one of the older members remaining is Pierre Pellerin.
>
> Charlie [Meinhold] was instead asked to attend to Committee 2 and seriously try to get the Committee to also deal with external radiation.* He was given Ralph Thomas and Drexler (despite strong protests from the latter) for that purpose. He also took on a reluctant Jan Olof who was removed from Committee 4.
>
> Having John Dunster as Chair of Committee 4 will be real test for the Committee. At the Committee's meeting in Eastbourne in October there were only three who spoke: John, Abel González and Geoff Webb (who is Secretary of the Committee). Ilari, who

* Committee 2 originally dealt with protection against internal radiation but its mandate was changed to 'secondary limits', i.e., limits derived from the recommended dose limits but applicable to other magnitudes such as concentrations of radioactive substances or doses of radiation in the environment.

had been dropped from the Committee, was there as an observer for the OECD/NEA but was fairly quiet. Gunnar Bengtsson is now on Committee 4.

- - -

Anneli Salo has succeeded González as head of the IAEA's radiation protection section. It has not improved Ilari's mood since he applied for the same job. Anneli is already stationed in Vienna and appears to be getting to grips with the problems.

Yes, there was no doubt that Anneli was competent. Her self-control, intelligence and good judgement have been an invaluable asset in the Nordic cooperation.

The meeting in Paris was my last meeting as Chair of ICRP and also as ordinary member of the Main Commission. Dan Beninson would go on to take over from me, but the formal time set for the reorganisation was the International Congress of Radiology which was to be held in Honolulu. I received respect and thanks from the Secretariat, David, Mrs. Price and Margaret with a book on fungi given at a dinner together at the Odéon. David was very disappointed and said he did not understand how the Commission could have chosen Ramzaev over him.

From a meeting of ICRP Committee 3 in Leningrad, 1985,
The Russian physician Angelina Guskova in conversation with Gunnar Bengtsson.

19.5. **Gun Astri Swedjemark defending her thesis**

At the start of the 1970s, Gun Astri Swedjemark was busy examining foods contaminated by radioactive substances from the big nuclear weapons tests at the start of the 1960s. At the same time there was increasing concern regarding the radiation in our homes, and then primarily from radon. Our problem at the Radiation Protection Institute was that there was still no international expert group that wanted to take on the problem. The fact that we had high radon levels was taken to be a local oddity because we used to build houses from shale-based materials. When I unsuccessfully appealed for support from the OECD/NEA's CRPPH, I said that it was our measurements, not our living habits, which had exposed the problem. If you started measuring as well, you would discover the same problem!

After all the chivvying, in 1973 the CRPPH appointed an expert group to survey the presence of radioactive building materials (it was probably still thought that this was a unique occurrence and there was no particular interest in looking directly at the problem – the air in homes). Gun Astri ended up as Swedish representative of the expert group. This started her on the path of becoming a radon expert with responsibility for extensive radon measurements in homes. Her efforts became particularly important following the Tidaholm surprise in 1978-1979 (see Section 13.1) and Gun Astri quickly became an internationally respected expert.

On 22 March 1985, Gun Astri defended her thesis called *Radon and its decay products in housing*. It consisted of a 90-page summary based on four attached papers. The estimated Swedish annual collective dose from indoor radon was found to be approx. 40,000 man-Sv. Owing to substantial uncertainties in the risk estimate, it was difficult to state the probable number of resulting annual cases lung of cancer, but the measurements indicated between 100 and 1000 cases. An international comparison showed, exactly as we had thought, that the radon risk was not unique to Sweden.

19.6. **KASAM**

The government appointed a Scientific Committee, the National Council for Nuclear Waste, which is called KASAM, with Lars Persson as Secretary from 85-90 and *Camilla Odhnoff* as Chair. When it came to looking at ethical matters, KASAM became a pioneer with a policy that was largely formulated by *Anne-Marie Thunberg* (1926-2006) who was affiliated to the Council in 1986.

19.7. **The NEA in Paris: Points of contact re. safety/radiation protection/waste**

In 1985, the NEA arranged a joint meeting of the three Committees in an attempt to reduce the alienation between the NEA Committee's which worked on reactor safety, radiation protection and waste issues.

19.8. **Professor Shinji Takahashi is dead**

We had just arrived at our summer cottage for Easter when David Sowby rang and said he had received a telex from Professor Yoshizawa saying that Shinji Takahashi had died. I wrote to Mrs. Takahashi and her daughter, who visited us in May 1984 to express my sympathies. At the same time I was able to inform her that the Royal Academy of Sciences had decided to give its radiation protection medal to Takahashi, although it was unfortunately too late for him to find out. I had been asked to hand it over to a family representative at the Congress of Radiology in Honolulu in July.

19.9. **IAEA in April on exemption rules**

I was consultant for IAEA from 25-26 April to finalise the document prepared at the Meeting of Senior Experts on the Exemption Rules to the Basic Safety Standards for Radiation Protection.

19.10. **The IMO in London in June**

In 1985 a new meeting was held, this time in London, regarding a follow-up of the London Convention on matters regarding radioactive substances. Ragnar Boge took part as Swedish expert and Dan Beninson was there for Argentina. I took part as observer for ICRP. Arne Engström led the Swedish delegation. Criticism was levelled by Friends of the Earth, which led Dan to have an informal discussion with their representative. Dan loved such discussions. He asked whether Friends of the Earth really did see the dumping of small quantities of radioactive substances in the world's oceans as a major problem. Well, he received a response. What we are actually after is industrial society. The energy problems are the things that characterise it and nuclear power is the easiest thing to criticise. The weak point of nuclear power is the waste problems. No-one is keen on waste, so that is where our criticism is levelled.

19.11. **UNSCEAR's 34th session in Vienna**

UNSCEAR met in Vienna from 10-14 June for its 34th session. The Chair of the Committee this time was T. Kumatori (Japan), Deputy Chair was A. Kaul (the Federal Republic of Germany) and rapporteur was A. Hidayatalla (Sudan). Bob Moseley was Chair of the biological sub-group (for the final time) and Dan Beninson for the physics sub-group. Chair of the genetic sub-sub-group was K. Sundaram. The Committee was now able to celebrate its 30th anniversary.

The Swedish delegation was made up of the same people as at the previous session. We ate an evening meal together at the Pan Asia restaurant at Praterstrasse 22 to discuss the Committee's work. We were concerned about the international ongoing discussion concerning the future of UNSCEAR. UNEP, who had been given responsibility for the Secretariat's resources, seemed to think it was natural to change the Committee's authority from the UN's General Assembly to UNEP.

After the meeting, the Swedish delegation drew up a 19-page memorandum ('UNSCEAR – WHAT AND WHY?') on how UNSCEAR came about and its objective and work. We sent it to the Ministry for Foreign Affairs and proposed that the memorandum also be given to relevant specialist Ministries and, if appropriate, the Academy of Sciences' National Committee for Radiation Protection Research. We summarised our concern with the following words:

From the UNSCEAR meeting in 1985 (the 30th anniversary).
Bo Lindell, Gunnar Walinder, and 'Bill' Pochin.

> Recently, Secretary General of the UN [Javier Pérez de Cuéllar, born in 1920] and the head of UNEP [Mostafa Tolba] have put forward proposals stating that UNSCEAR's activity should be extended to also cover the risks from non-radioactive but chemically-hazardous environmental contaminants. This worries the Committee. On the one hand, it absolutely thinks that it is reasonable and desirable for its experiences to be useful within general environmental protection as well, but on the other it fears that further assignments would require such changes to the size of the Committee and the way in which it works that in practice it would put an end to UNSCEAR as an effective and efficient body. The Committee is a unique organisation that is generally respected for its work and as the prime source of knowledge of levels of radiation and radiation risks. The Committee does not believe it can maintain the same high level if it is obliged to expand its activity, and is afraid that the practical difficulties have been underestimated.

The memorandum was critical of UNEP. It stated:

> Administration through UNEP does not appear to facilitate the activity. Appointments to office have been particularly drawn-out affairs, by all accounts because of problem within UNEP. There is also a risk that UNSCEAR even as a Committee will start to be seen as 'belonging to' UNEP. On its own initiative, UNEP has decided to draw up and make available to the public a version of UNSCEAR's 1982 report in order to celebrate the Committee's 30th anniversary, although, formally speaking, UNEP has nothing to do with the Committee. However, Francesco Sella, the former Main Secretary, works for UNEP. In the first draft, written by a popular-science journalist, UNSCEAR is presented as a Committee under UNEP, although the only way in which UNEP is linked to the Committee is through the administration of the Secretariat.

By all accounts, Sella was not exactly ambivalent about UNEP's attempt to sever UNSCEAR from the General Assembly. Mostafa Tolba himself was more cautious when he spoke before the Committee in June:

> I am sure that, given your early successes within the field of radiation, you now feel that a powerful attempt on your part to assert your authority in the other areas can be accommodated. For example, in the more extensive and largely unexplored field of putting global and regional environmental risks, including radiation risks, into perspective – is that not a role for UNSCEAR?
>
> ...
>
> It seems to me as though these areas of study would be well suited to the Committee's work. The only things you need to enter into this arena are scientific insight and decisiveness; two characteristics that you have shown you have more than enough of.
>
> I am fully aware that this cannot be brought about overnight. A great deal of preparations and purging will be needed before you can establish your own strategy. Here, as in all of your work, the support from your Secretariat will be crucial, as it will from the new experts who must be appointed. I want you to know that I will do everything in my power to make every new assignment that you decide to undertake just as successful as those you have succeeded with so far.
>
> As you know, UNEP's only responsibility for the Committee is organisational and it does not guide in terms of policy. Its role is therefore limited to supplying you to the best of our ability with the infrastructure that your work requires and the support that I have already mentioned. We cannot and would not wish to pretend to establish the orientation of the Committee. That is a task that you and the General Assembly must perform.

At the 30-year anniversary celebration, *Mowaffak Allaf*, Director General of the UN's office in Vienna also read out a notification from the Secretary General of the UN, Javier Pérez de Cuéllar. Since this notification is said to have been worded within UNEP, perhaps through Francesco Sella, it was no surprise that the message was similar. The head of the UN had written:

> There is no doubt that [UNSCEAR] can play a very positive and constructive role in other areas of environmental protection. ... One instance that springs to mind is the formulation of internationally-agreed constraints on the emission of noxious substances.

The Committee was very worried about these proposals since they could forebode a declaration of intent on the part of the UN. The proposals were dangerous because they seemed to be so reasonable. Shouldn't they make the same efforts for other environmental contaminants that UNSCEAR had done for radioactive substances? Shouldn't UNSCEAR's experiences be useful here as well? The answer was of course yes. But it was not easy to know how to continue. Shouldn't UNSCEAR continue in this new area? The Committee's response appeared to be no! There were objections in two regards: it would not be appropriate to broaden UNSCEAR's area of responsibility and it would be inappropriate to incorporate UNSCEAR into UNEP. In the memorandum we wrote:

> The new area would require new expertise, probably to such an extent that UNSCEAR would become another Committee altogether. The issues where UNSCEAR's experience can be beneficial are only sub-issues. The broad field under consideration is heterogeneous while UNSCEAR has been successful in being able to work within a homogenous, well-delimited specialist field (the radiation risks are the same type of thing irrespective of whether it is a patient who is being irradiated by an x-ray device or a child who is eating food contaminated by radioactive substances.
>
> This does not mean that UNSCEAR's experiences should not be used. The desires for UNSCEAR's knowledge and experience to be made available for other environmental protection activities are completely reasonable and justified. In a contribution to the UN's Environmental Protection Conference in Stockholm in 1972, the Committee itself has also previously highlighted that the experiences from the field of radiation could be applied more generally.
>
> However, the matter is so significant that it cannot simply be solved with an expanded mandate for UNSCEAR. This would all but put an end to UNSCEAR. However, it ought to be possible to find ways of enabling UNSCEAR and other bodies to cooperate in order to make UNSCEAR's experiences and methods useful in the other areas as well.

The Secretaries of UNSCEAR during the first 30 years.
From right (oldest, in a pale jacket) Ray Appleyard, then Francesco Sella,
Dan Beninson, and Giovanni Silini.

The scientific work during the 34th session on the next major report, which was now estimated to be ready in 1988, continued with no great surprises. One incident that may be worth mentioning was described in the Swedish memorandum:

> The Soviets were critical of tables which reported in far too much detail where different nuclear weapons tests had been carried out. The justification was that there were no official details about this and that the information was not used for dose calculations. Initially, the Russians were also negative towards a table showing the Swedish Defence Research Establishment's estimation of subterranean test explosions. This was because the table was initially interpreted to suggest that the agreement on limitation of the strength of the charge had not been complied with. Once this turned out to be due to a misunderstanding there were no longer any objections.

19.12. **Consultancy assignment for IAEA**

On 17 June I came to IAEA in Vienna as consultant for a single day to discuss and finalise a report on radiation protection research and development.

19.13. **The ICR in Honolulu**

The International Congress of Radiology was held in Honolulu in 1985. Marrit and I flew to Los Angeles on 5 July and then on to Honolulu on 7 July. We stayed at Hilton Hawaiian Village in Honolulu. After the Congress we hired a car for the day (a Datsun from Hawaii Rent-A-Car for 21 dollars) and visited the Polynesian Cultural Centre.

Dan Beninson was there at the Congress to appear as Chair of ICRP after me. From Sweden we met Rune Walstam and Karl Johan Vikterlöf and their wives. After coming home, I wrote to Lars Eric Larsson and gave an account of the Congress:

> So I left the Chairmanship of ICRP to Dan in Honolulu during the Congress of Radiology. Both the Congress and Honolulu were atrocious.
>
> Honolulu and the island it is located on [Oahu] are awful. Honolulu is Mallorca on steroids with skyscraper hotels in triangles like sardines in a tin. Cars everywhere and the beaches full of refuse and plastic. Everything is artificial, Hollywood-style, all shops selling the same knick-knacks, made in Taiwan or Hong Kong or Tokyo. Generally speaking the island consists of sugar plantations and American military stations, current or derelict since the war. Eight-lane motorways dissect the city and there is nothing interesting to see apart from a sort of South-Sea Skansen in the northern section with various Polynesian huts and an impressive aquarium outside the city.
>
> The Congress of Radiology was a substantial and expensive fiasco. It had hoped for around 10,000 participants, which was seen as normal. The Americans' North America Radiological Society Congresses have many more. Last year, when I visited the one in Chicago, there were more than 20,000. It was reckoned that 7,000 would be needed in Honolulu for it to be economically viable. Not even 4,000 came and it is said that most of those were exhibitors. There were so few people at the technical exhibition – which was a long way from the hotel – that the buses were withdrawn for half a day after a couple of days. The exhibitors were furious - no customers came.
>
> ICRP and ICRU had symposiums (as required by the ICR's bylaws), but they were scheduled at lunchtime one day when most people were on the beaches or in the pools. 28 people came to a hall which seated 500.
>
> The worst thing of all was the ceremony to hand over The Swedish Academy of Sciences' gold medal. It had been awarded to Takahashi, who unfortunately died on 1st April. Mrs Takahashi came to Honolulu to receive the medal, accompanied by daughter and son. She had never been outside Japan before and saw it as a very big event in her life. She had brought with her a special ceremonial kimono in honour of the occasion.

Her son had prepared an acceptance speech in English to say how honoured the family was and how grateful they were for the honour that had been bestowed on his father.

The medal was to be handed over at the Congress' closing ceremony which would be held in something called the Waikiki Shell. Afterwards, the participants would get to see a Kodak Hula Show.

Marrit, Dan and I set off for the Waikiki Shell in plenty of time, luckily. We found that it was an outdoor theatre in a park and that there was room for a Hula Show which Kodak regularly held for a few days for advertising purposes with free entry.

At the front of the stage were twenty or so rickety-looking folding chairs. Behind them there was room for maybe 500 people on permanent benches. A number of older ladies had taken their seats and did not appear to belong to the Congress. We were a little uncertain and tagged on behind a man and a woman who turned out to be the director of the Hula show and his wife.

It emerged that he intended to start Kodak's Hula Show at exactly the same time as the Congress' closing ceremony was meant to start.

'But that's just not possible!' we said, outraged. 'At that time the closing ceremony for the big Congress of Radiology will start here and continue for one and a half hours with speeches, medals being handed over (Harald Rossi was also to receive a medal, the ICRU's Gray Medal) and the ceremonial ringing of the Congress clock, one strike for each previous Congress.'

The Hula director laughed indulgently.

'Not at all. That's when we'll be starting our Hula Show. They have a fixed time; they can't be changed. We have agreements with all the artists. That can't be disrupted.'

We were appalled and rushed out to meet Bob Moseley, President of the Congress, when he was due to arrive. He did not come until ten minutes before the time it was due to start. We told him what had happened. Moseley laughed just as indulgently as the Hula director had and said:

'No, we're starting in ten minutes. The Kodak show will have to wait until we've finished.'

And he walked away confidently to explain this to the director. The result was a disaster. The Hula show could not wait for the time that was necessary. The Congress had 30 minutes to hold its closing ceremony.

So, there sat Mrs. Takahashi balanced on an uncomfortable folding chair in her special kimono. The ceremony began at record speed. It was a bit like when old silent films are shown at modern speed. People were rushing up onto and down off the stage, recited reports and speeches, and when the moment came I had to grab hold of Mrs. Takahashi and rush her up into the limelight to give her the medal. Her son had to rush forward to read out his speech at record speed, and then it was all over.

The Kodak Hula Show then began immediately, which took its time and took up the rest of the evening. Poor Mrs. Takahashi had made the long trip and dressed herself up for the big ceremony to simply be sat in a folding chair in front of a Hula Show. A terrible culture shock.

Bob Moseley's inadequate planning and the collapse of the Congress can be explained and, where he was concerned, forgiven because he had been affected by cancer and would end up dying soon. His colleagues did not have the same excuse.

19.14. **Palme's energy agency**

In July, the government appointed a reference group, called the Energy Agency, for the forthcoming nuclear power phase-out. Birgitta Dahl was Chair of the Energy Agency. The Agency included representatives of the political parties, trade and industry, the power industry, research, the trade unions, the municipalities and environmental organisations.

19.15. **Oskarshamn 3 and Forsmark 3**

In August, the Oskarshamn 3 and Forsmark 3 power plant reactors were commissioned. Sweden now had the twelve planned reactors in operation, i.e.:

Oskarshamn 1	criticality:	12 December	1970
Oskarshamn 2		6 March	1974
Oskarshamn 3		29 December	1984
Barsebäck 1		18 January	1975
Barsebäck 2		20 February	1977
Ringhals 1		20 August	1973
Ringhals 2		19 June	1974
Ringhals 3		29 July	1980
Ringhals 4		19 May	1982
Forsmark 1		23 April	1980
Forsmark 2		16 November	1980
Forsmark 3		28 October	1984

Of these, Ringhals 2, 3 and 4 were Westinghouse pressurised water reactors and the others were Asea-Atom boiling water reactors.

19.16. **Clab**

In 1985, the central holding storage for spent nuclear fuel (Clab) was put to use at the Oskarshamn plant. Clab is run by OKG* (*Oskarshamns Kraftgrupp*, operator of the Oskarshamn nuclear power plant). The purpose of Clab is to store spent nuclear fuel for 30-40 years, lowered into and cooled in water in a repository which, in 1988, had room for 5,000 tonnes of fuel in five pools and which went on to be extended to 8,000 tonnes, enough to store all spent fuel from the Swedish nuclear power plants until the year 2010†.

The fuel in a nuclear reactor is spent after 4-5 years so 20-25 % is replaced each year, i.e., approx. 250 tonnes of the total quantity of fuel in the Swedish reactors. Before being conveyed to Clab, the spent fuel is stored for at least a year in pools of water in the reactor halls to allow the radioactivity to decay to make the material easier to handle. It is transported from the nuclear power plants on *M/S Sigyn*, a specially-built vessel with a deadweight of 2,044 tonnes. At the end of 2005 there were 4 229 tonnes of spent nuclear fuel in CLAB.

19.17. **Lars-Eric Larsson in Manilla**

In August I received the following letter from Lars-Erik Larsson who had left ICRP Committee 3 and was now on a WHO assignment in Manilla:

> First of all I would like to extent heartfelt thanks for the lovely words you expressed to the ICRP retiree. Had I not known you and not known that you were not exactly someone who used complimentary words I would probably not have appreciated your letter as much as I did. Yes, there are major changes afoot at ICRP. Many of the older people – you, David and I and several others whom I am not listing – are leaving.

* In October 2006, the Swedish Nuclear Fuel and Waste Management Co (Svensk Kärnbränslehantering AB, SKB) took over the operation of Clab.

† An extension to handle up to 11,000 tonnes is under way and is expected to be sufficient because the planned final repository will begin to accept spent fuel deliveries from Clab.

Regarding C3, I certainly was a bit surprised at some of the people who were still there. On the other hand, new people are coming instead. I hope good choices are made. If a Swede is to go into C3 I would put money on Sören Mattsson of Gothenburg.

Enough about ICRP. Inga and I have now been here for more than 3 months. Time flies by here in a constant heat which hovers close to +30° C in the daytime and around 23-24° C at night. We live in an apartment in a new building with a swimming pool on the roof. We spend plenty of time in it.

We live in a district (Makati) which can be compared with Östermalm in Stockholm. Nearby we have a big shopping centre where you can buy everything provided it is not out of stock.

The teaching takes up a great deal of time, but that is the reason I am here. The domestic teachers have MScs in Medical Physics but have never actually acquired any practical experience of medical physics. Unfortunately, they have not had the opportunity of practising the subject, either in the UK, the USA or New Zealand where they were educated. You get a feeling that these MSc courses for foreigners are a type of 'B' course where the aim is to register as many successful graduates as possible. This has led to the teaching in most subjects (they use the American university model here) consisting of reading aloud various sections from textbooks with no support from practical activity.

I am now in the process of trying to change this. I have gained my perception by holding seminars within the different areas of medical physics alongside my lessons. The students are eager to learn and, by Philippine standards, study hard. Not only that, most of them are living on the poverty line.

We have been invited out into the provinces a good few times and have been to celebrate Easter in the rural areas, to family parties on farms, etc. This is something that the usual visitors do not get to experience.

One weekend we were invited to see the reactor which was close to completion and which will supply electrical energy. It is 620 MWe and supplied by Westinghouse. The cost is now up in the region of 1.5×10^9 US$ and they are awaiting permission to charge it. There seems to be a delay. There is strong opposition which is probably aimed more at the current regime but which does focus on the reactor.

On the way there we encountered a good number of carts drawn by water buffalo. Yes, it is a country of contrasts. We have experienced an earthquake. We woke with our beds feeling as they were floating around. The centre was around 300 km to the north where a number of people died. All struts and supports in the reactor have shock absorbers to avoid or reduce the effects of any earthquakes.

Celia Anatalio[*] is still just as active as before. She has an extraordinary ability to procure funds for her institution, Radiation Health Services. She is now getting personnel and equipment to be able to get to work if there is an emergency. Out at the reactor there are USA advisers coming and going all the time.

Most things here are cheap compared with Sweden but expensive to the Filipinos. The disorder you read about is taking place in the southern archipelago. There are some trouble spots here on the main island of Luzon as well but a long way away from Manila. It is not really a guerrilla war. The rebels are concentrating on local politicians to scare them away. Mayors of small towns and chief constables are the main people who are killed.

19.18. **The Social Democratic government continues**

The 1985 election was won by the Social Democrats once again. Olof Palme continued as Prime Minister and Birgitta Dahl as Minister for Energy.

[*] Celia Anatalio had studied at *Radiumhemmet* under Rune Walstam.

19.19. **IAEA in Vienna on Safety Series 45**

IAEA Safety Series 45 on the limitation of releases was updated at an expert meeting in Vienna in September 1985. The new version was published as Safety Series 77.

19.20. **IAEA in Vienna on exemption rules**

In October, an expert meeting on exemption rules was held at IAEA.

19.21. **ICRP in Eastbourne**

ICRP and its Committees met at The Cavendish Hotel in Eastbourne from 27 October-7 November. I made the following notes about this:

> Taking part as Emeritus Member for the first time. Pochin is the only other Emeritus Member present. He is still vital, but his age is showing in the way he shuffles along.
>
> The new members [of the Main Commission] are there. Ramzaev expressed heartfelt thanks to me for having been elected, but I am slightly dismissive bearing in mind how disappointed David Sowby had been that Ramzaev had got into the Commission rather than him. Tajima and Li Deping are cautiously quiet. Giovanni Silini is full of energy and enthusiasm at having got into the Society. Roger Berry makes a good impression of common sense and judgement.
>
> Dan is now Chair. He has problems with the Secretariat where rumour has it that there are now discordances between Andrea Price and Margarete on the one hand and David's successor, Mike Thorne, on the other. Thorne has employed his wife on a part-time basis and the other ladies think she knows too little and does not contribute enough for the money she gets. Dan is worried about the lack of good judgement. It turns out that Jack Vennart sees Thorne as being excellent when it comes to the scientific matters but naive as a child where social matters are concerned. Dan has a serious talk with Thorne at the end of the meeting.
>
> The decision is to spend a couple of years collecting information and discussing policy issues before starting work on a revision of Publication 26.
>
> Gunnar Bengtsson advertises for Swerad* and gives out ball point pens bearing Swerad's name. I do not know whether he notices the secret smiles. Swerad also invites the Chinese (Li, Wang, Chen and Wu Dechang) to dinner with the Swedes (Jan Olof, Lars-Erik Holm, Sören Mattsson and me).
>
> Sunday 3 November is free. Pochin asks me whether I want to accompany him on a walk over the Downs. I gladly accept. Dan is in London to vote at the Brazilian office for 'Argentinian affairs' [Argentina and the UK were still in conflict after the 1982 Falklands War and the diplomatic relations were not restored until 1990] and then out to the Sowbys' [in Wimbledon].
>
> Pochin has a small Peugeot. We drive north to Willingdon, ask where the climb up to the Downs is and park nearby. In the UK you cannot walk around anywhere. The whole of the Downs are surrounded by a belt of either fields or building plots and you can only walk along a narrow path between areas of private land. It is marked Public Pathway and has special gates through, or ladders over, the barrier. We wander on up. Pochin is only lightly clad: he is wearing a white shirt, open at the neck, and an old anorak which he soon removes. I am wearing an overcoat (with lining!) and a beret. The initial climb is fairly steep.
>
> The hills are broad and sweeping like the *Transtrandsfjäll* mountain area in Dalarna in Sweden. A short way up there is a small flock of young bulls grazing, but they are

* A temporary commercial activity within the Radiation Protection Institute.

not interested in walkers. The view is magnificent, both inland and out towards the coast. It is an unusually fine day with a cloud-free sky, a real 'Indian summer'.

We walk in a westerly direction and Pochin shows how he had come from the other direction on another day, from Alfriston. Down in a valley we eventually see a small village. The road running through the valley is, however, completely invisible. The village is Jevington. We walk down there, cross over the road and continue up the slope on the other side until we reach the next 'top' and can see towards Alfriston. We then turn and take a semi-circular route back towards Jevington, where we pass the church just as the service has finished. We make our way to a pub for a beer and a sandwich. The pub is full of walkers but there is room at a table outside in the sun where it is not that cold. Then we walk back to Willingdon and manage to find the path down towards the car. We have spent five hours walking! Although Pochin looks as though he is having trouble walking, we really have been on a long walk. It was a beautiful day.'

One of the next few evenings, John Dunster drives Dan and me to Alfriston for dinner. He has a new Volvo. The restaurant is excellent, as is the food. Alfriston is a lovely small village, by all accounts well worth paying a longer visit.

On Thursday 7 November, Giovanni Silini joins Dan and me to go to London. We all have rooms at Manzi's [now closed] by Leicester Square on the edge of Chinatown. In the evening I want to eat at either an Italian or a Greek restaurant, but Dan cajoles us into a Chinese restaurant at Leicester Square. The worst in the world! The following day we go to the Greek restaurant around the corner, which is very good.

From the ICRP meeting in Eastbourne, 1985.
Giovanni Silini and Bo Lindell.

From the ICRP meeting in Eastbourne, 1985.
Dan Beninson, the chess master, drawing a crowd.
From left Bo Lindell, Serge Prêtre, and the British biochemist David Taylor and his wife.

19.22. **Royal Society in London: The 90th anniversary of Röntgen's discovery**

My account of Eastbourne and London continues:

> Friday 8 November marks the 90th anniversary of Röntgen's discovery with a seminar at the Royal Society. Many well-known faces, Mayneord and Spiers among the older gentlemen. Mayneord and Spiers both look to be in fine mental fettle. Brian Windeyer on the other hand does not – he is using stereotypical phrases and speaking altogether mechanically. Professor Harder[*] gives an interesting lecture on Röntgen.

[*] Professor Dietrich Harder.

> Afterwards we [i.e., Dan Beninson and I] go with David Sowby to The Atheneum for a drink and a talk about the ICRP Secretariat.

It was no surprise that Mayneord (83) and Spiers (78) were in good shape. Spiers had played table tennis with me in his retirement years. But it was tragic to see Sir Brian's dementia; we had gone to Canada on a fishing trip together just nine years ago.

19.23. **New Radiation Protection Act**

In December 1985, the Committee reviewing the radiation protection legislation submitted its report, 'New Radiation Protection Act' (SOU 1985:58). It was extensively referred and led to the government bill on the matter in 1988.

20. THE YEAR 1986

20.1. The Soviet satellite Cosmos 1714

A couple of thousand Soviet (spy) satellites had been launched since 1962. The Kosmos 1714 satellite was one of them, but it had trouble adhering to its path. It was expected to come down on 29th February 1986, possibly over Sweden. This was reason to test the emergency preparedness centre at the Haga Court of Justice, a test whose outcome, unlike that of the satellite, led to general satisfaction.

20.2. The murder of Palme on 28 February

A letter from foreign colleagues expressing condolences. Warren Sinclair's wife, Joy, wrote:

> We were very sorry to hear of the assassination of your Prime Minister, Olof Palme.
> In addition to the tragic nature of the event itself – a decent and honourable man, serving society, killed without warning and for no obvious reason; this is something we all hoped that Sweden was immune to, an idea we valued.

Yes, this was a sudden wake-up call from the dream of a secure environment. And those of us who were appalled by the hate campaigns against Palme which we had seen in many places were surprised by just how much international appreciation he was shown at the time of his death, particularly in the USA.

Ingvar Carlsson became Prime Minister after the murder.

20.3. UNSCEAR's 35th session in Vienna

UNSCEAR met in Vienna from 14-18 April. Chair of the 35th session was K. Kumatori, Deputy Chair A. Kaul and rapporteur A. Hideyatalla. Henri Jammet was Chair of the biological sub-group, Dan Beninson for the physics and K. Sundaram for the genetic sub-sub-group.

The Swedish delegation was unchanged compared with previous sessions. In addition to my deputy, Gunnar Walinder, the Ministry for Foreign Affairs paid for Kay Edvarson, K-G. Lüning and Jan Olof Snihs to take part while the Radiation Protection Institute (SSI) paid the expenses for Lars-Erik Holm, Sören Mattson and Jack Valentin.

The Committee had two work assignments during this session. One was to complete three scientific reports to be published in 1986 and the other was to continue discussing the documents that were to be included in the big 1988 report.

The Committee elected functionaries for 1987-1988 as per the programme. I became Chair for these years with Australian K. H. Lokan as Deputy Chair and J. Maisin of France as rapporteur. The departing rapporteur, Dr. Hideyatalla, expressed disappointment that the Committee had not consistently applied the principle of allowing rapporteur and Deputy Chair to be 'promoted' to Deputy Chair and Chair respectively. The fact that this had not happened this time was probably because the election was for the period during which the 1988 report was to be completed. It was an important report that could be difficult to agree on. The Committee may have thought that the combination of Lindell and Lokan could be more likely to bring about this agreement than the combination of Kaul and Hideyatalla. But it was only natural for Hideyatalla to feel discriminated against, as he may well have been – in the name of efficiency.

The Committee's work took place as usual 'informally and objectively'. The only deviating political incident concerned the wording of a paragraph 95 on subterranean nuclear charge explosions. The paragraph ended as follows:

> Prohibiting atmospheric tests thus did not hamper nuclear weapons development very much, although it was a crucial step in lessening the doses to the world's population from tests of weapons. In fact, a well contained underground nuclear explosion delivers extremely low doses or dose commitments to any group of people. However, there have been occasions when mishaps in connection with underground tests led to dissemination of radioactive debris over at least regional distances.

From 1986, the Chernobyl year.
Bo Lindell and Dan Beninson, according to critics 'travelling salesmen flogging allegations that radiation is harmless'

The Polish and the Russian delegate wanted to change this mainly by adding the following sentence:

> Completely stopping these tests would mean that this contribution to the radiation exposure of the world's population would be completely precluded.

This was of course a platitude which was not really intended to be approved by the Committee. An Argentinian expert said that matters concerning the stoppage of tests came under bodies other than UNSCEAR. American, German and Polish experts proposed different wordings. Various people then pointed out that it was a waste of time discussing details in a text that would be reviewed by the Secretariat and come up for discussion at the next two meetings so a decision was made to discuss the matter once again at the next meeting.

Dr Silini reminded people about the lack of resources. The UN's method of cutting 20 % off all expenses ('the salami method') was difficult to do for such a small organisation as UNSCEAR which had only one Scientific Secretary and had already previously had problems paying consultants. There tended to be a lack of coordination between the different Annexes since the Secretariat now no longer had the option of allowing the consultants to spend any length of time together. The scientific quality fell because the contributions had inadequacies which would have been detected with better Secretariat resources and action taken at an early stage.

The Swedish delegation's report to the Ministry for Foreign Affairs about the meeting had been signed by me and Gunnar Walinder but had still not been submitted when the Chernobyl accident occurred. I wrote a supplement and emphasised that the Secretariat lacked resources for the additional consultation and meetings needed to follow up the accident. Later, on 6 June, I wrote to the Ministry for Foreign Affairs once again:

> As Swedish representative at UNSCEAR I have recently reported on the Committee's 35th session. As mentioned in the report, the Committee has designated me to be Chair of the 36th and 37th sessions during which the work on the next extensive report for the UN General Assembly will be completed. The report is expected to be submitted in autumn 1988.
>
> The extensive radioactive contamination from Chernobyl over large parts of Europe, and not least Sweden, will influence the Committee's work. It falls within UNSCEAR's mandate to assess the radiological consequences of the accident within the framework of the normal work with reporting levels of radiation and radiation risks. The Committee must therefore anticipate carrying out this evaluation for the 1988 report.
>
> However, the situation is complicated by several factors. Not only is there little time to do the evaluation because an initial work document must be available before UNSCEAR's 36th session in March 1987, which will involve concentrated work by consultants during autumn 1986; there are also strong requests for an objective investigation which, given the current situation regarding the debate, means that the consultants must be very carefully selected.
>
> IAEA and WHO have prepared joint contributions to assist UNSCEAR with the collection of measurement data, but expect the Committee to be responsible for its evaluation.
>
> As Chair of the next two UNSCEAR sessions, I am thus faced with the full expectation of a sterling contribution from the Committee, and at the same time the Secretary of the Committee reports that the available funds scarcely cover even the work that is already taking place.
>
> Bearing in mind that, faced with this situation, Sweden is not only responsible for the Chairmanship but is also one of the countries which has been most affected by the radioactive fallout from Chernobyl, I would hereby like to ask about the possibility of a Swedish initiative for a special wording in this autumn's General Assembly resolution on UNSCEAR's work so that it emphasises that UNSCEAR is expected to assess the radiological consequences of the accident. Such a passus in the resolution would probably give the Committee a greater possibility of a quick contribution. I would be grateful for the opportunity to discuss this matter further.

20.4. **UNEP brochure on UNSCEAR**

To our surprise in the Swedish UNSCEAR delegation, UNEP had allowed a journalist to write a brochure on UNSCEAR's activity and latest report. We suspected that the initiative had come from Francesco Sella, who was now linked to UNEP. After correcting the usual mistakes by a layperson, the brochure had certainly been useful but we were worried that this could be a step towards UNSCEAR being incorporated into UNEP.

20.5. **ICRP in Vienna**

The ICRP Main Commission met in Vienna the week after UNSCEAR.

20.6. The Chernobyl accident of 26 April

Much has been investigated and much has been written about the Chernobyl accident. This is not the place to update the story, but it is to state what was known and written in 1986. The following text, which I wrote for the Swedish Food Agency's magazine *Vår Föda* (Our Food) at the time, may serve as a summary of the early development of the Chernobyl accident:

> The disaster actually occurred at 01.24 [local time] in the morning of 26 April [a Saturday]. Reactor number 4 at the nuclear power plant next to Chernobyl in The Ukraine had gone wrong. Its overheated and fire-ravaged reactor core lay naked in a building that had exploded. Volatile radioactive fission products had been vaporised and carried high up into the atmosphere where they were carried by strong winds towards Sweden and Finland, more than a thousand km away. The vapours sublimated into radioactive dust which slowly fell towards the ground. However, the most powerful decay was caused by rain. In Sweden, the primary area affected in this way was from Västmanland up over Uppsala and the county of Gävleborg out towards the county of Västernorrland.
>
> The direction of the wind gradually changed from Chernobyl towards the west and south-west. New masses of contaminated air swept at a lower height over Poland and later over large parts of Central Europe. A few days later the wind was blowing in an easterly direction. If radioactive substances were still leaking from the reactor in Chernobyl it was being conveyed over Russia and later southwards towards Turkey.
>
> The radioactive contamination outside the Soviet Union's borders was not discovered until the Monday morning of 28 April when measurement instruments at the Swedish nuclear power plant in Forsmark indicated elevated levels of radiation.

In 1986, three important staff members at the Swedish Radiation Protection Institute:
From left Svea Forss, Margareta Rydell, and Elsie Lindhé.

The initial fear was that an accident had occurred at the Forsmark plant but it was eventually realised that the contamination must have come from elsewhere. Before wanting to completely rule out the possibility of a leak from the power plant, the plant management decided to evacuate the whole of the plant with the exception of operating personnel and those responsible for safety. Eight hundred employees, contractors and visitors were advised to go to the Norrskedika sports hall where they would have their outdoor clothing and footwear examined. During that time, radioactive contamination was reported from other parts of the country. In the afternoon, cooperation between the Swedish Defence Research Establishment (the FOA) and the Swedish Meteorological and Hydrological Institute (the SMHI) in Norrköping showed that the contamination probably came from the Soviet Union and in the early evening it was possible to show that the source had to be a nuclear power plant at Chernobyl in the Ukraine.

From initially having denied that an accident had occurred, when faced with facts, Moscow was forced to admit the accident (through the Russian News Agency TASS at 09:00 Swedish time) and later provide full information. The details from Sweden about the radioactive contamination were the first notification of the accident outside the Soviet Union.

The reactor that had failed was known as a RBMK reactor. The letters are those representing the Russian words *reaktor bolshoy moshchnosti kanalny*, i.e., high-power channel reactor. These reactors are water-cooled but have graphite moderators which can catch fire. This type of reactor is unstable through a positive void coefficient. *

The exact time of the accident could be established because it was started by an explosion. I wrote in *Vår Föda*:

> The explosion was a consequence of a strong power increase in the reactor due to a combination of design weaknesses and a series of almost unbelievable breaches of the safety regulations at the time of an urgent generator system test.

In Sweden, the Radiation Protection Institute appointed an analysis group in the Haga Court of Justice and the organisation of national cooperation with radiation measurements began. It was a strange feeling to leave the Court of Justice in Hagaparken with a measurement instrument and ascertain that the background radiation had increased tangibly, despite the fact that Stockholm was not located in a particularly exposed area.

20.7. **The Swedish reaction**

The Swedish Radiation Protection Institute found out about the accident through a telephone call at 10.10 on Monday 28 April from Lars Wahlström, the senior radiation protection officer at the Forsmark nuclear power plant, to Curt Bergman at the Swedish Radiation Protection Institute's nuclear power bureau.

This started the Radiation Protection Institute's emergency preparedness work. Following the reactor accident at the Three Mile Island nuclear power plant in March 1979 and the 1979-1980 report, 'More Effective Emergency Preparedness', by the Swedish Radiation Protection Institute and the County Administrative Boards of counties with nuclear power plants, the government had decided on a hefty improvement to the emergency preparedness in these counties (bill 1980/81:90). The Radiation Protection Institute had been given a central role in the extended emergency preparedness. While the responsibility for decisions lay with the relevant County Administrative Board, the Radiation Protection Institute had the task of analysing the decision basis and being responsible for advising the County Administrative Boards. For this purpose, the Swedish Radiation Protection Institute had an analysis group in readiness to convene at the Haga Court of Justice, which the Institute's nuclear power department normally used. The Radiation Protection Institute cooperated with the Nuclear Power Inspectorate (SKi) and the Meteorological and Hydrological Institute (SMHI) regarding the advice.

* In reactor technology, 'void' means 'empty space' created by vapour-filled bubbles in boiling cooling water. The 'void coefficient' is a magnitude which states how a void in the cooing water affects the reactivity of the reactor. Boiling water reactors have a negative void coefficient, i.e., the reactor reduces the power when the void increases. In the RBMK reactors, the power increases when the water starts to boil, i.e., the void coefficient is positive.

When the Urban Siting Report was submitted for consultation in 1974, both the Radiation Protection Institute and the Swedish Defence Research Establishment had emphasised that the report had disregarded the radioactive ground covering following a major accident, as well as the risk of cancer and the damaging psychological effects. In the ‘More Effective Preparedness’ report we had emphasised the significance of the ground covering and pointed out that the greatest radiological consequence of a major accident could be expected to be the risk of cancer from the fallout of primarily caesium-137 at a great distance. However, there was no special preparedness against this at the Radiation Protection Institute; we reckoned that the central government authorities in such a case would take over the responsibility for protection measures.

One problem in the case of an extensive radioactive ground covering, affecting also other counties than those with nuclear power plants, was the organising of radiation measurements. In this respect it was possible to count on close cooperation with the Swedish Defence Research Establishment, which was facilitated by the fact that Kay Edvarson had previously been head of research at both the Defence Research Establishment and the Radiation Protection Institute. Edvarson therefore had good contacts with the Defence Research Establishment’s scientists, primarily *Robert Finck* (who was *en route* to becoming the Radiation Protection Institute’s expert on measurement and analysis activities), *Lars-Erik De Geer* and *Ingemar Vintersved*.*

Both the Radiation Protection Institute and the Defence Research Establishment had measurement stations which registered levels of radiation or collected radioactive air contaminants. The Radiation Protection Institute had the twenty-five measurement stations which Rolf Sievert had initiated and which registered gamma radiation from the ground. Through commendable efforts by the Institute’s engineer Per Einar Kjelle these measurement stations had been saved from closure. The Defence Research Establishment’s section for radiation detection, FOA 215, had the task of detecting whether the air over Sweden had been contaminated with radioactive substances. The objective was to monitor whether the agreements to stop above-ground nuclear weapons testing were being respected. FOA 215 had access to seven measurement stations from Kiruna in the north to Ljungbyhed in the south. At the measurement stations, air was sucked through fibreglass filters which were changed every two days and sent to Stockholm for measurement of the radioactive substances which had become stuck in the filters. In both cases, some time passed before that which had been registered or collected was read off, but this was not regarded as disadvantageous to the purpose of the measurements.

However, the first demonstration of the elevated level of radiation after the Chernobyl accident came from neither the Radiation Protection Institute’s nor the Defence Research Establishment’s measurement stations since they had not yet been read by that time - it was actually the measurement device which was used at the Forsmark nuclear power plant to check that the personnel had not been contaminated with radioactive substances which gave a response at around seven on the Monday morning of 28 April. It was initially feared that there had been a leak in the power plant, but an hour later it was concluded that the radioactive contamination had probably come from outside. The Radiation Protection Institute, the Nuclear Power Inspectorate, the County Administrative Board, and Östhammar municipality were contacted at around ten. Roadblocks were set up and a cleaning station (Norrskedika sports hall) was staffed.

In the morning, Robert Finck was at the Defence Research Establishment where he received an email from the VAX computer at the Haga Court of Justice at 12.15. It was the Radiation Protection Institute’s computer manager *Erik Lindblom*, who said:

> Unfortunately, things have not slowed down at Forsmark. Some form of emission is taking place, or at least has been, so the meeting at 13.00 has been suspended. Come here instead and bring Kay and Gunnar with you.

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* The information in this section comes from notes made by *Robert Finck* in 1986.

‘Gunnar’ was the Defence Research Establishment (FOA) physicist *Gunnar Persson*. At FOA 215, scientist *Björn Bjurman* began measuring an air filter that Vintersved had fetched from the Royal College of Technology (KTH) that morning

The daily lunchtime news chronicle on the radio, which began at 12.30, stated that radioactive substances had been detected outside the Forsmark nuclear power plant. The Nuclear Power Inspectorate contacted the Defence Research Establishment to find out whether anything had been seen. The head of FOA 21, *Anders Fröman*, found out from Bjurman that the Radiation Protection Institute had recently warned the Defence Research Establishment and that the air filter from KTH was being measured. Just before 13.00, Bjurman informed the Nuclear Power Inspectorate that the air filter contained large quantities of radioactive substances.

At the Haga Court of Justice, the Radiation Protection Institute’s analysis group had been convened, headed by Jan Olof Snihs. Kay Edvarson and Robert Finck also went there at 12.40. At 12.55, Finck contacted Vintersved at FOA 215 on behalf of the analysis group and found out that the measurement of the air filter from KTH had been completed and that substantial iodine-131, caesium-134, caesium-137, barium-140 and lanthanum-140 activities had been encountered.

Kay Edvarson pointed out to the analysis group that it was now important to clarify the presence of caesium-134 in relation to caesium-137. Nuclear charge explosions form only insignificant quantities of caesium-134, so if the relative activities were known it would be possible to determine whether the air contamination came from a nuclear weapon or a reactor.

So, just after 13.00, Finck rang Vintersved to get further information. It turned out that nuclear weapons explosions could be precluded since the caesium-137/caesium-134 activity ratio was as low as 2. Vintersved was also able to report that trajectories* from SMHI showed that the air contamination came from the east.

Just before 13.30, the Radiation Protection Institute’s analysis group told Uppsala County Administrative Board what they knew, including the fact that the contamination must be coming from a reactor and that elevated levels of radiation had also been detected in Studsvik and at the Oskarshamn nuclear power plant.

By this time so many journalists had started to telephone the Radiation Protection Institute and the Defence Research Establishment that the lines became blocked. Fortunately the contact between the two agencies could be upheld by direct internal lines. At 13.50 Curt Bergman from the Radiation Protection Institute spoke to *Leif Blomqvist* from the Finnish Radiation and Nuclear Safety Authority (STUK). There, they had not yet got any measurement results on the basis of which to determine whether Finland had also been affected by the pollution.

Since it was unclear where the source of the contamination in the east was situated, the head of section at FOA 215, Lars-Erik De Geer, decided to get the Target Aircraft Division in Linköping to test the air using an A-32 *Lansen* jet fighter. Such testing usually took place for the Defence Research Establishment when it was suspected that radioactive substances were approaching Sweden from nuclear weapons testing.

While waiting for the results from the aircraft sampling, the Defence Research Establishment informed the Radiation Protection Institute at 16.20 that the source of the air contamination was initially suspected to be the Soviet nuclear power plant Ignalina in Lithuania which also had two RBMK reactors.

During the afternoon, news came from the Barsebäck and Ringhals nuclear power plants that it had also been possible to show radioactive contamination of collected grass samples. Readings at the Radiation Protection Institute’s measurement station at Erken in Uppland showed that the contamination had started at around 14.00 the previous day, i.e., Sunday and was now responsible for a 30 per cent increase in gamma radiation.

At 17.10, defence director *Hans Linder* from Gotland said that the coastal artillery had measured 15 milliroentgen per hour using the ‘Intensimeter 21’ instrument. This aroused grave concern among the analysis group since it would mean a thousand-fold increase in background radiation. They agreed to requisition a helicopter for the FOA 215 scientists De Geer and Bjurman. The helicopter landed on

* Trajectories are curves on a map that show the direction that a particle takes when being driven by the wind.

Gotland at around 22.00 and the two scientists began measuring the radiation intensity from the ground. Luckily, it proved to be no higher than it was in Stockholm. It has never been possible to establish why Linder's instrument initially showed such high values. The radioactive substances from Chernobyl could scarcely have led to such crazy readings. Nor could a calibration error – which was the initial thought – since the result went over half the scale. Robert Finck now believes that the instrument was one of a number which had been supplied with a device that could simulate irradiation for practice purposes.

At around 19.00 on the Monday evening, it was evident that it was not the nuclear power plant in Ignalina but the one in Chernobyl that was the source of the air contamination, and the Russians would soon admit this.

In the early hours of Tuesday 29 April, it began to rain over Gästrikland and northern Uppland and the measurements that were taken by the Defence Research Establishment on the Tuesday showed considerably elevated levels of radiation. This heralded the start of extensive measurements for a long time. An early measurement was carried out by the Radiation Protection Institute's Kenneth Magnusson in a military vehicle rented by the Defence Research Establishment for a trip between Stockholm, Uppsala, Gävle, Västerås and back to Stockholm, a distance of 470 km. From 15 microroentgen per hour (μR/h) in Stockholm, where it had not rained, the dose rate increased to 90 μR/h in Uppsala and 250 μR/h at Dalälven, all measured from inside the vehicle[*]. Up to 700 μR/h was measured in the terrain in the Skutskär-Furuvik-Gävle area. Where the vehicle turned back 30 km north of Gävle, the dose rate in the terrain was 1000 μR/h. On the way to Västerås the dose rate was lower, between 100 and 500 μR/h. Along the route between Västerås, Enköping and Bålsta, the values were between 50 and 85 μR/h to then drop back to 15 μR/h in Stockholm.

20.8. **Guests of WHO in Copenhagen**

Immediately after the Chernobyl accident I received a telephone call from WHO's regional office in Copenhagen. The person ringing was *Michael Suess*, a tall person with surplus energy and a drive that sometimes put his superiors to shame. I had previously had dealings with him in connection with expert meetings which I had chaired. He was now asking whether I was willing to travel down to Copenhagen to act as consultant for WHO in matters concerning the reactor accident. It sounded interesting; I was retired and had no binding undertakings.

In Copenhagen I was given a special room in WHO's building close to the Tuborg brewery. Like most international organisations (with the exception of ICRP), WHO's bureaucracy was sluggish. This first manifested itself when I was to look at how the accident had affected the different European countries. The bureaucracy required me to obtain information on measurement results from WHO's formal national contacts, i.e., the healthcare authorities in the different European countries. In Sweden, that would be the Swedish National Board of Health and Welfare, but I knew that they could not give any early information. That being the case, the right contacts were in fact the Defence Research Establishment and the Radiation Protection Institute. Rather than wasting time ringing around WHO's own contact authorities, which I was expected to do, I used my own network of contacts and simply called the radiation protection experts I knew in the different countries. This brought rapid results and I probably obtained a better overall picture of the situation than they had at home in Stockholm.

My next dilemma with the bureaucracy was that I was expected to take part in a number of meetings, which I usually refused to do on the grounds that this would not be the best way of utilising my knowledge and would delay the information analysis. The leading WHO officials, from doctor *Jean-Paul Jardel* to biologist *Ian Waddington* and the worried Suess tried unsuccessfully to convince me but I insisted on devoting myself to surveying the situation.

With one exception, my contact people quickly left valuable information on the scope and type of the radioactive fallout. The exception was Pierre Pellerin, which was strange since he was in charge of

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[*] If the numerical values are divided by 10, the results are approximately expressed in nSv/h.

WHO's laboratory in le Vésinet outside Paris for the collection of measurement data on radiation in the environment. He refused to provide any detailed information, justifying his refusal by saying that publishing the measurement values could harm the nuclear power industry! Pellerin was a friendly man but a dedicated advocate of nuclear power - so dedicated, it was said, that with such advocates, nuclear power needed no enemies.

We at WHO drew some important conclusions early on. Many had referred to the experiences from the studies that had previously been carried out on radioactive fallout from nuclear weapons testing and advice that had been given in a number of investigations containing curves and tables showing how that radioactivity could be expected to decay over time. According to those curves there was no need to fear any objectionable development as the activity would lessen rapidly within a relatively short time. But the Chernobyl accident was no insignificant reactor accident and the radioactive substances that were spread into the atmosphere were not of a composition reminiscent of the fallout from nuclear weapons testing. The extensive core melt had released substantial quantities of long-lived caesium-137. One could not expect that to disappear in the short term.

The second important conclusion was that the quantity of measurement data did not give any easily-interpretable picture of the dynamics of the course of events. Remembering how the Swedish meteorologists had succeeded in identifying Chernobyl as the source of the radioactive cloud that had reached Sweden, we realised how invaluable meteorological information was in the initial stage of a reactor accident. Armed with that information you could determine early on which areas could be severely contaminated and which you would not need to devote such substantial resources to when investigating.

With the distribution of the radioactive fallout roughly charted it was time to call in a few experts to write a situation report. At my suggestion they called Dan Beninson, who was Chair of ICRP at the time, to the meeting to take charge of the work. I also suggested that a Swedish meteorologist should take part and work out trajectories to illustrate which areas had been affected and how the situation had developed over time. The meeting took place on 6 May at the same time as the emissions from the broken-down reactor ceased. The report showed that high enough doses of radiation to involve a tangible risk to the irradiated person could not really be expected outside the Soviet Union.

One anecdote that is worth recounting concerns Dan Beninson's cigars. At the time, Dan, as Rolf Sievert had previously been, was a dedicated cigar smoker. There was a total ban on smoking throughout WHO's building. My tension bore out until the end. Dan openly declared that he did not intend to give up smoking cigars. The WHO management gave way but Dan was forced to smoke his cigars in a separate, small pavilion. Since we were cooperating to write the report from WHO, I, as usual, had to endure Dan's cloud of cigar smoke which he unfortunately also had the habit of using as an argument – good-naturedly blowing his smoke in the face of someone who did not agree with him. Luckily we did usually agree.

Debate-loving journalist *Sven Anér* referred to WHO's expert meeting in an article in the local daily newspaper *Norrtelje Tidning* on 12 May. He referred to me and Dan Beninson as 'Salesmen of harmlessness' and wrote:

> One of the more sensational statements in the Chernobyl affair comes from [a delegation from] the World Health Organisation, WHO, which met in Copenhagen.
>
> The danger is over, says this delegation, whose composition is not presented in any particular detail. All measures undertaken in primarily Poland and Italy – to some extent in Sweden as well – would have been superfluous and, to the extent that they are still being taken today, the WHO delegation makes them seem almost ridiculous.
>
> In a *Dagens Nyheter* report from the WHO meeting I find two names that I recognise, former head of Swedish radiation protection Bo Lindell and the current head of Argentinian radiation protection Dan J Beninson – interesting!
>
> ...
>
> Old friends Lindell and Beninson are now sitting side by side in Copenhagen and assuring people that the Chernobyl accident, which has shaken the world, has actually

> influenced only an area a few tens of kilometres around the site of the disaster. It is as though Chernobyl never occurred – are we back in Harrisburg?
>
> Lindell and Beninson – professional nuclear power pundits. Be it a question of predicting risks or making statements following disasters, they are always as calm and conciliatory as ever and offset their travel expenses and daily subsistence by giving the nuclear go-ahead.
>
> Lindell and Beninson, men who stand by their view. It is always the same: nuclear power is not dangerous.

Dagens Nyheter's Karl Erik Lagerlöf criticised the Radiation Protection Institute (and me) in a press article on 17 May:

> The Soviets attempted to conceal their core meltdown but Chernobyl scattered itself over all of Europe like a fine dust, singling out even the most secluded place in the woods. For the first time in the history of the world we shared an accident with Greece. There may be godforsaken places. There are none that radiation has left out. This is centralisation on a huge scale.
>
> The authorities in Sweden were considerably more successful in hiding [information about] the radiation in our homes. In 1974, a representative of the Radiation Protection Institute held a presentation in the USA about the dangers of living in our Swedish homes. The Swedish public were not informed until 1978[*]. A Commission was appointed. Two limit values were introduced. In new houses it was dangerous to have more than 70 becquerels per cubic metre and second [!]. In old houses, triple that dose was not dangerous[†].
>
> Today, they say to reassure the public that the radiation on the ground is no worse for small children who put clay and sand in their mouths than the radiation in a radon home.
>
> The benefit gained from being casual about one hazard is being able to refer to the first casual attitude to justify the second.

20.9. **Public anxiety following the Chernobyl disaster**

The public was extremely worried. At the Haga Court of Justice, the head of the Swedish Radiation Protection Institute Gunnar Bengtsson did what he could to keep the journalists informed. He became a popular figure in the press and was nicknamed 'The Cardy' because of his casual clothes. Sven Löfveberg, the Radiation Protection Institute's head of information, later recounted how he saw the events during the critical days in the book called *Strålande vår* ('A radiant spring').

In June, the evening daily *Aftonbladet* arranged a question time which was referred to in the newspaper on 4 June. As well as me and Jan Olof Snihs from the Radiation Protection Institute, Karl Johan Johansson, Professor of Radioecology at the University of Agricultural Sciences in Uppsala, had turned up to answer the questions that people had rung in to ask the newspaper. And yes, answers were reassuring because reassurance was actually justified and legitimate.

On 11 June, the cartoonist Poul Ströyer had a drawing in *Dagens Nyheter* showing a man reading a newspaper which says 'We can trust the Radiation Protection Institute, so Ingvar Carlsson says', worryingly continuing with 'But can we trust Ingvar Carlsson?'

Gunnar Bengtsson met the journalists at the Haga Court of Justice. It was not easy to explain the protection philosophy and the Institute was accused of being inconsistent in simultaneously saying that

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[*] Here, Lagerlöf was wrong. In 1974, the Radiation Protection Institute issued a press release warning of the risk of reducing the ventilation in homes, bearing in mind the level of radon indoors. In 1976, the Institute issued the brochure called 'The radiation in our homes' to all of Sweden's healthcare boards, describing the risk of lung cancer.

[†] Lagerlöf had not understood the difference between the *limit values* for new radiation sources and *action levels* for existing sources. To make a rustic comparison: You do not immediately discard an existing, usable oven if it poses no particular risks and inconveniences, but you do make sure an oven satisfies stricter requirements if you buy a new one.

the risk was negligible yet they recommended banning grazing for a limited period. The apparent inconsistency was because the Radiation Protection Institute assumed a no-threshold connection between radiation dose and risk which meant that there was a small risk at low doses of radiation as well, although small enough to be considered negligible to the irradiated individual. But although the risk was negligible to the individual, there was still a possibility that some members of the population could be injured. If there was a simple way of avoiding this it would be worthwhile doing. Sometimes a comparison was made with monetary loss. If someone wanted to demand ten *öre* (= 1/10 Swedish krona; a coin which was around at the time) from every Swede, that would be a loss which nobody would worry about, but overall the Swedish population would lose close to one million Swedish kronor, which might be worth taking the trouble to prevent. This was difficult to explain to journalists and even more difficult for them to explain to the people of Sweden. The most successful was *Roland Gyllander* from *Dagens Nyheter*.

Birgitta Dahl, Minister for Energy and the Environment, was quoted in *DN* on 18 June:

> Our way of living and working has brought upon us many types of risk which are unacceptable. I believe we must use this as a basis to change our way of living in a number of ways so that we have a more environmentally-friendly society. And we must act quickly.
>
> However I do believe those who say that people's lives are not at serious risk from the Chernobyl fallout.

On 22 June I was interviewed by *Dagens Nyheter* about the limit values for doses of radiation and activity concentrations. The newspaper said the following:

> Where there has been an accident, like now after Chernobyl, there are no limit values. Instead it is a matter of action levels that are determined by which actions are available in any given situation. The objective must be to 'improve the overall situation' and can vary across the scale from evacuation to simple recommendations to wash leafy green vegetables.
>
> The use of a loaded expression like 'limit value' for action levels is unfortunate, says Professor Lindell. It gives the impression that you are on the verge of entering a dangerous area if you cross to the other side of the border.

On 3 August, Roland Gyllander had a five-column article in *Dagens Nyheter* with the headline 'After Chernobyl, everything is relative'. The article gave an instructive and well-informed summary of the problem of handling limit values and action levels in radiation protection on the basis of having assumed a specific, albeit small, risk even at very low doses of radiation.

20.10. **Göran Möller's ethical analysis**

In 1986, a book called *Risker och människolivets värde* ('Risks and the value of human life') was published, the result of a study carried out by ethical scientist Göran Möller. Möller's analysis of ethics deals with many of the problems that also need to be solved by drawing up a radiation protection policy.

Regarding the risks we take ourselves, Möller writes:

> Several of our day-to-day activities are ... associated with some level of risk that we will die, but that does not stop us from doing them. We think they are worth the price of the likelihood of a slightly shorter lifetime. An approach avoiding everything perceived as the slightest bit dangerous we perceive as neurotic.

But are we entitled to expose others to risks? Möller refers to *Charles Fried* when he writes:

> We imagine that ... I agree to expose myself to [risks] because of [other] people's actions on condition that I have the option of correspondingly exposing them to risks

> when I realise my goals. Allowing other people to expose me to some risks enables me to act in a way that can lead to some risks for them. We are exchanging risks as it were. Fried calls this forming a risk pool.

The risks accommodated by this risk pool are those we count on being exposed to as a price for living in a normal society. We should not worry about them but should be critical of other risks that are not included in the risk pool. However, having acquired experience, we are probably still not willing to immediately accept some natural risks such as exposure to solar radiation and radon in our homes.

20.11. **The Chernobyl article in *Vår Föda***

I was asked to write a popularised description of the Chernobyl accident and the consequences thereof in the Swedish Food Agency's magazine *Vår Föda* ('Our Food'). It was published as a 60-page supplement (no. 3) to volume 38 of the magazine. I was now able to give an idea of the consequences of the accident.

Acute radiation injuries to people from the accident had been caused within the Soviet Union only. The energy development when the reactor energy increased was assumed to have corresponded to the explosion of tens of tonnes of Trinitrotoluene. I wrote:

> [The energy development] broke the concrete cover of the reactor and caused a number of raging fires. The reactor fuel's zirconium encapsulation chemically reduced large quantities of high-temperature water vapour to form hydrogen gas. When air flowed in, the hydrogen gas exploded and the building above the reactor was totally demolished. The substantial energy development meant that radioactive particles, together with released radioactive noble gases and vapours of radioactive isotopes of iodine, caesium and tellurium, were projected 1 200 metres up into the sky. The radioactive substances that had not been vaporised largely fell to the ground a relatively short distance away, but the noble gases and iodine, caesium and tellurium along with smaller particles from the non-volatile substances were carried towards Sweden and Finland.
>
> There was high-pressure situation and the vertical distribution of the radioactive cloud was insignificant. Radioactive vapours and particles which were not projected as high were carried in another direction; a smaller contaminated air mass passed southern Sweden and Denmark, for example.
>
> The closest community was Pripyat, 4-5 kilometres away, a town with 45,000 inhabitants, inhabited by the power plant's employees and their families. Here, the exposure rate from gamma radiation from radioactive substances on the ground was low to begin with but strongly increased on 27 April, up to one roentgen per hour [corresponding to approx. 10 mSv per hour], i.e., one thousand times greater than the highest values experienced in Sweden. The town was completely evacuated for this reason. The evacuation began on 27 April at 14.00 and took less than three hours.
>
> The doses of radiation to the residents are estimated to have been between 15 and 50 mSv from gamma radiation and skin doses between 100 and 200 mSv from beta radiation. These doses are not high enough to cause non-stochastic [i.e., acute] effects from radiation. And nor indeed did any cases of acute radiation injury arise among those who were eventually moved from the surrounding area a few days later. The collective radiation dose to the residents in Pripyat is estimated at 1,500 man-Sv.
>
> The Soviet report gives estimates of doses of radiation to the residents in some communities between 5 and 10 km away from the power plant. In these communities,

the highest radiation dose from the radioactive cloud was 0.1 Sv. The doses to the thyroid gland in children were between 0.25 and 2.3 Sv.*

In the power plant, the situation for the workers was more serious. At the time of the accident there were 3 people in the control room and 4 or 5 people in the turbine hall. Two people died immediately. One of them has never been found and the other died of burns.

At 6 in the morning [the Saturday] on 26 April, 108 workers had been sent to hospital, suspected as having been exposed to life-threatening doses of radiation. In all, it is said that 300 workers were sent to hospital to be examined. Some of them were employees at the power plant and some were fire personnel who made heroic attempts to fight the fire in the reactor. It turned out that 203 people had acute radiation sickness [according to UNSCEAR 2000, the number was lower, 134]. These were divided among four grades as follows.

Grade	number to hospital in Kiev	Moscow	Estimated doses of radiation, Gy	Number dead 25 August 1986
4	2	20	6–16	21
3	2	21	4-6	7
2	10	43	2-4	1
1	74	31	1-2	0

The treatment of the patients with radiation injuries at grades 3 and 4, i.e., with doses of radiation in excess of 4 Gy, was complicated by the fact that the irradiation was very uneven, with severe skin injuries from beta radiation and heat; 26 of the deceased at in these grades died between 10 and 50 days after the accident. In several cases the skin injuries themselves were fatal. Attempts to perform bone marrow transplants were therefore not effective.

The reactor building was completely demolished. The graphite in the reactor core burned and the core continued to emit radioactive substances with the flue gases since the temperature was close to 2,000 degrees Celsius. However, the emissions lessened during the first few days when rescue workers began to swamp the wrecked reactor with boron, lead, sand and clay and eventually cement to enclose it. But on 2 May the temperature rose in the reactor core and thereby the emissions began to increase once again. From 2-5 May, large quantities of radioactive substances leaked out in this connection, a total of double the amount of activity of 26 April. However, these emissions did not travel as high and were initially distributed south with the winds, but eventually also reached Sweden (on around 9 May). The leak was successfully largely stopped on 6 May.

...

The increased doses of radiation in the nuclear power plant's surroundings meant that after a few days, the whole of the surrounding area up to a 30-km radius was evacuated with another 90,000 people being moved in addition to those [45,000 people] who had already been moved from Pripyat.

I wrote the following about the situation in Sweden:

Substantial inputs from primarily the Swedish Defence Research Establishment and *Sveriges Geologiska AB* (the Swedish Geological Survey), including measurements taken all over Sweden by aircraft, made it possible to chart the distribution of the radiation better and better. ... With the knowledge of which radioactive substances were

* The radiation exposure of the thyroid gland in children quite a long distance away from Chernobyl brought a radiobiologically unexpected result – fairly soon, a surprisingly large number of children got thyroid cancer, the only injury to definitely be proven over and above the acute radiation effects.

> in the fallout and of their lifetime, it was possible to estimate the collective radiation dose to Sweden's population due to gamma radiation from the ground for an indefinite time. The estimate is ... very uncertain but is around 10,000 man-Sv.
>
> With radiation protection's ambition to eliminate every man-Sv at a cost of up to 100,000 Swedish kronor if this is possible, this would justify a protection contribution of 1 billion Swedish kronor. Unfortunately, it is not possible to reduce the collective radiation dose drastically for that amount (after all, the average equivalent is just 100 Swedish kronor per Swedish person). We must therefore reckon that the collective radiation dose from the gamma radiation in the ground is largely unavoidable.
>
> With the risk factors that were previously discussed, the ground radiation could thus be expected to cause some 400 cases of cancer plus 40 cases of hereditary injury over the next two generations. Of the cases of cancer, approx. 120 would be anticipated to be fatal. It should be emphasised that knowledge of the actual extent of the risks does not justify exact figures, but these are the figures you obtain when calculating using the ICRP risk factors.* The collective dose and expected cases of cancer from the inhalation of radioactive substances or direct radiation when the radioactive cloud passed over do not change the estimated impact. However, in addition there is the collective dose that comes from consuming foods contaminated with radioactive substances.
>
> ...
>
> Thus, what still has to be discussed is the radiation dose from the radioactive contamination of foods. This can be greatly influenced by protection inputs and is generally expected to be smaller than the dose due to gamma radiation from the ground covering.

I also wrote in the report that the critical nuclides during the first few weeks following the contamination of crops and thereby foods were the isotopes of iodine, primarily iodine-131 with a half-life of 8.1 days. Later, the radioactive isotopes of caesium become the most significant.

Luckily, not that many animals had yet been let out to graze in the most affected areas, so this reduced the risk of milk being contaminated by iodine-131. However, in some places the action level for intervention against contaminated milk, 2600 Bq/l, stated by the Radiation Protection Institute (in other measurement units) in its recommendations to the County Administrative Boards in 1962, could be exceeded. Bearing in mind that contamination with iodine-131 could not be long-term, the Radiation Protection Institute recommended that the farmers keep dairy cows in stalls and feed them with clean food for a while. As a consequence, the milk sold was shown to contain only low levels of iodine-131.

The problem was worse for the isotopes of caesium. The Swedish Radiation Protection Institute's recommendations to the County Administrative Boards in 1962 stated the action level to reject milk which had been contaminated with caesium-137 as 0.15 microcuries per litre, which in today's units is approx. 5,500 Bq/l. Immediately after the accident (from 2 May), when there was concern about temporary contamination of imported foods, a provisional limit of 10,000 Bq/l was applied to the imported foods. An action level of 300 Bq/kg was later applied in Sweden when foods had been contaminated with radioactive caesium. The situation was complicated by the fact that the contamination from the Chernobyl accident contained two isotopes of caesium, caesium-134 and caesium-137. There was much confusion where these values were concerned. I attempted to clarify the situation in *Vår Föda*:

> Radioactive caesium follows potassium and is taken up in the muscle tissue but excreted from the body comparatively quickly; a 'biological' half-life between 50 and 200 days is assumed for adults and a shorter one for children. According to ICRP Publication 30, the two dominant isotopes of caesium, caesium-137 with a 30-year half-life and caesium-134 with a 2.1-year half-life, have dose factors which are 14 and 20 nanosieverts per becquerel respectively. This means that an annual intake of <u>either</u>

* The risk factors are now assumed to be greater, with a factor of 2-4 depending on what is referred to.

75,000 Bq of caesium-137 or 50,000 becquerels of caesium-134 is needed to generate an annual dose of 1 mSv.

During the first year after the Chernobyl accident, when caesium-137 was always accompanied by approx. 50% [in terms of activity] caesium-134, one can calculate the radiation dose generated jointly by caesium-134 and caesium-137 to be approx. 25 nSv/Bq caesium-137. Because caesium-134 also gives a dose contribution, an annual intake of 40,000 Bq of caesium-137 will therefore lead to an annual dose of 1 mSv. Later, when caesium-134 has disappeared, an annual intake of approximately 75,000 Bq is needed to give the same dose.

ICRP does not state a dose factor for children*. However, the UK National Radiological Protection Board (NRPB) had stated dose factors for infants that were as high as 70-80 nSv/Bq. The Swedish Radiation Protection Institute therefore initially cautiously assumed 100 nSv/Bq for infants. It was later shown that the NRPB's dose factors were too high. Children excrete caesium more quickly than adults and no tangible differences have been found in radiation doses for children and adults for one and the same caesium intake.

The fallout situation for caesium-137 did not start to become clear until sometime in May. The ground covering was surprisingly high. In Sweden, the measurement in a contamination sample at Tärnsjö on 30 April was 65 kBq/m^2 and 120 kBq/m^2 in Gävle on 9 May. ... By comparison, it is worth mentioning that the deposition of caesium-137 from all nuclear weapons testing has been rated by UNSCEAR at an average of around 5 kBq/m^2 at 40^o – 50^o latitude in the northern hemisphere.

According to [the Radiation Protection Institute's report] 'More effective emergency preparedness', between 5 and 40 Bq of caesium-137 per litre of milk are expected with a ground deposition of 1 kBq/m^2. The values of 100 kBq/m^2 [as in Gävle] could thus be expected to lead to caesium levels between 500 and 4,000 Bq/l. The question was whether it was then appropriate to bring out the stalled cows when the risks of iodine-131 were over.

If one used (the overestimated) dose factor of 100 nSv/Bq for caesium-137 for infants, with previously-recommended action levels, these would receive doses of radiation that were too high. In mid-May, the Radiation Protection Institute estimated that a reasonable action level for the rejection of foods ought to be an annual dose of a total of 5 mSv from all contaminated foods during the first year. With the dose factor of 100 nSv/Bq, which in the first year meant a four-fold overestimation, an annual dose of 5 mSv would correspond to an intake of 50,000 Bq, i.e., an average of 140 Bq/day if you did not take into account the fact that there was also a dose from caesium-134, which was initially disregarded. With the right dose factor for the combination of caesium-134 and caesium-137, i.e., 24 nSv/Bq of caesium-137, the annual intake corresponding to the annual dose of 5 mSv would be as big as 200,000 Bq†.

However, the Swedish Radiation Protection Institute, unaware that the NRPB's value was incorrect, worked on the basis of an annual intake of 50,000 Bq, i.e., 140 Bq/day. Assuming that infants might drink half a litre of milk per day, the action level became 280 Bq/l or, rounded off, 300 Bq/l. The 'correct' value, assuming that the dose factors for infants and adults are equal and want to work on the basis of

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* That was then. Since then, the values have been stated in ICRP Publication 74 (1996) on *Age-dependent doses to members of the public*. This states the dose factors for caesium-134 as 19 and 16 for adults and infants respectively (1 year old) and for caesium-137 as 13 and 12, all in nSv/Bq.

† Because two isotopes of caesium were present in the fallout, care had to be taken in selecting dose factors. Let's say that the relevant dose factor for caesium-137 is 14 nSv/Bq and for caesium-134 is 20 nSv/Bq for infants and adults. If you reconcile yourself to applying 14 nSv/Bq to the activity of caesium-137, you disregard the radiation dose from caesium-134 as the Foods Agency had done. If you want to take into account caesium-134 but apply a dose factor to the activity of caesium-137, it should be $14 + 0.5\times20 = 24$ nSv/Bq. If you want a dose factor to apply to the total activity of caesium-137 + caesium-134, it should be $24/1.5 = 16$ nSv/Bq. You can obviously also apply the dose factors 14 and 20 nSv/Bq directly to the activities of caesium-137 and caesium-134 respectively, but that requires more advanced measurements.

the annual dose 5 mSv and also take into account caesium-134, ought to have been 1,100 Bq of caesium-137 per litre. But 5 mSv per year may have been too high a value.

The Swedish Food Agency took on the Radiation Protection Institute's recommendation and interpreted it as though 300 Bq/kg applied only to caesium-137. With that interpretation and the incorrect dose factor, the annual dose for the action level would have been approx. 8 mSv instead of the Radiation Protection Institute's guideline value of 5 mSv.

For the isotopes of caesium, milk was the critical food for usual consumers, but some foods could show particularly high caesium levels, primarily reindeer meat but also meat from moose and roe deer, sheep and goats, freshwater fish and mushrooms. However, these foods were not dominant in the diets except for certain groups such as Saami, hunters and freshwater fishermen. However, the action level 300 Bq/kg was recommended for all foods.

The doses of radiation were particularly high for the reindeer-herding Saami. However, caesium levels exceeding 300 Bq/kg had previously been shown because of the nuclear weapons testing. The action level applied at the time had concerned only milk. In the worst contaminated areas, Saami whose basic food was reindeer meat could then receive an annual radiation dose of tens of mSv, i.e., on a level with the dose limits for those working with sources of radiation, if they ate half a kilo of reindeer meat every day. The Saami were therefore now advised to watch their consumption of reindeer meat while the reindeer meat did not constitute a danger to those who ate reindeer meat only occasionally.

The Swedish action level was criticised as being too low (which it did mistakenly happen to be compared with the one that was applied in other countries), but Gunnar Bengtsson had support from the Minister for the Environment Birgitta Dahl for a cautious policy. It was important for the consumers to have confidence in the authorities' protection measures. However, in the paper in *Vår Föda* I attempted to clarify that it was the total intake of the isotopes of caesium that was significant rather than the concentration in different foods.

Professor Carl Erik Danielson reviewed my contribution to *Vår Föda* in a consumer magazine under the heading 'Commonsensical thoughts about Chernobyl'. He wrote:

> There is not enough room here to give a detailed account of the content. A recommendation to obtain the paper in question will have to suffice.
>
> However, I cannot help but quote some of the most commonsensical sentences that were spoken in this context:
>
> 'Worrying about the contamination of foods like dill, parsley and morels is therefore unnecessary. For the ordinary consumer, this applies also to the contamination of moose, roe deer, reindeer and freshwater fish. On the other hand, there are groups for which these foods really are staple foods, and that is when it is necessary to respect the action level'.
>
> Most of it has been said with that. The Swedish Food Agency should have made this announcement long ago. Instead, it sent out one of its higher officials – a Professor – together with a photographer to pick blueberries in the Gävle region. How inappropriate can you get.

20.12. **A Radiant Spring', Sven Löfveberg's book**

When the Chernobyl accident occurred, the Swedish Radiation Protection Institute's head of information Sven Löfveberg had just begun a two-week holiday. 'There's a lot I want to get done during my free days. I'm going out into the country to spring clean, tidy up and things like that. I'll sit on the veranda and edit the manuscript for my children's book'. This is what he writes in his book, 'A radiant spring', which is about his experiences during the Chernobyl accident.

When too many journalists had called him at home on Monday 28 April and disturbed his holiday he gave up:

I ring my colleague [at the Radiation Protection Institute] and ask resignedly what has happened, what the power plant is called and whether we must increase our preparedness.

So, Chernobyl becomes a new name on the map for me.

I find out from my colleague that the Radiation Protection Institute is to stay open all night and that loads of measurements are already being taken.

'So do I get to sleep tonight?' I ask cautiously.

'Sleep, you may need it,' she replies. 'There's a possibility we may not get a full night's sleep for some time to come.'

Sven took notes in the first few weeks and obtained material for his book. It is an attempt to describe the events at the Haga Court of Justice and the other places in a down-to-earth way, with expressing the thoughts and concerns of ordinary, troubled people. He simplifies the explanations of many difficult concepts. But Sven was starting to worry about the Radiation Protection Institute. He wrote:

In a west coast newspaper I read:

There are still plenty of questions out in the field while the information from the governmental authorities are at an academic level which is light years from the reality that is practically applicable.

I am inclined to agree. In the twenty years I have now worked with radiation protection, the central authority has slowly removed itself from the practicality of life. We used to have inspectors who for several months a year travelled to hospitals and industries all around the country. We also had a clinical department which worked at *Radiumhemmet*. All of this gave us close contact with the people working in the field.

The inspections have now largely been decentralised, which is probably a good thing. However, at the same time the Institute has become a forum for the specialists. We occupy ourselves with comprehensive risk assessments and advice. The danger is that we will have less and less contact with the practical radiation protection work. Gunnar Bengtsson sometimes dreams of a central agency of nothing but very well-qualified colleagues with substantial specialist knowledge. I see before me an ivory tower that ordinary people cannot reach. An institution that is slowly killing itself.

As luck would have it, we have some brilliant exceptions from this effort. Not all inspectors and physicists have yet lost contact with reality. Even none other than Gunnar Bengtsson wants to have good contacts at grass roots level. However, several of us at the institution feel some concern for the future and for the ivory tower on the horizon.

20.13. **Armand Hammer and Robert Gale**

In June I received a strange telex from Los Angeles. It was sent by Armand Hammer and Robert Gale. They both need to be introduced.

Armand Hammer (1898-1990) was 88 years old at the time and an incredible character. His father had taken part in the formation of an American communist party, himself being the multi-billionaire owner of the huge oil company Occidental Petroleum Corp., a remarkable contrast. Hammer had already visited the Soviet Union in 1921 and, thanks to his father's communism, made good contacts with the country's leader. He stayed for almost ten years and developed an extensive business activity while strengthening his relations with the communist leaders. This meant that the American capitalist and industry magnate Hammer was free to act in the Soviet Union throughout his life, which made him think that good business contacts constitute a route to peace and *détante*.

Robert Gale was a young Assistant Professor at UCLA's Department for Haematology and Oncology and an internationally-renowned expert on bone marrow transplants. He was also power-hungry and resourceful and had probably contacted

> Hammer for economic support for a study on the health effects of the Chernobyl accident in the Soviet Union.

The telex I received from Hammer and Gale was an invitation to take part in an expert meeting whose objective was to draw up recommendations for a cooperation initiated by Gale. Twenty-two people would attend the meeting at Occidental Petroleum's office and their names were shown on the telex. I recognised most of them: Dan Beninson, Hans Blix, Michael Fry, Seymour Jablon, Charles Land, Sir Edward Pochin, Morris Rosen, I. Shigematsu, William Schull, Giovanni Silini, Warren Sinclair and Arthur Upton. Most of them were radiation biologists; Hans Blix was on the list because he was Director General of IAEA.

The meeting did not show any great enthusiasm for the proposal since Gale's ambition was evidently to assist the Soviet Union with bone marrow transplants for those who had been harmed by radiation at the time of the accident. Many of us remembered previous poor experiences with bone marrow transplants following the Vinça accident and to a member of the crew of the 'Lucky Dragon'. The transplants could be effective within only a fairly narrow dose area. At lower doses they did more harm than good and at higher doses they were pointless.

I experienced an earthquake during the night while in Los Angeles. There I was in my hotel room being woken up by the wardrobe starting to dance on the floor, which made me wonder. But I was not awake enough to take the trouble of investigating the phenomenon further so I slept on. I heard about the earthquake in the morning.

Robert Gale went to Russia with instruments and support from Hammer but, according to my Russian colleagues, his transplants made no difference. Armand Hammer on the other hand did. After a meeting with Professor Ilyin, he granted the latter's request for equipment worth 500,000 dollars to examine irradiated children. The equipment was flown to Moscow using Hammer's private aircraft.

20.14. **Chernobyl – myth and reality, Professor Ilyin's book**

In 1995, the former ICRP member Leonid Ilyin in Moscow published a 400-page book in English entitled *Chernobyl: Myth and Reality*. It is an outspoken and critical account of the events in the Soviet Union following the Chernobyl accident and ought to be read by everyone who has the slightest interest in preparedness work. Ilyin ascertains that in the nuclear arms race the Soviet Union, like the USA, had developed an all-embracing secretive culture which, in principle but not in reality, had been softened by the *glasnost* (openness and dissemination) introduced by Mikhail Gorbachev in 1985. This is what Ilyin wrote about it:

> So, during the period when public awareness in the country was gradually freeing itself of its shackles, other tendencies essentially prevailed when it came to 'Chernobyl secrets'.
>
> ...
>
> When the accident at the Chernobyl nuclear power plant had occurred, the national tried-and-tested secrecy system was put into action with no modifications.
>
> ...
>
> Although at the time of the Chernobyl accident a radical social and political reform had started in this country, attended by glasnost, the government's secrecy system continued to function as before, uninfluenced by these events.
>
> ...
>
> At the same time I would like to emphasise that, in spite of all bans related to Chernobyl, healthcare personnel from the various counties did succeed in organising a mutual exchange of professional information, mostly on unofficial grounds.

Ilyin ascertains that the first scientific estimate of the impacts of the accident was made by the group that was convened by WHO in Copenhagen on 6 May with Dan Beninson as Chair. The next major analysis was carried out at the meeting arranged by IAEA in Vienna in the last week in August. The Soviet delegation had brought with it a reviewed and approved report. Ilyin writes:

> Just before the departure of the big Soviet delegation, accompanied as usual by a KGB man, we were told that no information beyond that which was in the report should be given during the conference. The next morning when we arrived in Vienna we made our way to the city's International Centre where a large number of people had gathered in the big conference room, the world's leading scientists and nuclear power experts. The atmosphere was tense with anticipation of important events; what would the Russians say about the explosion?
>
> Following a short statement by Hans Martin Blix, Director General of IAEA, the Soviet delegation led by Academy member Valery Legasov was introduced and the reporters were asked to leave the room. Then it was Legasov's turn to speak. Clearly embarrassed, Valery stepped up to the podium and spoke for five hours, with just one break, about the content of the report. There was no disputing that it was a remarkable address. The auditorium was literally shocked by the frank way in which Legasov presented facts and the self-critical tone of his statements. No-one appeared to have expected such exhaustive and detailed information on the explosion at reactor no. 4. At a plenary meeting the next day, a representative of the State Committee of Hydro-meteorology presented data on the radiation situation. I spoke about prognoses and about the radiation protection measures that had been taken, and A. K. Guskova's presentation was about the results of the treatment of patients who had been affected by acute radiation sickness. Several task groups were formed with foreign experts who would give their points of view on data and observations presented by the Soviet side. All material from the conference and the experts' statements was then immediately published by IAEA.
>
> ...
>
> The results of the conference were published in the Soviet Union as they were reported by the media, and I had the impression (although I may have been mistaken) that they did not arouse any interest or reaction in either Moscow or the provinces. This was clearly because of the public apathy and indifference which had been encouraged for decades. This was the Gorbachev period and there were still no election campaigns in sight. There was still no political activity among different social groups and the secrecy rules still applied when it came to the Chernobyl accident.

The next international evaluation of the Chernobyl accident took place in 1989 when, on request, WHO sent three experts (Dan Beninson, Pierre Pellerin and *Peter Waight*) on a round trip of the Soviet Union (see chapter 23). The next big evaluation, the international Chernobyl project, was reported in 1991 (see chapter 25).

In his book, Ilyin also discusses the matter of the number of deaths in the group of workers (the 'liquidators') who cleared up after the accident. It had been said that between 6,000 and 8,000 clean-up workers had died as a consequence of the accident. Ilyin examines the question thoroughly. He found that the number of deaths stated was correct, but that it was a question of the number of deaths that would have been expected among the group without the Chernobyl accident having taken place. No excess mortality had been proven and nor had any been expected. But the claim concerning thousands of deaths among the clean-up workers is still circulating, the urban myth for the risks of radiation.

20.15. **Ill due to Chernobyl?**

An editorial with the headline 'Ill due to Chernobyl' by *Dagens Nyheter* in December may be suitable to conclude the account of the major nuclear power catastrophe:

> The Swedish Medical Association's annual general muster is currently ongoing in Älvsjö. Thousands of doctors have been gathered from all over the country.
>
> ...
>
> On the Wednesday, the section for medical radiophysics invited people to a symposium on 'Chernobyl – health risks for Sweden's population?'; the subject was highlighted with admirable clarity from both the physics and the medical points of view.

To put it simply, the dominant impression from the experts' presentations and the opinions they exchanged was that luckily, the question intimated in the headline can essentially be answered with a no. Various people have actually maintained this for some time; on the other hand, as we know, the opposite has been energetically claimed in the public debate.

'Firstly you issue provisions on how we must protect ourselves against something and the next day we hear that it is not dangerous' was the brilliant way that the discussion leader Professor Sören Mattsson drastically summarised the information that had been made available.

...

An essential contribution by Professor Bo Lindell reminded us that people must remain level-headed in the face of the guideline values for this or that number of becquerels so eagerly paraphrased; they are only a means, not an aim. The aim is to keep the total intake at a reassuring level. The grotesque example is obviously the fear regarding meat from moose and reindeer; with the exception of the Saami, it is practically impossible to find a single person who will consume enough of these expensive delicacies to bring him anywhere near a risk zone.

The cure should not be worse than the ailment. Or, as Mr. Lindell quietly pointed out: a safety action should not be tailored so that it leads to greater harm than the risk you want to prevent.

There is a difference between a recommendation to wash your vegetables and an order to evacuate a town.

20.16. **Mordechai Vanunu and Israel's nuclear weapons programme**

In September 1986, *Mordechai Vanunu*, a 32 year-old Israeli technician, revealed large parts of Israel's strictly secret nuclear weapons programme. Vanunu was born in Morocco but came with his family – his father was a rabbi – to Israel at the age of nine. They lived in Be'er Sheva in Negev where Vanunu also received his technical education and also studied at the university. He was employed by the nuclear plant in Dimona. At the university he had been interested in politics and had begun to criticise Israel's action against the Palestinians. His sympathy for the Palestinians lost him his job after eight years. He was appalled at Israel's increasing nuclear weapons arsenal at the time and worried about the development. He decided to reveal the ongoing activity and, on leaving Dimona, he had taken 60 or so colour photographs of what was going on in the secret subterranean premises.

Having emigrated to Australia, Vanunu travelled to London where he was in contact with the *Sunday Times* and showed his photographs and told them about Dimona. He was asked detailed questions by a nuclear physicist, who confirmed his statements. While the cautious *Sunday Times* continued to reassure itself that Vanunu's claims were sustainable, Vanunu was tempted by a female Israeli agent to travel to Rome where he was kidnaped by Israelis who took him to Israel. The *Sunday Times* published Vanunu's story on 5 October 1986. Vanunu was brought before a court in Israel in August 1987 and was sentenced to 18 years in prison. The surrounding world has viewed him as a hero. In Israel he is considered to be a spy and a traitor.

Vanunu's revelations and photographs have been examined and accepted by nuclear physicists and weapons experts. He reckoned that Israel had produced between 100 and 200 fission weapons up until 1986. According to Vanunu, the solid plutonium spheres for the bombs weighed 4.4 kilogrammes. He revealed for the first time the subterranean plutonium separation plant which produced 40 kg per year, several times more than previous estimates. The weapons shown in Vanunu's photos were so sophisticated that the experts thought it was necessary to perform nuclear tests.

20.17. **Letter to Mostafa Tolba**

As future Chair of UNSCEAR I naturally continued to feel concern about the Committee's problem with resources and a responsibility to improve the situation. On 13 October I wrote a letter to the head of UNEP, Mostafa Tolba:

Dear Dr. Tolba,

This is a personal letter rather than an official one. As you may know, I have been elected Chair of UNSCEAR from its next meeting, which is to be held in Vienna in March 1987. Formally, I am still only the Swedish delegate for UNSCEAR, but I am of course interested in the preparations for the meeting of which I will be Chairman. I am therefore writing to you in the hope that you are not against my involvement.

The tragic accident at the Chernobyl nuclear power station has aroused concern in many countries. Estimating the radiological impacts of the accident indisputably falls within the boundaries of UNSCEAR's assignments to assess doses, effects and risks from radiation on a worldwide scale. I have heard that during the discussion of the Committee's annual report to the UN's General Assembly this autumn, a number of delegations expected UNSCEAR to include this estimate in its next extensive scientific report, which is planned for 1988. The International Atomic Energy Agency and the World Health Organisation have both already requested information through their respective channels from the Member States about environmental contaminants and doses of radiation, and have worked on the basis that the information they receive will be used by UNSCEAR in its 1988 report.

However, as you well know, UNSCEAR's budget has already been stretched to breaking point because of the work that was started before the Chernobyl accident occurred. This places the Committee in a very difficult position.

...

On this basis, I am writing to you with a personal appeal for assistance. If it were possible for UNEP to immediately put up funds, this would solve the current problems. I know you are interested in UNSCEAR's work and know about the situation the Committee is in. That is why I am taking it upon myself to write this somewhat unusual letter regarding the urgent matter.

...

20.18. **A peek into the future**

So what happened? Did the qualms of the apprehensive about the impacts of the Chernobyl disaster come true? Were the experts' expectations met? The reader may find it interesting to look at what WHO, the World Health Organisation, said in a 'fact sheet' twenty years after the accident, in April 2006 to be more precise, following an investigation report which was presented at a conference in Vienna in September 2005 by IAEA, WHO, FAO, UNSCEAR and UNEP in cooperation with the governments of Russia, The Ukraine and Belarus. In the years that had passed, the Chernobyl accident had captivated the interest of the media time after time and in particular the qualms of the apprehensive had been reproduced as though they really had come true. There were particular discussions about cases of cancer among children and a supposed substantial fatality among those who had been summoned to do the clean-up work, the so-called 'liquidators' (from *liquidate* in the sense of to neutralise). In 1986-1987, 350,000 people from the army, fire brigades and the power industry had worked to clear and clean up, approx. 240,000 of whom had worked within a 30-km distance of the reactor. The latter received doses of radiation which on average were more than twice the amount that would normally have been permitted in radiation work. Later on, 600,000 clearance workers were registered but by that time the doses of radiation were significantly lower.

In addition to the clean-up workers, the 116,000 people who were evacuated in 1986 received doses of radiation which, on average, exceeded 30 mSv. The 270,000 people who were still living in the relatively heavily contaminated areas received a total of more than 50 mSv from 1986 - 2005.

According to WHO, in these groups, including the clean-up workers, you could expect a total of around 4,000 extra cases of cancer due to the radiation, an increase of 3 – 4 % over and above the normal number. The considerably larger numbers of cases of cancer which, due to ignorance, have been attributed to the reactor accident are no higher than the numbers that normally occur. Cancer is a common cause of death, and the idea of people being led to believe that all cancer they hear about has been caused by the radiation is no surprise. However, no major increases in the normal fatality level have been observed.

More remarkable and completely unexpected are the surprising number of cases of thyroid cancer among those who lived in the most contaminated areas and who were children when the accident occurred. According to WHO, so far, 5,000 people have been affected by such cancer. Luckily there are good treatment options, but up until 2002 it is still said that 15 of those affected have died.

Extra cases of cancer are expected among the public who were exposed to low doses of radiation, but the likelihood in each individual case is so low that it is not thought possible to prove the increase by the cancer statistics. It may be a question of a total of tens of thousands of cases, but we will probably never know whether this will become a reality. No increase has been proven, but we do also know that the latency times for radiation-induced cancer are a matter of decades.

20.19. **North Korea's plans for nuclear weapons**

North Korea, which already had plans to procure nuclear weapons during the 1960s and was supported first of all by the Soviet Union and then by China, started a small nuclear reactor in Yongbyon in 1986 with the option of producing plutonium. The reactor was closed in 1994 following an agreement with the USA where North Korea promised not to develop nuclear weapons. The promise was broken in 2002 when the reactor was restarted.

20.20. **A Ministry of the Environment and Energy**

In October 1986 a new Ministry of the Environment and Energy was formed in Sweden with Birgitta Dahl in charge.

20.21. **Fusion energy**

There have long been great expectations regarding the possibility of extracting *fusion energy,* i.e., producing energy by fusing light atomic nuclei, rather than splitting heavy nuclei to produce *fission energy* as happens now in nuclear power plants. The advantages lie in the much greater access to 'fuel' and a virtual absence of disaster risks and difficult-to-solve waste problems. The disadvantage is that a solution has not yet been found regarding its actual application. The difficulty is that it requires temperatures of up to one hundred million degrees; the reactor has to imitate the sun on a small scale. This is probably a good place to give an account of the difficulties.

Atomic nuclei consist of nucleons, a collective name for protons and neutrons. These are held together by forces, so there is a need to exceed a *binding energy* to split the nucleus into its constituent parts. This is what makes the total mass of the nucleons slightly greater than the mass of the nucleus, and this is called the *mass defect*. The mass defect and the binding energy are two forms of the same quantity, expressed by Einstein's formula $E = mc^2$. You can thus calculate the one from the other.

The binding energy (the mass defect) per nucleon is at its greatest for medium-weight atomic nuclei such as for iron. These are therefore the most stable. It is at its least for the lightest atoms like the isotopes of hydrogen as well as for the heaviest atoms, like isotopes of uranium.

This means that a surplus of energy is emitted if you split the heaviest atomic nuclei (fission) or combine the lightest (fusion). The fission can be brought about in neutron-induced chain reactions, i.e., the reaction gives rise to new neutrons. The fusion is generated by increasing the kinetic energy of the atomic nuclei (isotopes of hydrogen such as deuterium and tritium), i.e., through heating, so that they can collide with one another. Since atomic nuclei have positive electric charges they repel one another and therefore have to be given very high speeds. The problem is that this requires extremely high temperatures, up to one hundred million degrees.

This is something that no construction material can tolerate. At such high temperatures, electrons and atomic nuclei behave like free charged particles; they are said to form *plasma*. The plasma must not come into contact with any construction material. This problem can be solved by keeping the plasma freely floating with the assistance of magnetic fields. Various technical solutions are being tried for this, primarily using a *tokamak* or a *stellarator*. The plasma is confined in a torus surrounded by magnetic coils.

The greatest tokamak reactor, the ITER (International Thermonuclear Experimental Reactor), is being built in Cadarache in the south of France at a cost that is said to be ten billion Euros. Experiments with ITER are not expected to start seriously until a good way into the 2020s.

Professor *Hannes Alfvén* (1908-1995) at KTH began plasma research as early as the 1950s, which resulted in a Nobel Prize in 1970. Enthusiastic plasma research has also since been done in Sweden by *Bo Lehnert* (1926-), also at KTH. Fusion research also takes place at Chalmers.

Unfortunately, it is easier to use the fusion energy in nuclear weapons than in peaceful reactors. I have written about the thermonuclear bombs (the hydrogen bombs) in the 1960s in *'The Labours of Hercules'*.

20.22. **No change to the risk assessment**

In November, the Energy Agency explained that the Chernobyl accident had not led to any change in risk assessments for the Swedish nuclear power plants. The Russian power plant was of such a different design that the accident led to no conclusions for the situation in Sweden.

20.23. **The testing of computer monitors**

A big international conference on VDU monitor work (Work with display units 86) was held in Stockholm in 1986. The conference was truly multidisciplinary and dealt with all aspects of work-related problems with what was, at the time, recently-introduced computer technology in offices. The radiation protection matters dominated the public's and the press's interest. The then Labour Market Minister *Anna-Greta Leijon* and Lars-Erik Paulsson of the Swedish Radiation Protection Institute held introductory talks.

At Leijon's initiative, the government asked the Swedish National Council for Metrology and Testing (MPR) in Borås to develop a standard for test methods for monitors. The Radiation Protection Institute came up with the necessary measurement methods through Lars-Erik Paulsson and became authorised monitor testing centre in 1987.

Monitors were tested for five years and this led to a considerable enlargement in the Radiation Protection Institute's technical resources within the area of non-ionising radiation. The test centre constituted a prototype and a good example of the application of MPR standardisation. By the end of the 1980s, the Radiation Protection Institute was the world's centre for this matter, which resulted in innumerable study visits and consultations from authorities, test centres and manufacturers.

At the start of the 1990s, commercial test centres had been established, in Sweden at SEMKO[*], among others, which is why the Radiation Protection Institute's test activities were phased out. The accreditation ceased in 1994.

[*] SEMKO AB was formed in 1925 as *Svenska Elektrisk Materialkontrollanstalten AB* and is part of the international Intertek Testing Services (ITS) which is active in 80 or so countries. Until 1990, SEMKO was written before what was then the obligatory S-mark for electrical equipment. SEMKO is now in Kista.

21. THE YEAR 1987

21.1. UNSCEAR's main text for its 1988 report

In January I was in Vienna as consultant for Giovanni Silini to write a draft for the main text in the 1988 UNSCEAR report. I had applied for a room at the *Pension Sacher* on the corner of Rotenturm Strasse and Stephansplatz. 'Applied' was the right word because the owner, Frau Sacher of the well-known café dynasty, demanded to interrogate me to ensure I was suitable whereby I was approved as a border, probably to some extent aided by my title of Professor. The accommodation I would rent for a couple of weeks was an apartment with bedroom, living room and kitchenette. The view over Stephansplatz and the cathedral was impressive and I could have done the work in the room. I did not do so on this occasion because I travelled every morning to the VIC (Vienna International Centre) and UNSCEAR's Secretariat where Silini had given me a workroom.

We had agreed that the main text for the report should consist of two parts. The first was an historic overview and the second gave an account of the current situation.

21.2. Thank you for the inputs

SSI-Curieren (the house magazine of the Swedish Radiation Protection Institute) said the following in January:

> Many thanks to Helène [Sundewall] and CG [Junback, the Swedish Radiation Protection Institute's head of administration] for a productive and pleasurable affair at *Piperska muren* [conference centre].
>
> There were approx. 250 of us, headed by the Minister for Environment and Energy Birgitta Dahl, who had gathered for a 'Post-Chernobyl party'.
>
> It all began in the afternoon with accounts of the experiences which the Chernobyl work had given. The speakers included the Swedish Accident Investigation Authority's Director General Göran Steen and Professor of Psychology *Göte Hanson*.
>
> Then followed a well-planned dinner which started with whitefish in aspic followed by a main dish of reindeer steak and ice cream with cloudberries for dessert. As well as all this we got to dance to the band that was playing, 'The Fossils', headed by Tore Nilsson from the Nuclear Power Inspectorate.

21.3. 'The Act prohibiting preparations for new reactors'

The Chernobyl accident also led to legal problems in Sweden. The Minister for Environment and Energy Birgitta Dahl implemented a change to the Nuclear Activity Act (1984:3). The new wording of Paragraph 6 of the Act read:

> No-one may produce design drawings, calculate expenses, order equipment or take other such preparatory measures for the purpose of erecting a nuclear power reactor in the country.

The change became valid on 1 February 1987. It was strongly criticised by technicians who thought that it prevented the emergence of safer nuclear reactors. The opposition parties' sarcastic name for it was ‘the Act prohibiting preparations for new reactors’. It remained valid for almost twenty years before it was annulled through a change to the law which became valid on 1 July 2006. During that period, when there were no major reactor accidents, the Swedes began to be less afraid of nuclear power, which was heavily highlighted by a turnaround in *Dagens Nyheter’s* editorials from Olle Alsén’s opinion-strengthening nuclear power opposition to pronounced nuclear power optimism which was marked by a turnaround editorial on 26 April 2006 under the headline ‘Twenty years of misunderstanding’.

21.4. **The King and Queen visit the Radiation Protection Institute**

A press cutting from the end of 1986, whose source I have not succeeded in identifying, discussed a visit that the King and Queen did not make to the Radiation Protection Institute. The text read:

> The King and Queen never got to meet head of the Radiation Protection Institute Gunnar Bengtsson in Solna yesterday.
>
> A bag got in the way.
>
> One of the Solna police patrol cars drove past the Institute’s premises in the old Court of Justice. The patrol noticed a bag underneath a car and the car next to it had been broken into. Bearing in mind the impending visit, the police decided it the safest thing was to investigate the bag. It could contain a bomb. The whole of the area around the Court of Justice was blocked off and the bomb robot Hunter was requisitioned from the police in Stockholm.
>
> ‘The King and Queen were instructed by the security personnel to wait because the area was being examined,’ said Press Secretary to the Court, Elisabeth Tarras-Wahlberg.
>
> Approximately three quarters of an hour later, the police were able to ascertain that the bag did not contain a bomb; it was more likely to contain goods stolen from the car that had been broken into. At the Institute’s premises at *Karolinska sjukhuset* there was a reception committee which had drawn the short straw. The interruption meant that the King and Queen did not have enough time for the study visit.
>
> Gunnar Bengtsson is now hoping for a visit in January.

It was Friday 13 February. From that visit on the same day I made the following brief notes:

> The King and Queen come to the Radiation Protection Institute at 10.00. BL [i.e., me] shows the Sievert exhibition in the corridor. Then a gathering in the seminar room with the following heads of division and personnel representatives: Gunnar Bengtsson, Jack Valentin, Jan Olof Snihs, Ulf Bäverstam, Klas Bergman, Hans Ehdwall and Britt Ekman.
>
> Gunnar talks about sources of radiation in Sweden; mainly damage from sunlight, then radon. Nuclear power very little but potential risk.
>
> The King and Queen are surprised that the reindeer retain the activity for so long and initially do not understand the difference between physical and biological half-life. Is it not possible to speed up the excretion? Well you can, with clay (bentonite). Do the reindeer eat clay? I say: Yes, if it’s mixed in with their food. If it’s loose, the animals blow it away. The King and Queen: but such a foddering can surely be done on only a limited scale?
>
> The Queen asks whether TVs lead to similar risks to those from computers monitors. Gunnar says yes, but you are sitting further away. The Queen: but children playing video games are sitting close. Gunnar: the risk to those who are pregnant is the worrying thing.
>
> The Queen asks about ‘microwave ovens’. The King smiles indulgently and looks around apologetically. Yes - microwave ovens!
>
> The Queen says: can’t someone explain the business with becquerels and millisieverts – it’s so confusing. Gunnar, a little surprised, says: it’s difficult to explain but I’ll try. Talks about decay per second and joules per kilo, but the King and Queen look lost. Gunnar tries to clarify: joule is the new measurement. Previously, the word ‘calories’ was used; you consume calories when you eat. The radiation also gives off calories. The Queen: but I assume you don’t get *fat* from radiation?

> The King asks if there are enough measurement stations – they're presumably simple enough for there to be many of them? Can't you also have them at airports and already provide warning when the cloud comes? Ulf: that's probably not a good idea. The King looks baffled and insists. Are there any stations on Gotland? Yes.
>
> The Queen asks whether they are satisfied with IAEA's inspection of the safety. [I] want to say that IAEA monitors only the misuse of plutonium, not the safety, but Gunnar averts this by reminding me that the Nuclear Power Inspectorate does exist and should be visited.
>
> The Queen asks about German dry milk and is surprised that there can be such high values in Bavaria. Why weren't they more cautious there? Gunnar calls for international unanimity.

The questions were intelligent and gave an insight into the most common misunderstandings.

21.5. **ICRP meets in Washington DC**

The ICRP Main Commission met in the Pan American Building in Washington DC on 2-6 March. *Hylton Smith* (1927-2001) was now Secretary and had succeeded Mike Thorne with whom Beninson had had personal difficulty. Thorne was knowledgeable and well-qualified but many thought he was immature in his judgement. Hylton Smith had been proposed by John Dunster. Hylton was academically qualified as a biochemist from the University of Edinburgh. Between 1959 and 1969 he worked as a pharmacologist at the medical faculty of Newcastle University. After a short time working as radiation protectionist at the Chapelcross reactor station which he did not enjoy. He spent four years as head of the pharmacology department at the University of Sunderland. In 1973 he was employed as head of the biology department at the relatively new UK National Radiological Protection Board (NRPB). Just before retiring (at the age of 60) Dunster, who was head of the NRPB at the time, made him available to ICRP. After his death in 2001, Dunster wrote in the Journal of Radiological Protection:

> Hylton Smith was a kind man. Faced with a professional conflict, his instinct was to act as a conciliator rather than a participant. But he was also determined and the conflicting participants often found, with some surprise, that they had been influenced by his quiet interventions.

In my letter of 10 April to David Sowby, I wrote:

> As you have no doubt heard from Hylton Smith, the ICRP Main Commission met in Washington DC in the first week of March. Dan tripped over the stone paving, fell and injured his right arm so he was out of action for about one month. Into the bargain, WHO had a total smoking ban in the Pan American Health Building, so poor Dan had a really miserable week.
>
> The temporary solution with Hylton as Secretary of ICRP seems to be working well; the previous problems are now history. Hylton is easy to get on with so that has now relaxed the Secretariat situation, thank goodness. There is still no long-term solution though.
>
> Laurie Taylor, who must be 87 now, was at the meeting and looked the same as always. We also met Harold Wyckoff at an NCRP dinner. He was due to have a heart operation, which he had a week later. It was successful from what I have heard.

21.6. **Alice Stewart and Rosalie Bertell**

In an article for *Dagens Nyheter* on 13 March I wrote about two women who had recently been given a lot of attention in the newspapers as nuclear power opponents. One was *Alice Stewart* (1906-2002) and the other *Rosalie Bertell* (1929-2012). I wrote:

> Last year, two women won the 'alternative Nobel Prize*' for their contributions to research into radiation risks. One of them, the British doctor Alice Stewart, is a recognised scientist. She has an extensive scientific production, certainly with controversial views, but her research colleagues always listen to her, even if they do not agree. Some of what Alice Stewart has concluded forms the basis for today's radiation protection standards.
>
> Rosalie Bertell, the other woman, is not a recognised scientist despite everything that is said about her in the mass media, and lacks credibility.
>
> I have taken the trouble to review the Bertell case. Rosalie Bertell is a scientist in so far as she has been academically educated and has published some scientific papers. However, she is not a biologist – she is a mathematician, and her scientific papers concern statistical methodology. There are not many publications and only a couple concern radiation risks. In my opinion, these papers are inferior from the scientific point of view, which may explain why Bertell has not published anything in scientific journals within radiation biology.
>
> On the other hand, Bertell has been very active in publishing diverse pamphlets, brochures and polemic statements on nuclear power issues. There, she combines correct descriptions of radiation and effects of radiation with sudden statements that are completely without basis or speculations which are made as though they were scientific facts.

I can also endorse this today. I also had some contact with Alice Stewart during the remaining fifteen years of her long life. We had different views on the radiation risks but treated each other with respect. Alice had a sense of humour and seemed to find a certain pleasure in fighting for her views.

21.7. **UNSCEAR in Vienna**

UNSCEAR met for its 36th session in Vienna on 23-27 March. In my letter to David Sowby on 10 April I wrote about the meeting:

> UNSCEAR met during the last week of March. There have been plenty of changes in the delegations. Bob Moseley died a month ago and, to the surprise of many, has been succeeded by Fred Mettler. Julian Liniecki represented Poland since Javorowski was ill.
>
> The next (1988) UNSCEAR report will contain new risk estimates, but it is too early to say what they will be. I sat with the geneticists (I was Chair of UNSCEAR for this session) to try and squeeze some useful estimates out of them, and they might perhaps, for the first time, say something comprehensible.
>
> The day after the meeting, Giovanni [Silini] collapsed and was taken to hospital. Since it is now approximately ten years since he had his big heart operation, he had planned to travel to the USA this spring to have another operation. The meeting was clearly too stressful for him. I have spoken to him on the telephone at the hospital; he is OK now but has a high erythrocyte sedimentation rate which the doctors are unable to explain. This means they have not been able to treat him properly but it looks as though they are keeping him in hospital for observation. This is troubling him somewhat of course because he is eager to travel to the States for his operation.
>
> Dan still had his arm in a sling but controlled the physics sub-group with good humour until the concluding session when Letourneau [the Canadian representative] formally proposed that smoking should be forbidden at the 1988 session (which is to be held in two weeks). The proposal was accepted with an overwhelming majority and the decision was applauded, so Dan is having a difficult time.

* The Right Livelihood Award.

What I did not get around to mentioning to Sowby was that the Committee had increased in number, courtesy of a delegation from the People's Republic of China with Wei Lüxin as representative, accompanied by Professors Li Deping and Wu Dechang. Dr. Wei expressed thanks for the friendly way in which the delegation had been received and said that their participation was of great benefit to the Chinese society.

The Swedish UNSCEAR delegation consisted, as it did at the immediately preceding sessions, of me with Gunnar Walinder as deputy and the experts Edvarson, Holm, Lüning, Mattsson, Snihs, and Valentin.

The Committee expressed deep concern over the Secretariat's limited resources. There was a lack of funds to pay the consultants who were needed to complete the Chernobyl investigation, and the Committee thought it was dissatisfactory that the Secretariat had only one Scientific Secretary (an additional job had been 'frozen' for budget reasons). The Committee asked me as Chair to write to Dr. Tolba to appeal for assistance.

21.8. Letter to Dr. Tolba regarding help for UNSCEAR

On 3 April I fulfilled the task of writing to Dr. Tolba for financial support for UNSCEAR. After having thanked him for previous support from UNEP and having reminded him of the Committee's ongoing work with completing a report on the Chernobyl accident, I went into the acute problems and wrote):

> The most pressing need is to find a solution to the immediate problems. Everyone seems to agree that UNSCEAR needs to complete its estimate of the impacts of Chernobyl and expect there to be a separate appendix about this subject in the Committee's next extensive report which is to be published in 1988. The last working session to approve a text will be UNSCEAR's 37th session, which is planned for Vienna from 6-17 June 1988.
>
> This means that money must be available in May 1987 to enable Dr. Silini to arrange for the consultants to continue and complete the work. Most of this work needs to be done during 1987 because the Committee needs to have the work documents, translated into the official languages, in plenty of time before the meeting in June 1988. Since the meeting will be the last before the report is published, it is important for the work documents to be well prepared.
>
> ...
>
> A number of extraordinary solutions are conceivable, such as contributions from Member States or from other international or regional organisations. The EU Commission has offered to contribute $ 40,000 through a special grant. However, the Committee's view is that such contributions are not the best solution to the problem if money can be made available rapidly through the normal channels which I assume are through the General Assembly and/or UNEP. However, the big problem is that the money is needed almost immediately. This is why the Committee thought I should write to you for assistance.
>
> ...
>
> The other problem worrying the Committee is the gradual reduction in general resources. The Committee's greatest concern is that Dr. Silini is the only scientific member of the Secretariat.
>
> ...
>
> The Committee has noticed that there is actually one additional job for a Scientific Secretary but has been told that this job has been 'frozen' for budget reasons. A minimum requirement would be to 'thaw' this job to employ a scientist with experience of the Committee's subject areas as soon as possible to assist Dr. Silini.
>
> ...
>
> I am eager to say that the Committee holds the work of Dr. Silini in high regard; he achieves more than can be expected of him under the prevailing circumstances.

> However, the Committee fears that the situation is unsustainable and that something must be done to restore suitable Secretariat resources before irreparable damage is caused.

I received no answer to this letter. I therefore wrote to Dr. Tolba again on 22 September (see Section 21.21).

21.9. **A better home computer...**

In a letter to David Sowby on 10 April, I proudly said that I had obtained a better home computer:

> Incidentally, I might as well mention that I have also bought a new home computer, so I now also have an Amstrad, but the new Amstrad 1512 with a 32-megabyte hard disk (corresponding to 15,000 pages of text). It is a remarkable machine, having excellent graphics, with a BASIC compiler, word processing software and spreadsheet software. I now finally have space for my 10,000 fungus descriptions.

From 5 megabytes in 1984 to 32 megabytes in 1987. A big step but still a long way to go until my 300,000 megabytes in 2006.

21.10. **In favour of or against**

On 23 May I wrote to David Sowby:

> Thank you for your letter, which I received yesterday, just as we were about to travel to the summer cottage for two weeks to paint the walls and tar the boat. I thought I had better send you a few lines in response anyway since you asked my opinion on a few things.
>
> It is true to say that zero effort and cost would not have caused a much higher collective dose from Chernobyl in Sweden. But most of the countermeasures were carried out not as a result of a cost-benefit analysis for the purpose of eliminating collective doses as far as was 'reasonably possible', but were taken to avoid individual doses which could have been too high to be acceptable, particularly for pregnant women, and to live up to the ICRP recommendation not to sell foods if the radiation dose in the first year was expected to exceed 5 mSv.
>
> ...
>
> You sound bitter (morose?) about Roger Berry. You are too old to be reprehended by me, but your feelings about different people worry me at times: you seem to either like or dislike people. I do not think I have ever disliked anyone. I am not someone who dislikes people; what I dislike are the things that people sometimes do. For example, I dislike many things that John Dunster or Henri Jammet say and do, but I still like them as people. I dislike nothing that Dan says or does, but that is not why I like him. I am sure I would like him even if he did something really silly, but I would not like the fact that he did it. If we tar people with the 'disliked' brush, we would also dislike the good things they accomplish just because they were the people accomplishing them. Do you follow me? I like you, so I would obviously not like it if you were to turn into a misanthropist.
>
> As things stand, Dan has probably already visited London to meet the Committee Chairs for Publication '126'. Did you meet him? I heard from Nenot (whom I met in Stockholm yesterday) that Dan's arm has now almost recovered. My worry now concerns Giovanni Silini, who has had his operation in Los Angeles and been given two new heart valves. The operation went well but Giovanni seems very impatient and worries about not recovering as quickly as he thinks he ought to, which in turn does not speed his recovery. He is expected back in Vienna at the start of June.

21.11. **'The Cardy'**

Gunnar Bengtsson's popularity from his contributions during the Chernobyl scare in 1986 began, like most popularity with time, to be chipped away by critically-minded writers. In the daily newspaper *Gefle Dagblad* on 29 May there was a big depiction of Gunnar and the headline 'The fallout saw 'The Cardy's' rise and…' and the following can be taken from the article:

> Exactly one year ago, we held The Cardy's hand and struggled through the worry we lived through after Chernobyl. As soon as the radioactivity rose, The Cardy came on the TV and said that things were now worse. And he then concluded by saying that we did not need to worry.
>
> *Sveriges Radio's* public surveys show that The Cardy was very convincing.
>
> He was next to God when it came to Chernobyl.
>
> When gods fall they fall from a great height.
>
> The Cardy has fallen.
>
> He is not on the TV as much. Other experts have more or less blatantly said that The Cardy took on too much responsibility, that he did not let others take their share.
>
> ...
>
> Gunnar Bengtsson, The Cardy's real name, attempted to appease everyone by giving various simple comparisons. He said that five packets of cigarettes were more dangerous than the Chernobyl fallout. He said: 'Gävle needs no special measures,' and he said much more.
>
> Some tried to say that The Cardy was too appeasing.

However, with the benefit of hindsight, one might say that Gunnar had every reason to use appeasing words. Delegating too much responsibility for what was said about the risks could have led to confusion and greater worry. An appreciative article was also written about Gunnar by *Maj-Britt Oldin* in the magazine *Ny Teknik* (New Technology) with the heading 'What's happening in the radiation protection world?'. The following are a few quotes translated from there:

> There's a strong wind at the top, as the saying goes, but if it's blowing from all directions we'll be stable.
>
> That is something that could definitely be said about Gunnar Bengtsson, the base of the country's radiation protection for five years.
>
> He would have been quite within his rights to have gone potty from all the criticism and all the attacks, just and unjust, but he sits in his workroom, calm and friendly as always, and does not allow anything from anyone to provoke him.
>
> The situation on the radiation protection front is still fairly desperate as far as an outsider can see. Gunnar Bengtsson actually has problems surrounding him, within the Radiation Protection Institute and outside.
>
> ...
>
> Criticism alleges loss of touch with reality. Gunnar Bengtsson feels he has good contact out there in Sweden through an average of one lecture or one discussion per week.
>
> The 'approach' is known throughout the country courtesy of all the TV appearances, with comfy cardigan and honest air, indiscriminately appeasing and concerned. 'National therapist' and 'anxiety controller' were the words used in the reviews.
>
> Personally, Gunnar Bengtsson was afraid just twice during the whole period. That was when measurement results (later corrected) could be interpreted as new fallout on the way, maybe 100 times stronger than the first.
>
> --
>
> People's concern does not worry Gunnar Bengtsson nearly as much as the lack of concern, i.e., indifference.
>
> According to surveys, using round figures, ten per cent of the people are deeply concerned when something happens ('and there are of course already plenty of people in this position').

Almost one third of the people are fairly worried. The main problem is that almost two thirds of the people do assimilate any information, do not care about it. It is like water off a duck's back.

'It's disastrous when it comes to the major health risks,' says Gunnar Bengtsson.

As far as he is concerned, Chernobyl is not the problem where the health of the Swedish people is concerned. It is solar radiation and radon. If Chernobyl, using an internationally-approved calculation method, leads to a few cases of cancer per year in Sweden in people under the age of 50 in the future, radon is calculated to cause 1 100 cases of cancer per year and solar radiation 1 500, but many of those less hazardous.

'In the future, much of our activity will be specifically aimed at radon and solar radiation,' declares the head of radiation protection, nice and brown in his short-sleeved, white shirt.

...

According to testimonials from work colleagues of many years, he is exactly as he looks. Friendly, well-behaved to the nth degree and so polite that he ought to have his party membership book full of gold stars (Gunnar Bengtsson was appointed by the non-socialist government, so that is that).

It is certainly a bit irritating that he can devote a few minutes' interest to the employees, one at a time, with the monotonous regularity of an automaton, but that seems to be part of his idea of how a boss should be. ... Gunnar Bengtsson lets ... no-one into his life, neither journalists nor closer friends.

...

'In all seriousness, Gunnar Bengtsson, why do you wear a cardigan rather than a jacket?'

'Because I'm a Social Democrat,' he replies in a stage whisper.

Does he have a sense of humour?

21.12. **Kurt Lidén dead**

Professor Kurt Lidén died in Lund in July. His student and colleague in Linköping, Calle Carlsson, wrote an obituary in *Dagens Nyheter* on 21 July. I was in our summer cottage in Västerdalarna in the summer and wrote from there a letter of condolence to Märta, Kurt's wife, saying that 'I am happy and proud to have been able to collaborate with Kurt and pleased with the friendship that you and he have shown me for many years. I shall always sadly miss Kurt and remember him with gratitude'.

That is how I still remember Kurt. He was a big radiophysicist but a complex person. He did not trust people from Stockholm and was often surprised when we from Sievert's institute sought his cooperation. However, once his instinctive distrust had been overcome, he was a friendly, generous cooperation partner, and I have nothing but good memories of friendly visits to Kurt and Märta.

Kurt was born in Ronneby, the son of a primary school teacher, which was sometimes noticed in his weakness for formal details. He defended his thesis in physics in Lund in 1949. From 1950-1964 he was Assistant professor in Medical Radiophysics and in 1964 became the first Professor of this subject in Lund. A number of radiophysicists had been educated at his institute since the mid-1950s, a good number of whom have achieved important positions, twelve becoming Professors and one (Gunnar Bengtsson) becoming Director General and head of the Swedish Radiation Protection Institute.

Kurt Lidén's primary scientific contribution was perhaps his reports on the principles of gamma spectroscopy, in cooperation with Nils Starfelt and Gunnar Hettinger.

Following the heavy radioactive substances fallout from the nuclear weapons testing at the start of the 1960s, Kurt began extensive research into the transport of radionuclides (primarily caesium-137) in the sequence fallout, lichens, reindeer, and the Saami people, in collaboration with Jorma K. Miettinen in Finland among others. This was close to Kurt's interest in outdoor life, which was also expressed in the form of success in orienteering.

On the international scene, Kurt was active primarily within the ICRU where he was a member of the Main Commission and Secretary of the Commission for several years.

21.13. **The radiation accident with caesium-137 in Goiânia**

In September 1987, a radiation accident occurred in Brazil which claimed four human lives. The cause was that a source of gamma radiation had gone astray. This represented a serious radiation risk. Similar events had occurred in Mexico (1962 and 1983), Algeria (1978), and Morocco (1983).

The accident happened in Goiânia, a city of two million people south-west of Brazil's capital Brasilia. The stray source of radiation contained about 50 TBq (1,400 Ci) of caesium-137 in the form of close-packed caesium chloride. The way in which this caesium spread in the surroundings and killed people who did not realise the risk is a bizarre combination of tragic events.

The caesium came from a disused teletherapy unit from a former radiation therapy clinic which, in addition to the caesium device, had also used a cobalt unit. The clinic had been called the *Instituto Goiano de Radioterapia* (IGR). In 1971, the National Nuclear Energy Commission (CNEN) had approved the plant, with one physicist and one radiologist responsible for running it. Essential changes were to be reported to the CNEN.

At the end of 1985, IGR had ceased its activity and new owners had assumed the responsibility. The cobalt device had been moved to one of their clinics but the caesium device was left in the abandoned clinic. Subsequently, a dispute evolved over the ownership of the clinic. The buildings became dilapidated but the caesium device remained there while the responsibilities were investigated. Those who were previously responsible should now have reported the circumstances to CNEN, but this did not take place. The room was invaded by scavengers.

A scrap collector (I will call him RA)[*] had heard the rumour about valuable equipment and on 10 September took a friend, WP, with him to find out what was what. After spending a couple of days using primitive tools, they succeeded in prying away the rotating cylinder containing the inner caesium-137 source. The shiny, mirroring surface of the capsule attracted their attention.

They took away the cylinder in a wheelbarrow to RA's home where they placed it under a mango tree. The source of radiation was still intact but is estimated to have given a dose rate of nearly 5 gray per hour at a distance of one metre. WP became ill and went to the doctor, who thought the man had had an allergic reaction from unsuitable food. He prescribed rest and WP stayed at home for a week.

RA continued to show an interest in the mysterious cylinder. On 18 September he succeeded in removing the vessel containing the caesium. By then he had damaged it which caused some caesium chloride grains to leak out. On the same day he sold everything to a scrap dealer, DF, who played an important role and succeeded in surviving.

DF took the damaged source to his home and placed it in a garage. There, he noticed a blue light coming from the caesium capsule. He thought it was beautiful and that it could perhaps be used, so he took the capsule into his home where he showed his neighbours, relatives and friends the phenomenon over the next three days. DF's wife, MF1, took a particular interest in the find. She would end up dying from the radiation while her husband survived, probably because he had received his radiation dose in several protracted exposures.

Two men, EF1 and EF2, who were friends of DF, visited him on 21 September and managed to poke out some of the caesium chloride from the capsule using a screwdriver. The caesium chloride salt was in the form of grains, about the size of a grain of rice, but disintegrated into a powder when they applied pressure to the grain. They took the grains home with them. DF shared loose grains with his family and friends. Many stroked the shining powder on their skin as if making up for a carnival. The accident was made worse by the fact that it was a powder that was being spread rather than a piece of radioactive metal.

However, the person with the worst injury was DF's wife, MF1. She became sick and had diarrhoea and sought medical help on 21 September at the same hospital that WP had gone to previously. She was given the same diagnosis, an allergic reaction to something she had eaten, and was sent home to rest.

[*] I also use the people's initials in an IAEA report.

Her mother, MA1, came to look after her, but returned home after a couple of days. She lived a good way away from Goiânia and took some caesium home with her.

A couple of DF's employees, IS and AS, were asked to deal with the lead which had been used as radiation protection in the treatment head. They were then irradiated by residual caesium with such high doses of radiation that they later died.

IF, a scrap dealer who was DF's brother, took home part of the source of radiation and let it stand on the table during a meal. His six year-old daughter, LF2, played with the powder while she ate. It was estimated that she had ingested about 1 GBq (27 mCi), from which she did not survive.

DF's wife, MF1, was now convinced that her illness was not caused by an allergic reaction but was due to the mysterious powder. She asked one of DF's employees, GS, to place the rest of the source of radiation in a bag and take a bus trip with her to a hospital where she placed the bag on the table in front of a doctor, Dr. PM. She said that the content of the bag was 'killing [her] family'.

The bag remained on the table long enough for Dr. PM to have received a radiation dose of 1.3 gray. GS carried the bag over his shoulder and received a 'burn injury' on his shoulder for having done so and an estimated whole-body dose of 3 gray. Dr. PM was worried about the bag and moved it to a bench in the yard.

MF1 and GS were referred to a hospital for tropical diseases since that was what Dr. PM thought MF1 had. A number of people who had placed caesium chloride powder on their skin had already been referred to that hospital after experiencing skin injuries. A Dr. RP at the hospital began to suspect that it could be a question of radiation injuries. He consulted a colleague, Dr. AM, who not only worked at the 'tropical hospital' but was also inspector at a toxicology information centre. By then, Dr. PM had already called Dr. AM, who had started to wonder about the mysterious bag.

Doctors RP and AM thought the case should be further investigated. They contacted Dr. JP at the Goiás State Environmental Agency. The former suggested that a medical physicist should look at the bag. He knew that a medical physicist, WF, happened to be visiting Goiânia at that particular time.

WF was called and found out what it was about. He managed to borrow a scintillation detector with a measurement area of 0.02 - 30 micrograys per hour. He turned on the instrument when he arrived at the hospital but the indicator needle jumped off scale. He then thought that the instrument was faulty and returned to replace it. He immediately turned on the new instrument and could then see how the signal increased as he approached the hospital. There was obviously a powerful source of radiation there. In the meantime, Dr. PM's concern had increased to the extent that he rang the fire brigade. WF arrived just in time to prevent the firemen from throwing the bag into the nearest river.

WF then initiated a number measures. He convinced those working at the hospital where the radiating bag lay to evacuate the area. When Dr. PM explained where the bag came from he also convinced DF and his neighbours to leave the scrapyard. WF and a few others then turned to the federal state's healthcare authority to convey the scope of the accident and obtain assistance. The official was not ready to believe them. WF rang the head of nuclear installations within the CNEN in his capacity as Nuclear Emergency Coordinator, NEC. The latter suggested that they approach the medical physicist at IGR who ought to be responsible for the event.

The authorities in Goiânia mobilised police, the fire brigade and the civil defence and had in the evening of 29 September designated the nearby Olympic stadium as a place where contaminated people could gather to be examined and isolated.

On 30 September, 22 people had been identified as probably having been seriously irradiated. They were isolated from others and examined by Dr. AM whereupon those who had skin injuries were sent to the 'tropical hospital' for treatment.

Although there was almost no preparedness plan for such a striking accident, the authorities succeeded in improvising measures to get the situation under control and prevent further serious irradiation.

The NEC arrived at Goiânia in the early hours of 30th September. Medical physicist WF had improvised an action level for evacuation from the contaminated areas. He had worked on the basis of the ICRP dose limit for radiation workers being 50 mSv per year and that the public ought not to be irradiated to more than one tenth thereof, which gave him a dose rate limit of 2.5 microsieverts per hour.

The group that came with the NEC from the CNEN agreed that they ought to try to keep the public's annual dose below 5 mSv and that WF's provisional dose rate limit could be used for the time being.

The caesium-137 in the bag which Dr. PM had moved to a bench in the yard was estimated to have an activity of 4.5 TBq (120 Ci), representing approximately one tenth of the original total quantity of caesium. The bench and bag were drenched in cement which was conveyed through a waste pipe that a crane had aimed at the target.

The work which then followed was extensive and involved many protection workers. A good number of authorities were involved. It would take too much room for me to describe these later events.

21.14. **The Nordic Society for Radiation Protection in Mariehamn with *Fachverband***

In summer 1987 the Nordic Society for Radiation Protection held a joint meeting in Mariehamn with the German-speaking countries' *Fachverband für Strahlenschutz.* The *Fachverbant* had built up a tradition of holding the meetings on islands.

21.15. **Christer Viktorsson to the NEA**

Christer Viktorsson, our skilled Ålander*, left the Radiation Protection Institute in 1987, i.e., after the Chernobyl accident, for a post at the OECD/the NEA in Paris where he made a significant contribution over the next six years before returning to Sweden in 1993 and becoming Deputy DG of the Nuclear Power Inspectorate. In 2005 he moved to Vienna and became head of section policy matters at IAEA in Vienna

21.16. **John Dunster has a brain haemorrhage**

Just before the ICRP meeting in Como, John Dunster had a stroke which damaged the visual centre of his brain so he was unable to take part in the ICRP meeting. It was not clear whether he would manage to recover for November when he was booked to chair a meeting session in Laxenburg outside Vienna. I was to give a presentation at the meeting and I would normally send my manuscript to the Chair of the meeting but did not dare to do so under the circumstances. Instead, I sent it directly to one of the Secretaries in Laxenburg. I wrote to John after the meeting in Como:

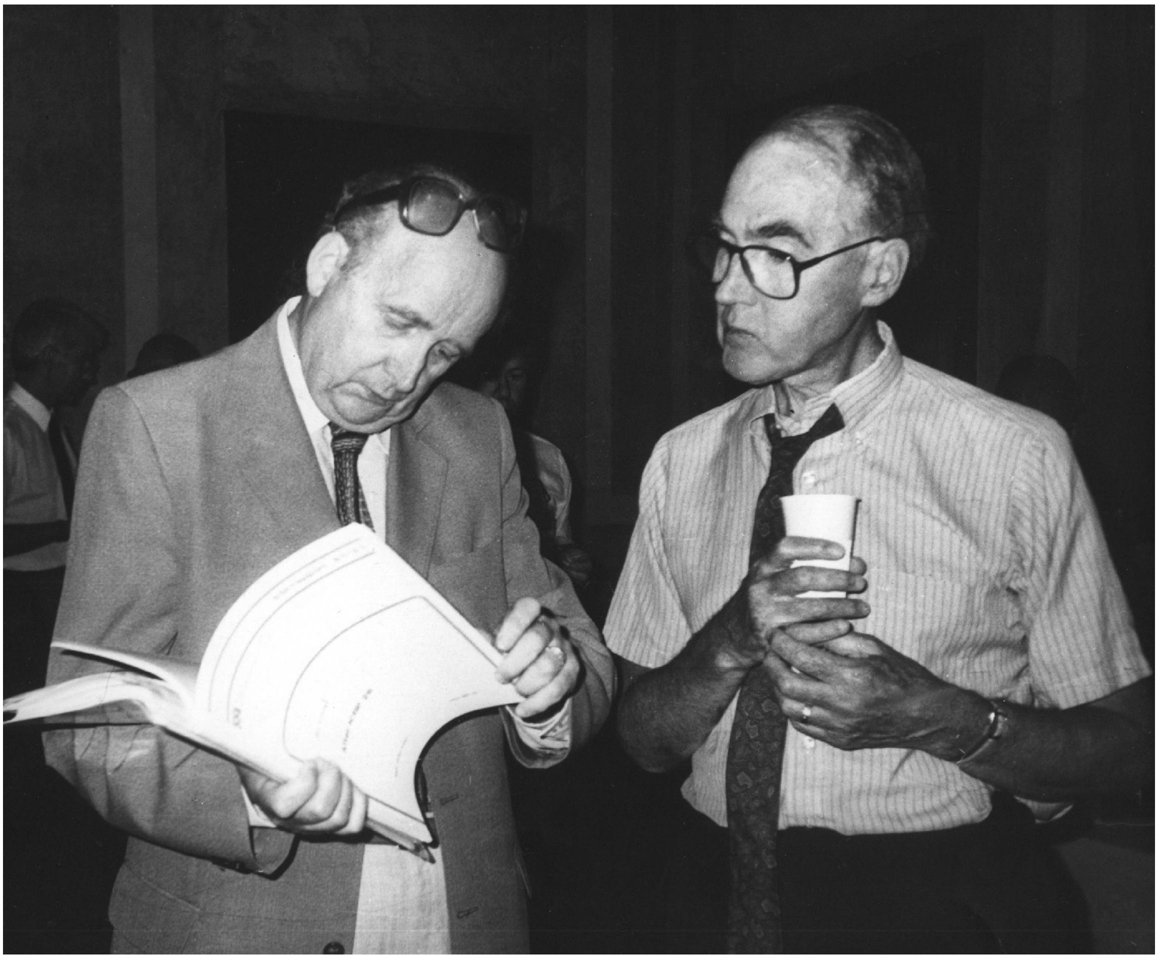
> Dear John,
> We missed you in Como, everyone but mainly the Main Commission which really needs you. What has happened to you must be completely intolerable for such a dynamic person as you. But there are many of us who would like to see you back among us, so do not take any risks by being impatient. Take your time and recover so we can be sure to see you hale and hearty again. ...

The consequences of John's stroke were striking and were described graphically by him – he was extremely interested in the phenomenon. A small section of his field of vision had been lost but his brain made up for what was missing so the loss was not usually noticeable. However, if a person stood in the section from which the field of vision had been lost, John could not see the person who would then surprise him by suddenly appearing during a movement, as if from nowhere, in the field of vision that still functioned. What could also irritate John was that a glass which he put in front of him on a table simply disappeared from view.

* I.e., he was born on the Åland islands, an autonomous, Swedish-speaking region of Finland.

21.17. **ICRP meeting with the Committees in Como**

ICRP convened with its Committees in Villa Olmo in Como from 7-16 September. The most important result of the meeting was that an editorial group was appointed for what would become 'Publication 60', a group comprising the ICRP Chair and Deputy Chair, the Chairs of the Committees (owing to the expected change of Chair in 1989 for Committee 4, both John Dunster – who was not present in Como - and Roger Clarke were included). I was also included, partly due to my experience from the previous three editorial groups (for publications 1, 9 and 26) but also because Dan as Chair wanted it (which amounted to a certain degree of collegial cronyism).



From the ICRP meeting in Como, 1987.
Bo Lindell and David Sowby.

David Sowby was present as Secretary of Committee 3. I discussed with Giovanni Silini the ethics behind the choice of dose limits. Why, wondered Giovanni, would it be considered acceptable to permit much more radiation for those who work with radiation than for the general public? I tried to explain that it was not a question of discriminating against a group of people but of different limitations for different types of radiation contribution. Those who work with radiation are also exposed to the same radiation outside work as members of the general public. In historical terms, a limit was first set for the radiation workers. Then, a limit had to be set for the radiation to which everyone was exposed as members of the public. It was considered unreasonable not to further limit the contribution; the radiation workers should not need to receive as high a dose outside work as at the workplace. Not only that, the radiation that affected people outside work could also affect children who could be assumed to be more sensitive. In addition, exposure of members of the public was controlled only through intervention against the sources of radiation and it was not possible to monitor and control the radiation dose to individual people in the way that occupational exposures are monitored and controlled. But it was not easy to explain all this.

We took trips along narrow roads along the beach of Lago di Como with Abel González driving and our hearts in our mouths. Dan Beninson and I also took a boat out onto the vast ocean. Benito Mussolini had met his fate in these parts at the end of April 1945 when he and his lover Claretta Petacci were forced out of a car and shot by partisans who had orders to kill him. There had been chaos and war here at the time. Now we felt only peace and quiet.

ICRP faced substantial issues, primarily concerning how dangerous to health ionising radiation actually was. This would have a great influence on the impending new recommendations that were now to be drawn up by the editorial group that had just been appointed under the leadership of Dan Beninson. What was currently new was a report from the RERF, the research institute in Japan which studied long-term effects of the atomic bombs. The report was written by the highly respected scientists *D. L. Preston* and *D. A. Pierce* and was discussed in detail by Committee 1. The account I gave in my travel report to the Radiation Protection Institute summarised the problems enough to justify a long extraction:

> The meeting aroused international attention for the first time in the history of ICRP, with German television on site and petitions from a number of environmental organisations, including Friends of the Earth, and critical scientists like Alice Stewart and John Gofman. Everything was discussed by Committee 1 and the Main Commission. Since a few letters to ICRP were polemic, the Commission decided not to embark on any argumentation, but everyone's response was instead to forward the 'Statement' that had been issued in the second week (ICRP usually had to issue statements after every big meeting with the Committees).
>
> ICRP's statements usually have a period of two months with no activity before being published to allow time for corrections and give the Commission time to cancel any incorrect decisions made in a hurry during the meeting. However, this time the 'change-your-mind months' were scrapped since they wanted to answer everyone who had given points of view before the meeting. The ICRP statement from Como is thus already official, but may have been linguistically edited by the Secretary before being issued.
>
> <u>The Preston-Pierce report</u>
>
> The main part of the statement from Como concerns the new information about the risk of cancer for those who were exposed to the bombs in Hiroshima and Nagasaki. The meaning of the revised dosimetry is that the neutron contribution is now considered to have been overestimated.* This means that the gamma radiation must take more of the responsibility for the observed increase in the incidence of cancer. The dose contribution to all those who are part of the monitored groups has been thoroughly assessed once again.
>
> The changes to the dosimetry alone – without any other changed assumptions – means that the risk estimate for the gamma radiation component increases by 40 % compared with what it was with the previous dosimetry.
>
> In addition, with a longer observation period (until 1985), enough cases of cancer have now been noted in the youngest age group (up to 20 year at the time of the bombing) for it to be possible to estimate the risk for that group as well, which had not been possible previously. For the relevant dose interval (0.1 – 2.25 Gy) 153 cases of cancer (non-leukaemia) were found in this group from 1950-1985 compared with the 107 that would have been expected.
>
> Not unexpectedly, this means a greater risk than for the older groups for which estimates had already previously been made. This was to be expected because the younger people have more years to experience the risk of radiation. ICRP thinks the risk

* The reason that the neutron dose was overestimated was that the experiment which was carried out to assess the quantity of neutron radiation took place in a dry desert climate in the USA, which did not correspond to the damper climate in Japan when the bombs were dropped.

to the young could be 2-3 times greater than the average risk previously assumed for people over the age of 20.

ICRP does not think that these observations constitute an adequate reason to change current radiation protection recommendations. The greater risk to the young justifies particular caution where doses of radiation to the public are concerned, but the Commission points out in its statement that the dose limit to the public was recently lowered from 5 to 1 millisievert per year.

However, it cannot be precluded that the risk to the survivors in Hiroshima and Nagasaki is significantly greater than the one adopted so far for low doses of radiation, for two reasons.

The first reason is that not all cases of cancer that may occur have yet been registered. ICRP's biologists could not support the view that it is possible to predict how many more cases of cancer may occur in the youngest age group right now, in the group in which most are still alive. The most pessimistic assumption is that the risk will continue to increase, in that radiation-induced cancer would continue to be a specific fraction of the normal incidence of cancer. Since the latter increases with age, many more cases of cancer should then be expected, a hypothesis which is supported by Gofman, among others. If on the other hand the incidence of radiation-induced cancer falls with time, as has been observed for leukaemia and bone cancer, the number of new additional cases will be significantly lower.

The second reason is that the estimate of the risk at low doses of radiation depends heavily on the assumed dose-response relationship. The increase in the incidence of cancer in Hiroshima and Nagasaki is significant only at high doses and the information does not lead to any conclusions regarding the dose-response relationship at low doses. If, like Gofman, one assumes that the relationship is completely linear from the high doses of radiation down to the dose of zero, and also assumes that the addition of radiation-induced cancer in the future will be the same fraction of the natural incidence of cancer, the estimated likelihood of cancer per gray may be ten times greater than that which is usually assumed.

This possibility was highlighted by several of those who wrote comments to ICRP and heavy pressure was placed on the Commission to lower the dose limits. However, the Commission's view is that the significance of the dose limits has been grossly overestimated. The Commission says that if all ICRP recommendations are applied as intended, in most cases the doses of radiation will be way below the dose limits. Experience has shown that the final result is not sensitive to the choice of dose limit. ICRP therefore feels that we can wait for the conclusions from the risk studies that UNSCEAR and the American Academy of Sciences' BEIR Committee ('BEIR-5') expect to conclude in 1988. These studies are based not only on the observations in Hiroshima and Nagasaki but also on epidemiological studies of other irradiated groups of people.

As I mentioned initially, ICRP is in the process of revising its entire dose limitation system, of which the dose limits constitute just one small part. This revision is not expected to be ready until 1990, at the earliest. To understand that such a revision does not consist solely of a change to the dose limits, one must be aware of the many problems studied by ICRP.

Dose limits are always a part of the system, but what is it that has to be limited? At the moment it is the effective dose equivalent. What will happen to this in the future if we obtain better estimates of the risk of cancer for a number of individual organs? Should ICRP change the weighting factors w_T for calculating the effective dose equivalent? Should ICRP continue to have a limit which covers just the risk of dying from cancer and serious hereditary injuries in the first two generations of descendants? Or should we also limit the risk of curable cancer and of hereditary injuries in later generations? If the latter is the case, do we have to have several different limits or can we weight all these injuries together to derive an overall risk measurement? If so, how will that be done?

The radon in our homes generates high doses of radiation. The low level of ambition for protection measures which prevails in Sweden (and also in other countries) means that people at home can receive doses of radiation which would scarcely be accepted at a workplace. But isn't the home also a workplace? Should the doses of radiation from the radon daughters in a work premises be counted as part of the dose limit that is intended to protect the workers? What happens then if we substantially lower the dose limit? Shouldn't we then generally demand greater efforts against radon?

ICRP's task is to find a revised dose limitation system that is logical, free from contradictions and applicable in practice, otherwise it will be an empty gesture. This is the work that is ongoing and which is consuming substantial time.

21.18. **De minimis**

A discussion which surprises many concerns the principle called 'de minimis', an expression originating from the Roman Empire* which means that jurisdiction must not concern itself with trifling matters. Examples of this include the requirement to have lights on bicycles even if used only in daytime, or that you must not walk through a red traffic light. These can be forbidden through regulations, but in practice, the police do not use their time and resources on small matters. At first glance (and for many for always) it seems reasonable to state a minimum radiation dose below which the radiation dose can in practice be regarded as zero. This seems reasonable particularly to those who do not believe there are any risks from low doses of radiation. It is less obvious to those who believe in a non-threshold connection between dose and radiation effect.

There are many differing views in this respect. Part of the confusion is caused by the fact that many do not understand the difference between the risk to individuals and the overall impact. We can compare it with the risk of being struck by lightning. In tables that risk appears very insignificant and, for society, negligible because so few people are affected each year. You are not struck by lightning if you are indoors in a town or are outside but acting with caution, but there is a considerable risk to those who are out rowing a boat or who take shelter beneath a tall tree when the lightning strikes. An insignificant extra radiation dose to all people can be considered negligible for each person and, in practice, non-existent, and is also from society's point of view insignificant compared to the considerably greater natural background radiation to which we are all exposed. Here, the 'de minimis' concept could seem appropriate. In many ways it would make things easier for us if we were to call the smallest doses of radiation zero.

But why should we compare the harmful effect of the tiny additional dose with the considerably greater injury that we might assume is caused by the background radiation? Or why should we care about very small extra doses of radiation when we receive much larger doses from elsewhere in any case?

The answer is that we must make relevant comparisons. The extent to which we should care about the small extra doses of radiation depends on what causes them. If it is an activity that is difficult to justify, the extra doses are also difficult to justify, even if the total injury they are expected to cause is insignificant. They are also difficult to justify if they can easily be avoided. You then save lives for a cheap price, and why would you not want to do that?

Another reason to shy away from the 'de minimis' concept is that if you call small doses of radiation zero, you are tempted to replace a few large doses with many small ones, for example by releasing radioactive substances through tall chimneys, and thereby causing global rather than local contamination, which is not always preferable.

The attitude to 'de minimis' differs between Europe and the USA. The Americans usually think it is obvious to discount small doses of radiation (see Whip, 1987), whereas in Europe, the tendency is to be more cautious (cf. Lind, 1989).

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* 'De minimis non curat praetor' is Latin for 'the law does not concern itself with trifles'.

21.19. **Lars-Eric Larsson in Java**

On a postcard from Javanese Bandung on 14 September, Lars-Erik Larsson wrote:

> Well, the pensioner is now out and about. IAEA assignment one month to examine the possibility of arranging to educate medical physicists at this university with IAEA's support. Bandung is on Java, approx. 200 km from Jakarta and I am going there tomorrow for a 2-day meeting. Not a drop of rain for the 2 weeks I have been here. Now have the summer that was rained off in Skåne. No vibrant life going on in this city of 2 million. Life is peaceful and the tranquillity of the evening is disturbed only by the Muslim calls to prayer.[*]

21.20. **A book about radiation**

Jack Valentin publishes a reader-friendly book about radiation (*En bok om strålning*) through Norstedts' publishers. The book has subtly humorous illustrations by Cecilia Torudd.

21.21. **Renewed appeal to Dr. Tolba regarding support for UNSCEAR**

On 22 September I wrote a letter to all national UNSCEAR representatives and sent a copy to Dr. Tolba in Nairobi with a short accompanying letter in which I also reminded him of my appeal to him in April for support from UNEP. I also sent a copy to the Ministry for Foreign Affairs requesting that 'everything reasonable should be done by Sweden in Nairobi and New York to sort out UNSCEAR's practical problems'. In my letter to the delegates I wrote:

> As requested by the Committee I wrote a letter to Dr. Mostafa Tolba, Managing Director of the United Nations Environmental Programme (UNEP) in Nairobi, to inform him of the problems and ask for his assistance. As you know, UNEP has been asked to provide Secretariat resources for UNSCEAR. I sent the letter on 3 April and Dr. Silini sent a copy to the UNSCEAR representatives.
>
> ...
>
> As Chairman of the Committee for the current period I would like to ask you to contact your country's representatives in Nairobi and New York well before this year's discussions about the Committee in order to find options to improve the situation. You cannot help noticing that the Committee's Secretariat, at a time when everyone appears to expect greater inputs from UNSCEAR, is being seriously damaged by administrative decisions.
>
> I suggest that you remind your representatives of UNSCEAR's unique position. This is a Committee which has spent thirty years producing extensive reports on a subject which is of great interest to the public, i.e., levels of radiation and radiation risks, covering all areas from natural sources of radiation to medical irradiation and environmental contaminants from nuclear weapons testing and nuclear power production. These reports have been received with great respect for their scientific qualities and constitute the fundamental reference material throughout the world. Scientific advisers in the UNSCEAR delegations have contributed to this work on the basis of information from innumerable laboratories at an insignificant cost to the UN, for which it must be difficult to find more cost-effective work in terms of budget. This has been produced with assistance from a handful of short-term consultants and a Secretariat which, on paper, used to consist of two jobs in the scientific category and two in the general job category. This represents an insignificant outlay bearing in mind

[*] Lars-Erik's journey appears exotic for a northerner but Indonesia must not be underestimated. With its more than 200 million inhabitants it is the world's largest Muslim state. The capital city Jakarta on Java has ten million inhabitants, but Bandung, where Lars-Erik was, is also a city of several million people with two universities.

> the results obtained and the hidden cost of all scientific contributions to the Committee's work. This modest workforce has now been reduced by 50 per cent through administrative methods brought in to shave small fractions from large organisations.
>
> As Chairman of UNSCEAR I cannot stay silent and watch this happen. I have therefore taken the liberty of writing to you to ask for assistance and renew my appeal to Dr. Tolba by sending him a copy of this letter.

21.22. **ILSI meeting in Laxenburg**

In November, a meeting was arranged in Laxenburg outside Vienna by the International Life Sciences Institute (ILSI). It concerned principles for measures against foods contaminated with radiation. As was so often the case, it was not the meeting negotiations but contact between the scientists which brought the best results. I could show Bill Pochin a diagram of how two phenomena varied according to the standard of living in a number of countries, viz., the mortality risk for a number of illnesses or accidents and the resulting average lifetime. It was the same diagram that I would show in my Lauriston Taylor lecture at the NCRP meeting in Washington DC in 1988 (see Section 22.8).

It was thought-provoking to see how the mortality risk for infectious diseases was sky-high in poor countries and very low in the rich countries, and that the average age at death from such diseases was low in the poor countries (where there were no longer that many old people left) but above retirement age in the rich countries. A corresponding picture was shown for infant mortality. The risk of dying from bronchitis and pneumonia was pretty much independent of the standard of living but for the very poorest countries, but the age at death increased with the standard of living. That which affected children in the poor countries affected the aging population in the rich countries. The risk of dying from lung cancer could tempt cynics into giving a sad smile. It was of course almost non-existent in poor countries where only a few people reached advanced age, but high in countries with more old people. The main thing that could make a cynic smile was that the age at death in all countries was high and around retirement age. A cold-hearted Minister of Finance must surely have been tempted to firstly tax cigarettes and then find out that the smoker had died without adding to society's pension liability.

Bill enthusiastically discussed these connections. The man who could be so explosive was always polite and friendly to me and never raised his voice during our conversations, although I could provoke him into breaking pencils in anger during the meetings.

John Dunster described the problems with his sight and how objects and people suddenly appeared as if from nowhere. But he appeared to take it with equanimity and described his problems with quiet humour.

21.23. **Improvised UNSCEAR meeting in Vienna**

Since many UNSCEAR delegates and experts took part in the ILSI meeting which was concluded on Thursday 5 November, and were thus available in Vienna immediately after the meeting, Giovanni Silini asked them to stay for an informal UNSCEAR meeting at the Vienna International Centre on the Friday. As the Chair of the Committee, I was asked to be Chair of this informal meeting. In my report to the Ministry for Foreign Affairs I wrote:

> First of all Silini told us what had happened regarding the Secretariat's resources. The acute difficulties had been addressed with temporary solutions. It had been possible to employ a clerk (for a short time) by redistributing funds courtesy of UNEP. Consultants to prepare the Chernobyl document were to be had because the consultants were paid by UNEP and by funds from American sources. In the longer term, Silini hoped that the consultant currently employed by UNEP could be transferred to an as yet non-existent job at UNSCEAR. According to sources in Nairobi, the hope was that the initially frozen and then withdrawn job of Scientific Secretary and colleague of Silini could be reinstated.

A preliminary timetable for UNSCEAR's next meeting (in June 1988) was then agreed at the proposal of the delegates who were present. This would be the last meeting in the current work cycle. The document that is then to be completed is very important because, over and above the customary report on natural radiation, medical irradiation, the environmental effects of nuclear power and biological effects of radiation, it is expected to include two tasks that are very much in demand, i.e.

(a) Revised estimates of the risk of cancer from ionising radiation, and

(b) Account of the radiological impacts of the Chernobyl accident.

The June meeting is therefore the last meeting for the completion of this report and since the meeting will last for two weeks, the delegates were anxious to be able to plan in time for the participation of the experts.

21.24. **Giovanni Silini leaves UNSCEAR**

On 3 December, Giovanni Silini wrote to all UNSCEAR delegates to say that his health did not permit him to continue as Secretary of UNSCEAR.

On 8 December I wrote to Silini:

> Dear Giovanni,
>
> Now that you are *en route* to leaving your job as Secretary of UNSCEAR I would like to express my personal thanks for your fruitful endeavours during your time at UNSCEAR. The Committee will doubtless agree when it meets in June; before then I would like to thank you not just on its behalf but also for the Swedish delegation, but primarily as your friend.
>
> I assume that it must already have been a difficult time for you after your first heart operation and I admire your capacity to take on so much heavy work with such energy for all these years. I still believe you made a wise decision to leave this burden of work to, hopefully with a lower level of stress, be able to concentrate on more diverting matters and at a rate that is determined by you alone.
>
> I hope that you do not leave ICRP and that, irrespective of which contacts you will still have with UNSCEAR, I may have the privilege of seeing you at the Commission's meetings for many years to come. As you know, I intend to leave UNSCEAR after the current report has been completed, but I would still like to remain in communication with ICRP.
>
> ...

On 9 December I wrote to all UNSCEAR delegates:

> You will by now have received Dr. Silini's letter of 3 December in which he says that his health does not permit him to continue his work as Secretary of UNSCEAR. I am sure that all delegates will be sorry to hear this and hope he recovers soon. I am also sure that you will all join me in saying a genuine thank you for the dedicated work that he has so successfully carried out for the Committee in recent years.
>
> Dr Silini's departure has obviously concerned me as Chairman of the Committee, bearing in mind that our meeting in June 1988 will be the last meeting for working on the 1988 report and that, as you will remember from my letter of 22 September this year, there has been no other scientific job at the Secretariat. I have therefore discussed the situation in detail with Dr. Silini.
>
> Luckily, Dr. Tolba has acted since he has now fully realised what the situation is. I am waiting for a letter from him with details of the arrangements and therefore still have no official information. However, I have reason to believe that the 'frozen' job of Scientific Secretary will be reinstated and that UNEP will make *Dr. Burton Bennett* available to UNSCEAR from the start of January to take responsibility for the Secretariat until a successor to Dr. Silini has been employed. As you know, Dr. Bennett

has been consultant for UNSCEAR for many years and is very familiar with the work of the Secretariat.*

I am also convinced that Dr. Silini will leave well-organised work, with consultants who are completely familiar with their assignments. Therefore, the situation that Dr. Silini is leaving us will not, although it is a pity that he is leaving us, be as disastrous as was initially thought.

It is not usually up to the Committee or its Chairman to get involved in matters concerning the management of the Secretariat, but since the Committee has asked me to contact Dr. Tolba about the Secretariat's resources, I thought that I ought to keep you informed of the development.

21.25. **The letter from Dr. Tolba**

On 15 December, Waltraud Holzer from UNSCEAR in Vienna rang and said that a letter had arrived for me from Dr. Tolba. The letter had been delayed because it had been addressed to UNSCEAR's old address on Wasagasse which the Secretariat had moved away from eight years earlier. Tolba wrote:

> It is with great regret that we have found that our colleague, Dr. Giovanni Silini, Secretary of UNSCEAR, has been found to be medically unfit to continue in his post and will be on indefinite sick leave.
>
> Bearing in mind the critical workload awaiting the Secretariat, I would like to fill the important gap arising with Dr. Silini's departure as soon as possible. I am therefore allowing the personnel department to take measures for Dr. Burton Bennett ... to take over the leadership of the Secretariat and stand in as temporarily-appointed Secretary of UNSCEAR while the job is currently vacant. I have just succeeded in upgrading the job which, as you know, has been frozen for a while due to the UN's financial situation. Bearing in mind the short notice and the space that Dr. Bennett will leave in his current job at the Centre for Monitoring and Assessment Research in London, the proposed move will demand significant efforts on the part of my and the UN's administrations. However, I am convinced that they will rise to this important task.
>
> Dr. Bennett has declared that he is willing to accept the assignment. I have been forced to act quickly in this regard and I hope you will agree with me that Dr. Bennett is a highly suitable candidate with the necessary experience. As you are no doubt aware, at my time of writing this he is in the process of taking over Dr. Silini's tasks with the support of my former colleague and current adviser, Dr. Francesco Sella, former Secretary of UNSCEAR.

I responded to Dr. Tolba's letter on 30 December, writing:

> Dear Dr. Tolba,
>
> At the request of UNSCEAR I would like to express our genuine thanks for your quick reaction to the problems that were caused by Dr. Silini's sudden sick leave. I am sure that the Committee will welcome your decision to allow Dr. Burton Bennett to act as temporary Secretary in Dr. Silini's absence.
>
> We are also grateful for your successful efforts to reinstate the 'frozen' position of Scientific Secretary to assist the Secretary. It pleases me to hear that you have managed to upgrade the job since it is exceedingly important for the UNSCEAR Secretariat to gain competent experts.
>
> Dr Sella has been in contact with me and assures me that the work left behind by Dr. Silini is well-organised. I would like you to know how much we have appreciated Dr. Silini's competent work during his period as Secretary and how sorry we are that his health does not allow him to continue.

* At the time, Dr. Bennett was employed by the UNEP as person in charge of the laboratory in Octagon Building in London.

> I am sure you are aware that UNSCEAR's two-week session in June concludes a work period for drawing up another extensive report. It is therefore a critical meeting, particularly as there are strong expectations on the Committee to present new estimates of the risk of cancer from radiation in the report. We are therefore more dependent than ever on an efficient and competent Secretariat.
>
> I would like to add my best wishes for the new year.
>
> ...

21.26. **UNSCEAR's work**

I also sent New Year's greetings to the biologists in the Swedish UNSCEAR delegation, i.e., Gunnar Walinder, Lars-Erik Holm and Jack Valentin:

> HAPPY NEW YEAR!!!
>
> Unfortunately, Giovanni Silini has been forced into early retirement due to his heart problems following the operation last summer. This of course leads to problems with the preparations for UNSCEAR's meeting in June, but everyone hopes that everything will come to fruition.
>
> The biggest problem of course concerns the work document about the risks of cancer and what can be said about risk coefficients in the main text. I have reminded people about the importance of having all papers in plenty of time, but this is the situation:
>
> *Jack Schull*, who is responsible for the work document, has promised that the first part will be with the Secretariat by Christmas and the final document by the end of January. He is simultaneously sending a copy to Silini in Italy and Silini has promised to read and edit the document in February. No-one expects it to be out of the Secretariat until March, but I have emphasised to the Ministry for Foreign Affairs the importance of sending it to Sweden quickly when it comes.
>
> We may therefore not see this important document until April. To facilitate the preparations, several delegates and I have asked Schull to make the background material available early on. We have already seen the Preston-Pierce report, but the one that is more important than this is 'Life span study report 11' which compares risk coefficients based on DS86 and T65DR.
>
> We have managed to get a pre-release of the report which I have had copied for the UNSCEAR work, so a copy is enclosed. It is important for everyone involved to study the document in plenty of time.
>
> With that, I wish everyone all the best for the new year!

And so the new year was nearly upon us.

22. THE YEAR 1988

22.1. Letter to the Ministry for Foreign Affairs regarding Swedish delegates for UNSCEAR's 37th session

On 20 January I wrote to the Ministry for Foreign Affairs and proposed who should participate in the Swedish delegation for UNSCEAR's 37th session in June. Since the meeting was estimated to last for two weeks, I proposed that some of the Swedish experts did not need to attend all of the time. I proposed that the group, like at the previous session, should consist of Gunnar Walinder as my deputy, plus Kay Edvarson, Lars-Erik Holm, K-G. Lüning, Sören Mattsson, Jan Olof Snihs, and Jack Valentin. I also proposed that Gunnar Bengtsson should take part in the second week to get to know the Committee. I also requested a representation grant:

> ... at the 36th session, the Ministry for Foreign Affairs had given me the option of using up to Swedish kronor 6,000 for entertainment. This was enough for a reception in VIC's restaurant for all participants, including interpreters, Secretariat and observers, approx. 100 people in all, which was much appreciated. A similar arrangement this time would be very popular. In practice, the previous arrangements were that the Secretariat was responsible for contact with the restaurant and it would then forward the bill, after I had approved it, to the Embassy for payment.

22.2. New Radiation Protection Act, etc.

On 11 February 1988 the government bill 1987/88:88 on the new Radiation Protection Act was formulated in accordance with government protocol. The rapporteur was Birgitta Dahl, who was head of the Ministry of the Environment and Energy at the time. Regarding the need for new radiation protection legislation, Cabinet Minister Dahl said:

> I have previously raised the fact that applicable Radiation Protection Act aims primarily to protect employees when working with devices intended to emit radiation or radioactive substances in nuclear plants. The need for protection against radiation has changed in line with the technical development in the different areas of society. The Radiation Protection Act must – despite its expansion in 1976 to cover non-ionising radiation – be considered to be out of date in several respects. My primary aim is not for the Act to allow for the broadening of the radiation protection activity which, in my opinion, is necessary to effectively and comprehensively be able to safeguard radiation protection.
>
> ...
>
> The new Radiation Protection Act shall aim to protect people, animals and the environment against the harmful impact of radiation. The Act must be based on the same fundamental principles as the valid one. This means that radiation activity, as it has so far, must be under society's control through a special radiation protection authority. The Act must cover both ionising and non-ionising radiation. Both natural radiation and that produced by or caused humans must come under the Act's regulations.
>
> ...
>
> My objective is for the Act to help to create as extensive a radiation protection as possible for society. A new Radiation Protection Act therefore cannot, as the current

> one is, be limited to protecting humans. Effects on the flora and fauna should be included in the Act, plus general impacts on the environment. The new Act should thus aim to protect people, animals and the environment. The Act should apply to animals roaming free outside and pets and other animals in captivity.
>
> ...
>
> According to the report, the obligation to safeguard radiation protection through a new Radiation Protection Act should in the first instance lie with whomever the current terminology describes as being in charge of radiological work.
>
> ...
>
> The term ‘radiological work’ is being dispensed with and replaced by ‘activity with radiation’.
>
> ...
>
> We must assess whether some activity really is justified with regard to potential radiation risks. This means that the benefit from the use of radiation will far outweigh the risks that can be associated with radiation. ... So, to achieve satisfactory radiation protection we must endeavour to optimise the protection. This means that all radiation exposure must be kept as low as is reasonably possible with the observance of economic and social considerations. - - A third factor that must be observed during activity with radiation is that all doses of radiation that can be brought about by the activity can be kept below specific limit values that have been established.

Head of division Lars Persson at the Radiation Protection Institute had been an expert in the committee on the proposed Act. He has written a book containing explanations and comments on the Act (‘The Radiation Protection Act with comments’). It is worth reading.

22.3. **The Swedish Parliament’s decision to phase out the development of nuclear energy**

At the proposal of the Social Democratic minority government, Swedish Parliament decided that the phase-out of nuclear energy should begin with two reactors during 1995-1996. At the same time, it was decided that carbon dioxide emissions from fossil fuels should not be allowed to exceed the 1988 level. Birgitta Dahl declared that the decision to phase out nuclear was ‘irrevocable’.

The many requirements regarding Swedish energy sources now began to seem contradictory and the debate began to focus on how the requirements for phasing out nuclear energy, the ban on the expansion of hydroelectric power, and the limitation of carbon dioxide emissions could be combined while not posing a risk to employment or welfare (see also Section 25.6).

22.4. **Radioactive Waste Disposal**

The term ‘SFR’ (as it was abbreviated from the Swedish) means ‘Final Repository for Radioactive Waste Disposal’, a plant next to the Forsmark nuclear power plant which is intended to deal with radioactive operational waste from the Swedish nuclear power plant, other industries, healthcare and research. The plant was commissioned in 1988. The intention was to extend it to also be able to accommodate the waste arising when demolishing the nuclear power plants. The spent nuclear fuel would be stored at CLAB in the meantime (see Section 19:16).

22.5. **ICRP drafting group in Bethesda**

The task group for drawing up ICRP Publication 60, the new recommendations, met at the NCRP in Bethesda.

22.6. **Consultant for UNSCEAR**

I was once again consultant for UNSCEAR for two weeks and again stayed at the Pension Sacher.

22.7. **Major conferences**

In March and April there were a number of major international conferences. I deal separately with those later on. The following overview of my trip is personal, but is included because it gives an idea of what was happening at the time. At the end of March, the NCRP's annual meeting was held in Washington DC. I had been invited to give the 'Taylor Lecture'. At the start of April, the big IRPA Congress was held in Sydney along with a major IAEA conference in the same city. I also took part in these conferences. To fit in with its budget - the NCRP was to pay for my trip to Washington - I had to purchase the cheapest possible ticket to Sydney, which meant there would be stop-offs during the journey which could not include Washington. Marrit accompanied me and we stopped off in Los Angeles. From there I was able to make a return trip to Washington DC at the NCRP's expense. Marrit also accompanied me there, but we had to pay for her travel ourselves of course. In Washington we rented a car at the airport and spent three nights at the Howard Johnson Plaza Hotel in Culver City, not far from there,* and where on 24 March we made the mistake of dining at a Mexican restaurant. We became very unwell, probably due to salmonella, and faced our upcoming trip to Washington DC with a certain amount of dread. We flew there in a wretched state on Saturday 26 March. We were extremely embarrassed when on the Sunday we were at a brunch held at the Cosmos Club in our honour, invited by our American friends the Taylors, the Wyckoffs, the Sinclairs and several others. We could not get any of the food down and were not amiable guests. We stayed at the State Plaza Hotel on E Street and felt rotten for the whole time, gloomy not to be able to appreciate the subsequent dinner invitations from each and every one of said couples, although we were particularly pleased to be invited to the home of Lauriston Taylor and his pleasant wife Robena, a talented artist. It was not the first time that I had had the honour of being invited to the Taylors', although to me it felt like an historical-type visit the same as it was when I had been invited to Gino Failla's home thirty-seven years ago.

On Wednesday 30 March I presented my lecture at the NCRP's annual meeting and we flew back to Los Angeles on 2 April. To make things even worse, this time we had landed ourselves with a heavy, long-lasting cold. We again hired a car to the airport and stayed at the Howard Johnson Hotel for another three nights, carefully avoiding the Mexican restaurant. On 5 April we flew out over the Pacific Ocean but stopped off in Fiji, at the Nadi International Airport on the west coast of the largest island, Viti Levu, to be precise. By then we had passed the international date line and thus never experienced Wednesday 6 April 1988. A fifteen-minute journey by taxi took us to the hotel, The Regent of Fiji, on the island of Denerau. So we finally got to swim in the Pacific Ocean! We should have flown to Sydney on Saturday 9 April but then came the heaviest rainfall we had ever seen, which kept the plane on the ground. We had to stay overnight and continue on to Sydney on Sunday 10 April. In Sydney we stayed at the Cambridge Inn on Riley Street, within walking distance, through Hyde Park, of the City Hall, the centre of the events.

22.8. **Taylor lecture in Washington DC**

The visit to Washington DC was for the NCRP's annual meeting from 30-31 March. I wrote about this in my travel report:

> The NCRP's annual meetings are well-attended events. The subject of the annual meeting was 'radon' which had attracted 365 participants. [The annual meetings] are also open to interested parties outside the NCRP and it is not unusual to find representatives of other countries' radiation protection authorities; this time the head of Canadian radiation protection Ernest G. Letourneau and Mike O'Riordan from the British NRPB, for example. My advice to the Radiation Protection Institute is to keep

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* Those reading the description of my travel may wonder how our trip was paid for; part of it was a tourist trip rather than a business trip, but all 'unnecessary' stays (in Los Angeles, Washington DC, and Fiji), along with all additional expenses for Marrit to come along, were paid by us of course. This applies to all of my trips.

> its eyes open for the NCRP programme each year and send an observer when the programme is of interest. Since practically all the important people within the field of radiation protection in the USA take part in the NCRP's annual meetings there are good opportunities to make valuable personal contacts.
>
> The NCRP programme included 25 presentations on different aspects of the radon problem under the leadership of Naomi Harley who had been Chair of the Programme Committee. It was not as though the lectures brought any new information to a Swede, but they did show that the awareness of the radon risks in homes had now permeated the whole of the USA. The action programmes from several states were reported (Pennsylvania, New Jersey and Florida). In Pennsylvania, households were offered free measurements from the sub-state's Bureau of Radiation Protection. The federal Environmental Protection Agency, EPA, said that there had been surprisingly high radon levels in schools, where low levels were expected owing to good ventilation. The ventilation had clearly led to such underpressure that radon had been suctioned up from the ground. Substantial information measures had been taken, through the AMA (American Medical Association) and through brochures to households, for example but also through brief warnings broadcast on TV. Comparisons were made between the risk models from ICRP, NCRP and BEIR IV, where the risk perception certainly varies with time but the overall results were not considered to differ significantly (within a factor of 3) bearing in mind the high level of uncertainty.
>
> ...
>
> As a European, I considered it as a great honour to be invited to give the Taylor Lecture, which was also regarded to be an honour if you were American. The lecture will be published in a special pamphlet and in proceedings from the NCRP meeting.

The special pamphlet was 'Lecture No. 12' in the NCRP's series of Taylor lectures. I have read through the lecture again and think it is still of interest and has ideas that are worth considering, but I am of course biased.

The first pamphlet in the series consisted of a lecture from 1977 by Herbert Parker entitled *The Squares of the Natural Numbers in Radiation Protection*. The particular attraction of this series is that the contributions are both eccentric and read worthy. The 1978 lecture was given by Sir Edward Pochin and was entitled *Why be Quantitative About Radiation Risk Estimates?* Bill Pochin was the only European who had been invited before me, which meant that I felt particularly honoured.

22.9. **IRPA in Sydney**

In my travel report I wrote the following about the Congresses in Sydney:

> Several people from the Swedish Radiation Protection Institute took part in the IRPA Congress from whom travel reports can be expected. The Congress was a traditional one, which means that most of the lectures were mediocre and you got the most out of it by meeting colleagues from other countries. The best way to illustrate this might be the fact that the two contributions which made the greatest impression on me had not even been approved by the Programme Committee for verbal presentation but had been referred for presentation in the poster session, i.e., through text and diagrams on a display stand and references by a rapporteur during the Congress.

The protective effect of Ginseng extract

One of the two contributions was Japanese and came from the Radiation Centre at the Osaka Prefecture with M. Yonezawa as the main author. It concerned a remarkable effect from a Ginseng extract. Mice had been irradiated with more than 7 gray from x rays. This resulted in the mice dying 10-20 days later. If on the other hand they were injected with the Ginseng extract within a couple of hours of being irradiated, 80 % of the mice survived. The authors were able to show that the injection heavily stimulated the formation of thrombocytes and the survival of stem cells.

The doctors whom I noticed on Yonezawa's poster all reacted in the same way. When they first saw the word 'Ginseng' they sniggered ('Ginseng's good for *everything*…!'), and when they saw the poster they said 'That's incredible!' and looked incredulous to say the least.

Natural occurrence of 'SOD' as sensitivity indicator

This is what I wrote in the travel report:

> The second contribution which was also referred to be a poster contribution and was also not noticed later came from the Pole, T. Domanski, from the Institute for Occupational Medicine in Lodz. He had examined the protective effect of superoxide dismutase, abbreviated to 'SOD', which was said to be a substance known for its radioprotective effect.
>
> Domanski had examined the quantity of naturally-occurring SOD in 600 young men and 400 women. The average value was in the area of 70-100 units of SOD per ml of blood but the distribution was very distorted, to the extent that some people showed a several thousand units. Domanski's hope was that people with extremely high SOD levels would be particularly tolerant of radiation. Since he could not irradiate people, his investigations involved mice and he found that these showed a similar distribution with approximately the same average value. He then irradiated the mice with a dose which led to an average survival rate of 55 %.
>
> ... Domanski showed me and Dan Beninson a number of diagrams in addition to what was shown on his poster. He had been focusing too narrowly on the effect of very high SOD levels. What seemed more important to us was the fact that the trial animals which had SOD levels lower than 75 units had a very low survival rate. Using the SOD levels as an index, it was thus possible to differentiate a group consisting of almost half of the animals which proved to be particularly sensitive to radiation.
>
> ...
>
> Irrespective of whether variations in the sensitivity to radiation are an effect from the level of SOD or whether the latter is dependent on a particular factor which also influences the sensitivity to radiation, if Domanski's results stacked up, the SOD levels would give you an index which you could use to identify people who are particularly sensitive to radiation, which could constitute half of the total population. I also feel that this may have great development potential.
>
> It is tragicomical that the lasting memory of the IRPA Congress, at least for me, is made up of two contributions that were rejected by the Programme Committee and went virtually unnoticed by the majority of the participants. ...

The level of knowledge of those taking part in the Congress

This is what I wrote about the level of knowledge of those taking part in the Congress in my travel report:

> Those taking part in the IRPA Congresses make up an heterogeneous group, yet a group which ought to have elementary radiation protection knowledge. However, it turned out that a great deal needed to be clarified during the discussions. The Chair of ICRP, Dan Beninson, in particular took the opportunity give what near enough amounted to basic education in his own lectures and in contributions to discussions. It is slightly worrying that, according to what he has since said, many listeners thanked him for information on what you would really imagine was already generally known. For example, to many it turned out to be news that people think there are also radiation risks below the ICRP dose limits and that these [limits] are no more likely to guarantee absolute safety than any other dose limitation.

Frequent questions

Many questions were asked of the members of ICRP who were present. Most of them were answered by the Chair of the Commission, Dan Beninson. This is what I wrote:

> Many of the participants are actively-practising radiation protectionists who have close contact with technicians and engineers. A view that is often expressed among the technicians was that the radiation protection requirements were exaggerated and that there cannot be risks at low doses of radiation since you do not see any harmful effects. On one occasion, Beninson replied that he would not feel comfortable if the technical operation and safety of reactors were controlled according to the views of doctors and biologists; for the same reason, technicians and engineers ought not to give opinions on radiation biology. Many asked about the 'de minimis' values for doses of radiation could always be seen as non-existent; however, the purpose may not always have been laudable. Beninson also pointed out that if you were to overlook all doses/risks which did not lead to significant evidence in the injury statistics, you would obtain different 'de minimis' values depending on the size of the population. Even doses of radiation exceeding current dose limits would be negligible, but it would scarcely be a pleasing protection ambition to wait until you could 'count the bodies' before providing the protection.

ICRP session and panel

A special session was devoted to ICRP's activity which was reported in four lectures. Many of the audience were surprised to hear ICRP giving recommendations for patient radiation protection within medicine. Many radiation protectionists had obviously believed that ICRP was an organisation that dealt with nuclear power problems only! The next day, a panel consisting of ICRP members answered questions about ICRP. I wrote the following about the panel debate in my report:

> The panel pointed out that the meaning and use of the dose limit were far more important than the level thereof. When ICRP definitively established through ICRP Publication 26 that doses at the dose limit were unsuitable, the meaning of the limit was changed from previously having been said to be useful for purposes of planning and design. This meant that the requirements had been significantly sharpened without the value of the dose limit having been changed.
>
> Everyone expects there to be an increase in the estimated risk of cancer per unit radiation dose by something like a factor of 3-4, but no authoritative interpretation of the new epidemiological information has yet been published. We are waiting until the autumn for UNSCEAR's report and BEIR V, and ICRP's conclusions thereafter regarding the consequences for the dose limitation system.

The Sievert lecture

The IRPA Congresses gave a 'Sievert Lecture' in memory of Rolf Sievert. Being appointed to give the lecture is a distinguishing honour. This time, the lecture was given by Professor Wolfgang Jacobi from Munich and was entitled *Environmental Radioactivity and Man*. The honour had fallen to Jacobi because he had come up with the basis for the definition of 'effective dose'.

22.10. **The IAEA Conference in Sydney**

The IAEA conference on Radiation Protection in Nuclear Energy was held in Sydney the week after the IRPA Congress. My travel report contained the following:

> [The IRPA Congress] had exhausted the subject area to a certain extent and there was therefore not that much to be gained from the IAEA Conference. The IAEA Conference [was] also more formal, partly because all those asking questions [were forced] to write down their questions on a special form. Some lectures are indiscriminately highlighted. Abel González from IAEA reiterated a report from the IRPA Congress regarding the proposal of a new policy to treat risks from actual doses of radiation in the same way as risks from events which have only a certain likelihood of occurring and giving doses of radiation. Webb from the NRPB together with

Lombard from Paris gave an account of decision-aiding techniques in addition to the cost-benefit analysis, a good summary.

Professor Ilyin from Moscow, the Soviet UNSCEAR representative and main person responsible for the protection inputs after the Chernobyl accident, spoke about the practical experiences following the accident. This will be reported later on in the UNSCEAR report this autumn. The collective radiation dose to 280 million people in the Soviet Union is approx. 330,000 manSv. Out of these, 230,000 manSv concern people who receive individual radiation doses of at least 10 mSv. Ilyin thought this meant that when assessing the number of expected cases of cancer, there was no need to concern oneself with radiation doses lower than 10 mSv (and this meant one could [avoid] ending up in debates regarding whether the risk at low radiation doses is hypothetical or not). Even if one only included doses of radiation exceeding 10 mSv, one would still cover 70 % of the total collective dose commitment.

The collective dose of 230,000 manSv from doses of radiation exceeding 10 mSv concerned a population of 7.5 million people. According to Ilyin, this amount could be expected to increase the expected incidence of cancer by less than a quarter of one per cent, which cannot be detected using available epidemiological methods.

A special session concentrated on *The Dose-Response Relationship* [i.e., the connection between the radiation dose and the increased caused in the likelihood of cancer]*: Implications for Nuclear Energy*. Rumour has it that the purpose of the session was to allow critics of ICRP's and UNSCEAR's assumptions regarding a linear connection between dose and risk an opportunity to be heard. However, in the introductory lecture, Beninson showed effectively and convincingly that the assumption that linearity was a practical necessity. If there were no linear connection, for practical reasons it would be necessary to postulate such a connection or else the sequence of different dose contributions would determine their significance. This stopped the discussion and the other lectures in the session did not touch the main issue.

Beninson also reminded everyone that it was not a question of linearity down to the zero dose: we are never exposed to the zero dose because we accumulate a not-insignificant dose of 100 mSv or more during a lifetime. What counts is the connection between small *dose contributions* and corresponding *contributions* to the risk of cancer. This connection is described by the gradient of the dose-response curve at a point corresponding to our total accumulated radiation dose. Since a smaller section of a curve can usually be approximated by a straight line, the assumption of a linear connection between the dose and risk *contribution* is by no means unreasonable.

However, we must remember that the risks in question are small probabilities concerning an average individual and that they are of no useful significance other than when calculating the expected outcome in a population of many individuals. [*] Or, as Beninson put it: '*individual stochasticism leads to collective determinism*'.

22.11. **Wolfgang Jacobi turns 60**

On 17 May, Wolfgang Jacobi reached the age of 60 and this was celebrated by his colleagues in Munich. He spent sixteen years in charge of the Radiation Protection Institute, which was run by the *Gesellschaft für Strahlen- und Umweltforschung*, and he was also a member of ICRP.

22.12. **BEIR IV**

In 1988, the American Academy of Sciences published the BEIR IV report which was called *Health Risks of Radon and Other Internally Deposited Alpha-Emitters*. Polonium, radium, thorium, uranium

[*] I should have added '…of the same gender and age distribution and the same living conditions as the population (e.g., the survivors in Hiroshima) whose incidence of cancer forms the basis for the risk estimate'.

and transuraniums were dealt with as well as radon and its daughter products. One chapter concentrated on the combined effects of radon daughter exposure and cigarette smoking.

22.13. **UNSCEAR's 37th session in Vienna**

Before UNSCEAR's two-week session in Vienna from 6-17 June I was quite pessimistic about whether or not the work on the big report could be finished. In my letter to the Ministry for Foreign Affairs in which I proposed who the Swedish delegation should comprise, I had written:

> However, it is not completely clear whether the meeting will succeed in completing the report during this session because the Secretary of the Committee, Dr. Silini, has been forced to leave his job for health reasons.
>
> I am also Chairman of the Committee for this session, but will step down as Chairman after the meeting. If the work with the big report is completed during the 37th session I will ask to be released as Swedish representative so that my successor can settle into the work at the start of next work cycle. If the work is not completed due to the Secretariat's problems, I am willing to remain for the next session to complete the work.
>
> ...
>
> I suggest that this time, DG of the Swedish Radiation Protection Institute Gunnar Bengtsson also take part at the end of the session to get to know the Committee. I already previously suggested that Bengtsson succeed me as representative.

However, the Secretariat functioned well, not least thanks to Frau Holzer's routines and efficiency, but also because Burton Bennett ended up succeeding Silini. The work with the big report was successful, although there were times when we all thought it would be impossible to agree. On one occasion, the most opinionated moved up to the Secretariat's premises and threatened to leave the meeting. I went after them and succeeded in persuading them otherwise although I do not remember how. After the meeting I received an appreciative letter from Gunnar Walinder at the time when we were to write a joint report for the Ministry for Foreign Affairs. I am not ashamed to reproduce it because, for once in a while, I had been very pleased with myself. Gunnar wrote:

> Allow me once again to express my open admiration for your brilliant Chairmanship in Vienna, which undoubtedly rescued the 1988 UNSCEAR report for the UN. I find it difficult to imagine anyone else being able to execute this combined masterpiece of patience and necessarily sticking to your guns. It was also 'lucky' that Warren Sinclair got to take over the Biology Committee or else we would definitely not have had time to do the cancer document.

I answered Gunnar in a letter of 7 July as follows:

> Thank you for the appreciative words in your letter of 26 June! However, it was not purely down to me that everything went well. If it weren't for the help of people like Beninson, Dunster, and Sinclair I would never have managed it.

This time, our report to the Ministry for Foreign Affairs, dated 8 July 1988, was eight pages long and described the new report. We pointed out that now, for the first time since 1977, UNSCEAR had estimated the risk of cancer from ionising radiation. The result was that the Committee thought the risk factor at low doses of radiation (the likelihood of cancer per sievert) could be between 0.3 % and 5 %. We commented on this uncertainty:

> As a Scientific Committee UNSCEAR has no reason to try to single out a 'best' risk estimate with the uncertainty is as high as it is. On the other hand, the International Commission on Radiological Protection (ICRP), which is in the process of revising its fundamental recommendations, has one and a half years to decide on a suitable

> assumption from a cautious radiation protection point of view. The risk value will probably fall within a narrower interval than that which UNSCEAR has been able to agree on as a compromise and with scientific reservations. Probably a value somewhere between 4 % and 8 % per Sv at high doses and dose rates and somewhere between 2 % and 4 % at low doses and dose rates. However, a risk estimate is of little practical significance when it comes to selecting dose limits, for example. What is much more important is the assessment of which risk level a dose limit should correspond to.

The Chernobyl accident was dealt with in a separate Appendix. Thirty deaths had occurred among the nuclear power plant's personnel and firemen within three months of the accident, twenty-eight of these deaths having been caused by radiation injuries. The local population did not receive high enough doses of radiation to allow acute radiation injuries to arise. The Committee noted that the substances which primarily generated radiation doses were short-lived iodine-131 and long-lived caesium-137. The collective radiation dose to the Earth's population was estimated to be 600,000 manSv.[*]

This was the first time that Gunnar Bengtsson took part in a UNSCEAR meeting, and he was eager for me to introduce him to all of the delegates. Dan Beninson and I suggested that he accompany us to dinner at a suitable restaurant and have chance to chat. The terribly well-behaved Gunnar said that talking trivia at restaurants was a waste of time but agreed, as an experiment, to accompany us to see whether he was right. We talked a lot of rubbish, of course, and Gunnar's conviction was strengthened whereas Dan and I thought that underestimating trivialities could be dangerous.

22.14. **Brookhaven in warm July**

In July Dan Beninson and I visited Brookhaven National Laboratory on Long Island to discuss ICRP matters with Charlie Meinhold. We stayed in a guest house and it was terribly warm and humid. Some of the activity was conducted in old aeroplane hangars which also exhibited some old military history material. There was a saw-toothed sabre which was said to be inhumane – and that made me wonder which weapons could be called humane.

At the home of Charlie and his sculptress wife I saw my first cordless telephone, which marked the breakthrough of life lived around IT. At the weekends we sailed on Charlie's boat, *Acceptable Risk*, over Great South Bay's lagoon.

22.15. **The testing of video display units**

In 1987, the Swedish National Council for Metrology and Testing (MPR) had established rules and criteria for the voluntary testing of computer monitors (video display units) and the Radiation Protection Institute had become an authorised test site for such monitors. These rules were aimed largely at manufacturers and test sites, so in 1988, the Radiation Protection Institute issued a pamphlet, 'The testing of monitors', in the attempt to answer the questions that could arise in connection with applying the advice.

22.16. **Radioecology in Rättvik**

The 5th Nordic Radioecology Seminar was organised by Jan Olof Snihs in Rättvik in the summer of 1988. One hundred and forty participants enjoyed the wonderful view over Lake Siljan and a boat trip

[*] The unexpected cases of thyroid cancer among children had not yet been observed. With the Committee's risk estimates, the global collective dose would be expected to cause between 2 000 and 30 000 cases of cancer, but the Committee did not want to take responsibility for such figures.

on the same. The subject was a quantitative description of the distribution of different radionuclides within different ecosystems. See also Section 23.15.

22.17. **The concept of risk**

The interest in the concept of risk culminated during the year. The word ‘risk’ has many different meanings which also involve many possibilities for misunderstandings. Two people can have a conversation about risks and be talking completely at cross purposes. However, everyone understands that risk concerns danger or loss. One makes an ironic joke if talking about ‘the risk’ of winning a lottery. The possible meanings include:

> **The nature of the risk**. What is the risk of taking a dip here? Answer: *You might be attacked by a shark.*
> **The likelihood of an event**: How great is the risk of being attacked by a shark today? Answer: *One in a million*.
> **The impact of an event**: What is the risk of being attacked by a shark? Answer: *You can die*.
> **The expected value of a loss**: How great is the risk if there is a 2 per cent (i.e., one in fifty) likelihood of the impact being that I lose 100,000 Swedish kronor? Answer: *2000 Swedish kronor* (the product of the likelihood and the magnitude of the impact).
> **Someone who can cause damage or injuries**: Is that man a risk? Answer: *Yes, that man is a safety risk.*
> **A summary of several meanings with no specified detail**: Dare we do this? Answer: *No, the risk is too great.*

One particular source of confusion has been the fact that radiation protectionists and reactor safety experts have used risk in different senses of the word. In publications 9 (1965) and 26 (1977), ICRP used ‘risk’ to mean *the probability of* harm (usually, death). The safety experts used ‘risk’ to mean the *expected value* of harm, i.e., the product of the probability of damage (e.g., a reactor accident) occurring, and the impact (amount of harm) resulting if the damage occurs. The Radiation Protection Institute has used ‘risk’ in both these senses in different contexts. It was not until the 1980s that we began to avoid the word ‘risk’ as a synonym for some of the concepts of probability, impact, or expected value of an impact and use these words instead.

None of these concepts are enough on their own as a basis for a decision. A very small likelihood with a substantial impact cannot be equated with a substantial likelihood that has a very insignificant impact. In the first case, a massive meteorite impact can be used as an example. In the second case, an ordinary cold can be the example. Technicians want to solve the problem by stating the product of the likelihood and the magnitude of the impact, i.e., the expected value of the impact, but unfortunately this is a simplification which does not give enough information. Sometimes, the expected value of the loss of lifetime due to a hazard is used, e.g., 10 days. But our willingness to accept such an expected value is definitely different if there is a 100 % likelihood of a death 10 days earlier at the age of ninety or an immediate loss of life with a likelihood of perhaps 0.05 % (irrespective of our age). The expected value is mostly of value for long-term card games, dice games and roulette games or where there is a central outcome in the outcome distribution such as the estimated number of traffic accidents during a given period.

In general, physicists, engineers and natural scientists have given precedence to the quantifiable quantities. However, many of those who deal with risk estimates and risk assessments in one way or another represent other branches of science such as behaviour research and sociology and have not been satisfied with such simple concepts. People began to talk about ‘perceived risk’ and how you could explain that, for example, cigarette smokers with a possible likelihood of one in five of dying early - and painfully - accepted this risk but were worried about likelihoods of injury which experts considered to be very small compared with other risks.

This concept became easier to understand when they realised that it was not the risk (the size and type of the impact and the likelihood of the harmful event) which determined people's attitudes but the activity or the situation that created the risk. Smoking is accepted, despite the very substantial risk, if you voluntarily choose to partake in this bad practice and like smoking. People are completely unwilling to accept a very insignificant risk from an activity that is obligatory and over which they have no influence, do not trust and derive no benefit from. It is the attitude to *the activity* rather than the magnitude of the risk which determines the level of risk that people accept. It is not the risk that is accepted – it is an activity or a situation where the risk is just one of many factors that influences the acceptance.

22.18. **The concept of probability**

The concept of probability is rooted in the 1500s where it was used to calculate expected outcome frequencies when gambling (using dice, playing cards or roulette wheels). At the time, the probability was defined as the ratio between the number of favourable and the number of possible outcomes. When throwing a die there are six possible outcomes. The probability of each and every one of these, call them i, is therefore $P(i) = 1/6$. If you throw the die many times, e.g., n times, you can expect the number of i outcomes, e.g., sixes, to be close to the expected value $P(i) \cdot n = n/6$ if n is a large number. On the same basis, you can expect the number of times you pick a king of spades from a full, well-shuffled pack of cards after n picks to be approximately $n/52$. The probability thus acted as a tool to calculate expected frequencies.

This first definition of the probability was based on symmetry. If instead of throwing a die you throw a box of matches, there is no longer any symmetry between the different sides and the classic definition of probability can no longer be used. Nor is it useful when calculating the cancer mortality rate or the frequency of traffic accidents. The alternative definition of probability is then based on the already-observed relative frequency of deaths or accidents. Expected future outcomes can then be calculated using the new, frequency-based probability. However. there is now another requirement, viz., that the conditions remain unchanged over time. In practice, the future frequency of traffic accidents may be lower than the one that has already been observed because of improvements to safety, or higher due to greater alcohol consumption. The relevant probability is thus dependent on an assumption.

The dependency of probability on a conscious or unconscious assumption actually also concerned the classic probability. The assumption then was that the condition of symmetry applied. However, this was not completely reliable. The die may have belonged to a cheat and have been loaded with a lead pellets!

It becomes even more difficult when talking about the probability of an individual outcome, e.g., whether my car will last another year or whether my aunt will die next year. This is where the frequency definition of probability loses its meaning. It is completely impossible to imagine an experiment with thousands of aunts. If they were all *identical* to my aunt they would all meet exactly the same fate and the experiment would be of no help. To gain assistance from any idea of frequency I would have to place my aunt in a special group. But which? 80 year-old women? 80 year-old women with weak hearts? 80 year-old women diagnosed with stomach cancer?

There are an infinite number of possible groups *en route* to a full identity, so there is no probability value that is independent of the estimator's knowledge and experience. *There is no objective probability*. And, in this case, the estimated probability will not be based on observed frequencies - it must instead be seen as the estimator's subjective faith in a statement ('your aunt will die next year') based on what he knows and thinks.

Broadly speaking, engineers and technicians often have the idea that a probability is an objective, existing quantity which we could reveal but which is currently concealed behind an uninformative curtain. They forget that every probability statement is basically subjective and dependent on a number of assumptions which may also be completely incorrect. This facilitates jokes about assertive predictions which in time prove to be grossly incorrect. We can find an example of the engineer's naivety in Carl-Eric Holmquist's book from 1978, 'A pure accident'. He writes:

> At a public debate the other year with Björn Gillberg regarding the risks of nuclear power, I wanted to use a few comprehensible examples to illustrate how low the probability of a serious reactor accident is.
>
> ...
>
> Well, to show how unlikely such an event is (mathematically expressed, once in a million to once in a hundred million years), I referred to the fact that the probability was just as small as that of a supernova (large star) exploding and destroying all life on Earth with its radiation.
>
> ...
>
> On the other hand, the public, who saw this type of risk as completely absurd, felt the reactor breakdown was significantly more real, despite both of the events being equally likely to occur and despite the fact that the effects of the supernova explosion would involve complete destruction of the Earth through radiation.

The public reacted appropriately. They were sceptical about the probability of a reactor accident being as low as Holmquist said. They were more inclined to rely on the fact that the probability of fatal radiation from a supernova was fairly low; it had not happened during recorded history after all. The events since that discussion have shown that they were right.

There is a quick-witted illustration of the dependence of probability on assumption in Parker and Hart's comic strip series *The Wizard of Id*. The newsreader announces from his tower:

> 'Eleven o'clock and time for the news!
> 'There is a 30 percent chance of rain tonight…
> '… a 60 percent chance of rain tomorrow…
> '… and a 90 percent chance I'm wrong on both counts!'

Lack of knowledge often leads the average lifetime to be taken as a measurement of how old members of a population can become. However, in a poor country with substantial need, starvation and infectious diseases, the average lifetime is heavily affected by child mortality. If three out of four new-borns were to die as infants and the fourth to grow up to become one hundred years old, the average lifetime of the group would be just 25 years. When I browse through the pages of old family papers I find the names of the children that the farmer's wife Anna Lisa Svensdotter had with her husband Sven Ljungner, my maternal grandmother's paternal uncle:

Janne	born in1851
Maria	1852
Janne	1854
Maria	1855
Johannes	1860
Sofi	1862
David	1864
Sofi	1868
Lotta	1870

Here, the infant mortality was 33%. The first lot of youngsters, Janne, Maria and Sofi, did not survive their first year. However, there were families who had better luck (or better hygiene, cleaner drinking water and more food available). My maternal grandmother's parents had eight children, all of whom survived into adulthood despite the family's poverty.

In Sweden in the 1700s, an average of one in five new-borns died before reaching one year of age. Since then, the infant mortality rate has fallen dramatically to approx. six in one thousand children born. The mortality rate for adults was first studied by the British insurance mathematician Benjamin Gompertz (1779-1865). In his time, the annual likelihood of death was thought to be the same for all ages, around the same as it was for birds. If that was the case, the likelihood of surviving fell exponentially with age and the likelihood of surviving fur a further number of years was then independent of age, which was convenient for the insurance companies. But Gompertz thought he could see the annual risk of death increased during old age, which he interpreted as an effect of aging in addition to the random, age-independent risk of death.

In 1825, Gompertz published an interesting article in *Philosophical Transactions of the Royal Society of London*. Gompertz assumed that aging meant that probability of death per unit time (*probability rate*, d*P*/d*u*) increased exponentially with age (*u*) so that

$$\frac{dP}{du} = A \cdot e^{Bu}$$

where A and B are age-independent coefficients. Gompertz' formula does show the death probability rate with age from around the age of thirty but underestimates the risk of death for younger ages. Another British insurance officer, William Makeham (1827-1891) added an age-independent term C to Gompertz' formula in 1860 which was then altered to:

$$\frac{dP}{du} = A \cdot e^{Bu} + C$$

Written like this, the formula is usually called Makeham's formula or Gompertz-Makeham's formula. The formula has been used by ICRP in publications 8 and 60 to show the impact of doses of radiation on the risk of death. Many studies thereof have been published. It is often thought that the coefficient B is time-dependent and approx. 0.1 per year.

22.19. **The Society for Risk Sciences**

At the start of the year I was contacted by Torbjörn Malmfors, the enthusiastic risk consultant who had arranged the seminar on chemical health risks at Carl Jan Granqvist's in Grythyttan in 1981 and then been very active when it came to risk matters. He and *Vattenfall's* Carl-Eric Holmquist had taken the initiative of trying to bring together people who were interested in risk research. Holmquist had been responsible for health and safety matters at *Vattenfall's* development section for electricity and heating technology since 1956. In 1978 he had published a book entitled 'A Pure Accident' which was about risks and risk assessment.

Malmfors and Holmquist looked for people who were willing to sign a petition for the formation of a 'Risk Society', a type of 'risk academy'. In March 1988, I received a proposed petition which I commented on, suggesting a number of changes. Some of what I wrote follows:

> The last sentence of the first page of the petition is unnecessarily provocative and a little naive. The reader will get the impression that the authors think that 'people's worry' needs to be alleviated (and, in that case, according to the authors is considered to be possible to alleviate) because it is without grounds. We cannot axiomatically work on the basis of the fact that all concern is unfounded until the Academy has had its say. If we do not work on that basis, we must accept that there may be cause for concern. Why should it be alleviated? And why do we *assume* that the Academy will be impartial.
>
> Our intention probably should be written as 'In order for it to be possible to assess how justified people are to be worried in different contexts, to provide support for measures against risk sources which lead to justified concern, and to be able to alleviate the concern that appears to be unjustified, the Academy must be credible and impartial. This places great demands on the knowledge, experience and integrity of its members'.

I completed my comments with:

> So, there is much to discuss and I am happy to help, and sign the petition, if I am convinced that it will be economically viable to carry out the proposed activity without becoming dependent on sponsors who have an axe to grind.

What worried me was becoming dependent on interests such as the tobacco industry, the pharmaceuticals industry, or the nuclear power industry, which probably would be willing to contribute money.

We met in Torbjörn Malmfors' premises (which was on Kammakaregatan at the time) to prepare the discussions. Arne Engström and Lars Werkö also joined us. Werkö had been Professor of Internal Medicine in Gothenburg but had then been head of research at Astra from 1975-1985 and was now Chair of the Swedish Council for Medical and Social Assessment which was set up in 1987.

The petition went out on 3 October and was signed by Engström, Holmquist, Lindell, Malmfors and Werkö. A further six people were stated as interested in supporting the petition, i.e., Edgar Borgenhammar, Bernt Brehmer, Olof Gunnarsson, Barbro Westerholm, Peter Westerholm and Gustaf Östberg. The heading of the petition was 'Invitation' and it began with:

> The undersigned have agreed that there is a need to create a forum to take note of and discuss the problems surrounding the risks in today's society. We have drawn up a petition to gather a number of people in a Society for Risk Sciences which will work towards greater understanding of the risk issues.

The actual petition was worded as follows:

> The concept of risk has no straightforward scientific definition. Opinions are also divided as to how we should identify, determine, value and action risks, and particularly how information on risks should be spread.
>
> ...
>
> The contradiction between what the experts think they know and what is perceived by the layperson can have serious consequences for both the individual person and for society as a whole, e.g., as regards finances and the formation of opinions.
>
> No research contributions can solve this growing problem. It is not simply a matter of obtaining more facts. It is a matter of increasing the insight into what risks involve and how they should be handled. There is therefore a need for a politically and economically-independent institute – a *Society for Risk Sciences* – through which independent scientists could guide the layperson. Political parties, companies and institutes also need guidance where matters associated with great risk are concerned.
>
> Such a Society for Risk Sciences should not issue certificates showing there is no risk or assess the level of danger. On the contrary, it should be able to give its opinion on how risk should be determined and assessed and how risk information should be provided, and consider the ethics of risk handling. The impartiality of the Society for Risk Sciences could create conditions for a nuanced opinion of risks with the help of greater knowledge and insight into risks.

On 8 November 1988 a statutory meeting was held at the Swedish Society of Medicine's premises. The first members of the Risk Society were:

Anders Ahlbom	Bengt Jönsson
Edgar Borgenhammar	Lars G. Larsson
Thomas Brante	Bo Lindell
Bernt Brehmer	Torbjörn Malmfors
Jörgen Bäckström	Göran Möller
Jerzy Einhorn	Birgitta Odén
Lars Ekman	Dag Prawitz
Arne Engström	Claes Ramel

David Finer	Eva Selin
Marianne Frankenhaeuser	Carin Sundström-Frisk
Olof Gunnarsson	Torbjörn Thedéen
Jan-Åke Gustafsson	Gunnar Walinder
Sven-Ove Hansson	Lars Werkö
Lars-Erik Holm	Peter Westerholm
Carl-Eric Holmquist	Gustaf Östberg

The group of five people who had regularly met at Torbjörn Malmfors' place were elected as the Society for Risk Sciences' Presidium. I was asked to be Chair on the basis that I had experience as Chair of ICRP. Arne Engström became Deputy Chair and Torbjörn Malmfors the Secretary of the Society. Carl-Eric Holmquist became Treasurer and Lars Werkö became 'another' member.

I accepted the Chairmanship because it concerned me that many people wanted to allay people's concern and had the idea that it would disappear if those who were worried found out 'how it really was'. That notion was still common among those who happened to meet people who were worried.

The Society for Risk Sciences ended up holding a number of well-attended seminars on various risk issues. Initially, during the first ten years, the Society also produced a series of papers, eleven in all, with the following titles:

1. Comparing risks
2. Limiting risks
3. Perceived risk
4. HIV/AIDS from the risk point of view
5. Our dominant health risks
6. Radon in homes
7. The ambition to save lives
8. Chemical risks – problems making decisions
9. How dangerous can nature be?
10. Electromagnetic fields
11. Decisions during uncertainty

22.20. **The 1988 UNSCEAR report**

The big report was published in the autumn; it was on 647 closely-printed A4 pages with text in two columns with many tables and diagrams. Its title was *Sources, Effects and Risks of Ionising Radiation*. At Silini's suggestion, the main text was divided into two sections: one with a historical overview and one addressing the current situation.

The section entitled *Historical Review* ought to be obligatory reading for every radiation protectionist since it summarises the problems dealt with by the Committee during the 25 eventful years from 1958 until 1982. That is where you find a summary of the concepts, quantities and units that UNSCEAR has utilised. It is where quantities are explained in terms of activity and dose (of different types) and the way the units have changed over the years. It explains concepts such as genetically significant dose, dose commitment, collective dose, collective dose commitment and effective dose. It describes the sudden change in the stated dose for the lung dose from radon daughters that developed in 1982 when the change from stating absorbed dose to using effective dose was implemented. It describes how UNSCEAR has tried different ways of stating doses of radiation from radioactive fallout from the atmospheric nuclear weapons testing over the years. It describes how the doses of radiation from the nuclear power industry's fuel cycle have been stated and expressed in relation to the energy produced (in MW × year) over the years. It describes the problems with stating the doses of radiation for patients and for those who work with sources of radiation. It discusses the radiation accidents that have occurred, primarily at Windscale and on Three Mile Island.* It discusses in detail how on various occasions UNSCEAR has presented the risk of hereditary injuries. It discusses how the risk of cancer has been rated between 1958 and 1972. It discusses the risk of non-stochastic injuries, primarily to foetuses.

The section on 'the current position' contained UNSCEAR's usual overview of doses of radiation and radiation effects, but the content was particularly interesting on two counts. First of all there was a summary of the consequences of the Chernobyl accident, and secondly UNSCEAR reported risk estimates for the first time since 1977. I have already mentioned the latter in the section on UNSCEAR's 37th session (Section 22.13).

22.21. **IAEA radiation protection meeting**

The 32nd session of the IAEA general conference was held in Vienna, Austria in September. On 20-21 September a special scientific radiation protection meeting was arranged in parallel with the general conference. The Chair of the meeting was Sir Edward Pochin who submitted a report to the general conference after the meeting.

22.22. **The ICRP Main Commission in Bariloche**

Directly after the meeting, i.e., on 22 September, Pochin, Warren Sinclair, and I flew to Argentina to take part in a meeting of the ICRP Main Commission. We flew with Lufthansa and sat comfortably in the small upper level of the plane. On 23 September, we continued on an Argentinian plane from Buenos Aires to San Carlos de Bariloche. We stayed there and held the meetings at the Panamericano Hotel in the city.

The draft of the new recommendations, ICRP Publication 60, was now being discussed. The main text had been written by John Dunster according to the Commission's instructions. Despite his strength of will and specific views, it was very praiseworthy of John to write this text with no attempt whatsoever to sneak in his own views where they did not agree with those of the majority. But John was an honest person.†

I was able to give an account of my proposal for an Appendix (C) entitled 'Bases for judging the significance of the effects of radiation'. We realised that the biological effects of radiation could be described in many different ways. The simplest was the likelihood of dying too early due to an extra dose of radiation. But how did one quantify 'too early'? And the extra risk of death means an addition to a risk of death that we all have for other reasons and which increases with age. How relevant would it be to compare these risks?

We had previously worked on the basis of an assumed 'additive risk', i.e., that a given radiation dose increased the annual likelihood of dying by a specific amount irrespective of the age at the time of the irradiation. It would then quite simply be possible to calculate the extra likelihood of death over a lifetime as the product of the expected remaining number of life years at the time of the irradiation and the additional annual probability of death. However, it now appeared as though the assumption of a multiplicative or 'relative' risk was more likely. A relative risk would give an extra risk-adjusted mortality rate (probability per unit time) which for every radiation dose was always the same proportional fraction of the total rate of the radiation dose. The annual risk would then increase strongly with age and the integral of the extra risk-adjusted mortality rate would diverge and not be a useful risk measurement. One would need to multiply the probability rate by the probability of being alive at

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* It is remarkable that the disaster with the Kyshtym waste storage area in 1957 (see *'The Labours of Hercules'*) and the substantial discharges to the Techa River in 1950-1951 were not mentioned by UNSCEAR in 1988. These events were known outside the Soviet Union through an article in *New Scientist* in 1976, through statements from the CIA in 1979 and through a book by Zhores Medvedev in 1979, but were initially dismissed by western scientists as unlikely. It was not until Gorbachev was able to implement glasnost in 1990 that the information on the Kyshtym disaster was generally accepted.

† John was an honest person who said what he thought and made a few enemies in doing so. One of his favourite expressions when someone whom he did not like had left an assignment was 'Good riddance!'.

different ages. Nor should one talk about an 'extra' probability of death; the probability of eventually dying at some stage is always 100% and cannot be increased through any additional risk. On the other hand, the expected distribution of the time of death would be affected. The time integral of the distribution curve would always be 100%. If the curve were depressed in one place, this would mean it would have to bulge out in another.

It was possible to calculate and illustrate these contexts with diagrams, which I had done. To assess the significance of a given radiation dose, it would be necessary to take into account all of this information.

Dan Beninson realised precisely what I meant, of course, but I was not sure whether the other ICRP members understood. I was therefore happy when both Dr. Li and Eizo Tajima showed that they had followed my argument, and finally so did most of the others, which paved the way for the Commission to accept my Appendix.

A meeting in Bariloche was not without its interesting trips of course. A couple of boat trips on the big Nahuel Huapi Lake were particularly memorable, one to Victoria Island and one along the Blest inlet with a walk to the border with Chile. Fresh air chilled the lake and most people sat in the cabin, but Bill Pochin and I appreciated the refreshing winds and the fantastic views and endured the winds.

22.23. **Lars-Erik Holm**

On 25 October I wrote to the Ministry for Foreign Affairs:

> Bearing in mind that, following my departure as representative of UNSCEAR, it may be appropriate to make a decision regarding both my successor and the latter's deputy I would like to suggest that Assistant Professor Lars-Erik Holm of *Karolinska sjukhuset* (*Radiumhemmet*) succeed Gunnar Walinder as the representative's deputy. I have consulted DG Gunnar Bengrsson of the Radiation Protection Institute regarding this proposal.
>
> The practice has been for the representative's deputy to be a medical biologist provided the representative is a physicist, bearing in mind UNSCEAR's method of working in two parallel groups, one physical and one biological.
>
> Dr Holm has been part of the Swedish delegation (at the Radiation Protection Institute's cost) since 1984. Since 1985 he has also been part of the International Radiation Protection Commission's (ICRP) expert group on radiobiology. His contributions in both contexts have aroused international admiration and respect. At *Karolinska sjukhuset* he is currently responsible for the cancer prevention activity but also takes the initiative for a number of epidemiological studies of the connection between ionising radiation and cancer, studies which have aroused substantial interest in the international work.
>
> Holm was born in 1951 and deservedly defended his thesis in 1980 with a thesis on the incidence of thyroid tumours among patients who had been treated with radiation or examined with radioactive iodine.
>
> In my opinion, Holm is without doubt the most suitable person to act as the representative's deputy at UNSCEAR.

Despite the attention that Lars-Erik attracted, he had shown great hesitation in accepting membership of ICRP Committee 1. He said he felt like out of his element and that he did not feel mature enough to be discussing things with the older radiation biologists, particularly not with the really dominant Baruch Modan from Israel. But as Chair of the Committee, Warren Sinclair was anxious to get Lars-Erik involved and succeeded in convincing him with a little help from me.* The uncertainty shown by Lars-

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* Lars-Erik Holm became Chair of the ICRP Main Commission in 2005.

Erik early on and which, with his knowledge and capacity, he had no need to feel did unfortunately also lead to problems for him when he took on important management positions later on.

22.24. **Ban radiation-causing circumstances!**

On New Year's Eve in 1988, *Dagens Nyheter* published an open letter to the Minister for Energy Birgitta Dahl with the above headline from the Chair of Electrolux' board, Hans Werthén. The letter ended with:

> All humans contain the element potassium, and all potassium contains radioactive potassium-40. This is not due to the Chernobyl accident or failure on the part of our Ministry for Energy, Mrs. Dahl, to carry out her duties, but to the contrivances at the time of the Big Bang when the universe was formed.
>
> Back to potassium-40. Every kilogramme of human being contains 100 becquerels of this radioactive isotope. Someone who adopts the horizontal position with an individual of, say, 60 kilogrammes is thus exposed to 6000 becquerels of radiation. If you move in with a slender 50-kilogramme person whose weight then proceeds to increase to 100 kilogrammes while living with you, the irradiation and the risk of radiation doubles!
>
> All sleeping together should therefore obviously be banned in order to reduce the health hazards from radioactive radiation. Even weight increase within marriage and between common-law partners should be criminalised as soon as possible since this would lead to such significant radiation risks for the other individual!
>
> Until these matters + radiofrequency radiation [!] from the blue clay in places like Helsinki have been investigated further, I think the nuclear power phase-out should be suspended, despite the short-term election disadvantages to which it is feared this will lead for various rather isolated politicians.

I wrote a retort to this which *DN* refused to include 'owing to lack of space'. I wrote:

> Hans Werthén related in *DN* on New Year's Eve in an outburst of burlesque humour how he had contacted Professor Bertil Åberg, member of the Academy of Sciences, and been given 'new observations' about the radiobiological risk of going to bed with a partner who was too fat. However, these observations are nothing new.
>
> Professor Rolf Sievert, the Swedish radiation protection pioneer, had already shown in the 1950s that the human body is source of gamma radiation which emanates from the naturally-occurring potassium isotope potassium-40, of which approx. 100 becquerels per kilogramme is contained in muscle tissue. Potassium is a natural component of muscle tissue. Sievert was also very rightly able to ascertain that women emit less gamma radiation than men. Professor Georg de Hevesy used to comment on this in his best Scandinavian: 'That Sievert, he's finally shown that women are less muscular than men!'
>
> Since potassium is found in muscles rather than fat, Hans Werthén need not worry about 'weight increase within marriage and observations' unless one of the parties takes up body building. But who would not be concerned if that were the case?
>
> Joking aside, Hans Werthén, I do not think that the doubts of knowledgeable politicians regarding nuclear power are based on the fear of small doses of radiation, even though it may be convenient to listen to voters who are scared by the mass media. Knowledgeable politicians must know that the Swedish protection ambition when it comes to normal nuclear power operation and waste handling makes it more environmentally friendly than competing energy sources. It is other aspects of nuclear power (primarily the conceivable risks of accidents, particularly in countries where there is a lack of knowledge and no desire to protect and, in some instances, the possibility of cooperation with the military weapon technology) which have led politicians who feel a certain level of responsibility to have doubts. I am scarcely competent to give an

opinion as to whether or not this hesitation really is justified – and that is probably also the case where Hans Werthén is concerned.

23. THE YEAR 1989

23.1. ICRP drafting group in Oxford

The task group which drafted what would end up as Publication 60 met in Oxford in January. My proposal for an Annex C on the principles for assessing the harmful effects of radiation was discussed. All of the curves and diagrams that I had calculated on the computer in the Haga Court of Justice were included.

23.2. Letter to the Ministry for Foreign Affairs regarding the Swedish UNSCEAR delegation's composition

On 21 February, Gunnar Bengtsson, who had now succeeded me as Swedish UNSCEAR representative, wrote to the Ministry for Foreign Affairs and proposed that, as well as himself, the Swedish delegation for the Committee's meeting in May should consist of Lars-Erik Holm as the representative's deputy and Jan Olof Snihs and Jack Valentin as experts. Gunnar also anticipated that an expert from the Swedish Defence Research Establishment would be needed at the later meetings. However, Jack Valentin did not end up being part of the delegation since he took part in the meeting as consultant to the Secretariat.

23.3. The irradiation of foods

At the start of the year, a proposal from the government to ban the irradiation of foods was discussed. In *Dagens Nyheter (DN)*, the head of the Swedish Foods Agency's laboratory Bengt von Hofsten criticised the proposal to then immediately be corrected by the Agency's Director General Arne Kardell, who said that the Swedish Foods Agency supported the proposed ban. I thought von Hofsten was right, and the fact that that my own report from 1983 was not mentioned in this context irritated me. I wrote an account of the problem to *DN* which rejected it with the following explanation: 'We are not continuing the debate on irradiation other than von Hofsten and the Minister for Agriculture having the option of coming back to us'. Since, despite everything, my account does illustrate the situation, I am reproducing it here:

> *DN* has bewildered its readers by firstly showing a contribution by Professor Bengt von Hofsten, head of the Swedish Foods Agency's food laboratory, and then a correction by the Agency's Director General, Arne Kardell.
>
> The headline given to Bengt von Hofsten's contribution said that the Swedish Foods Agency was protesting against the government's proposal to ban the irradiation of foods. Arne Kardell maintains that the Swedish Foods Agency supports the government's proposal and that von Hofsten's views are his own private ones, not those of the Agency.
>
> Since a government agency is identical to its board from the decision-making point of view, Kardell is obviously right about the Swedish Foods Agency's approach. However, what is equally certain is that von Hofsten is expressing the approach of most of the experts on the matter rather than some odd private opinion.

In 1982 the government asked me to look at the problems with the irradiation of foods. I was given the country's leading experts in the field to assist me. In May 1983 we issued a report (SOU 1983:26) entitled 'The irradiation of foods'.

Against this background, I see it as my duty to give my points of view on this matter, particularly since the fact that our report exists appears to have been completely forgotten in the current discussions, despite the fact that it was very well received, it is easy to read and generally deals with the whole set of issues.

Allow me to give my own opinion first of all. As a Swedish consumer, I basically have a negative attitude towards the irradiation of foods. However, I consider the irradiation of foods to be a pseudo-problem which elevated concern has brought up to an unnecessarily high decision-making level. I also think there are cases where the irradiation of foods is beneficial and desirable. A total ban would prevent the use of irradiated spices, for example, and thereby increase the risk of either life-threatening bacterial infections like *Salmonella* or injuries due to carcinogenic chemical treatments.

Despite all the information that has been provided, some fallacies still live on. It is therefore worth repeating that irradiated foods do not become radioactive or emit any radiation themselves. Harmful substances, known as radiolysis products, which are formed at the time of the irradiation are not unique (it would then not be that difficult to show whether a food had been irradiated). They are also formed when food is processed in other ways, such as frying and grilling.

On the other hand, all the talk about the fact that research and animal experiments have shown that irradiated foods pose no danger at all, speaking against better judgement for the simple reason that it is never possible, even with experiments on a large number of animals, to show that something is as non-hazardous as we would like it to be. This was pointed out in the 1983 report, although it did also emphasise that the quantity of radiolysis products did not exceed that which was found in food that had been processed in another way.

The strongest objection to the irradiation of foods concerns the way in which it has been misused. The cost makes it unreasonable to apply it to basic foods with a small volume expense. On the other hand, it has been used to kill microorganisms in more expensive and less voluminous foods such as prawns, frogs' legs and strawberries. This has 'saved' foods which ought actually to have been thrown away. This is not a consumer interest; what is actually being concealed is the poor production hygiene which has created the problems.

Only when it comes to spices such as black pepper does it seem as though there is no acceptable alternative. A number of severe Salmonella epidemics have highlighted the risk of untreated spices. There are residual carcinogenic products in spices that have been treated chemically (usually with ethylene oxide). High levels of the mutagenic and probably carcinogenic substance ethylene chlorohydrin have been found following treatment with ethylene oxide. A total ban on irradiation may therefore in this case lead to undesirable consequences.

High doses of radiation are required to combat microorganisms but, with the exception of the spice problem, this is a questionable contribution at an unnecessarily late stage. Other areas of application such as preventing sprouting, delaying the ripening of fruit or killing pests involve lower doses of radiation. Delaying the ripening of tropical fruits can simplify the problems with transportation over long distances. The fact that tropical fruits like mangoes and papayas are prevented from being destroyed by insects without being treated with chemicals does not exactly conflict with consumer interests. In some cases, irradiation may perhaps also save foods in areas of starvation, albeit the hope of this, bearing in mind the necessary technical resources and expenses, may be exaggerated.

I repeat that the irradiation of foods constitutes a pseudo-problem which does not justify a big commotion or drastic bans. The irradiated foods carry no greater risks than other foods and are no less suitable for consumption. The problem that is associated with misuse, i.e., the 'cosmetic' processing of foods to rectify irregularities in the form of poor hygiene, should be dealt with directly through better production hygiene requirements and not by being diverted by a poorly-substantiated ban.

23.4. **The Research Advisory Committee at the Queen's Pavilion**

In February I received a letter from Kjell-Olof Feldt, who was Minister of Finance at the time. He called a meeting which the government's research committee was to arrange at The Queen's Pavilion on 6-7 March for risk analysis and risk handling. I was invited because I was Chair of the newly-formed Society for Risk Sciences.

I walked from my emeritus room at the Haga Court of Justice to the Queen's Pavilion (now known as Haga Palace) in the afternoon of Monday 6 March together with Gunnar Bengtsson who had also been invited. We were all to spend the night at the castle and sleeping in such an historical environment felt a little strange. Feldt was Chair of the group that had been gathered. I particularly remembered his surprise when he found out how dangerous smoking tobacco actually was. 'No-one has told me this before,' he said. 'I found out that it was bad to smoke but not that it was dangerous.' It was clear that there was still a substantial difference between actual and perceived risk (in the sense of the likelihood of serious personal injury). Should the political decision-making be based on actual or perceived risks? This was before psychologists and social scientists had extended the concept of risk from natural science to areas of risk that had more space for opinions.

23.5. **Steam generator replacement and capacity increase**

Replacing the steam generators at Ringhals 2 took 100 days. The power of the reactor was increased by 70 MW.

23.6. **ICRP in Paris**

The ICRP Main Commission (MC) met, courtesy of Henri Jammet, in Paris on 17-21 April and was invited to where he and his wife lived one evening. David Sowby has written about this:

> [Jammet] was head of radiation protection at the atomic energy plant at Fontenay-aux-Roses. Henri, who was originally trained in radiotherapy, also had a high-up position at the Curie Institute where his elegant wife Jeanne worked as chief pharmacist. The childless couple with their three salaries lived in a luxury apartment with a view over the Seine, opposite the Renault car factory. Henri was a restless person, always travelling somewhere. There did not seem to be a country on Earth that he had not been to. China was one of his favourite destinations and where he happened to be during the tumultuous cultural revolution. On his visits abroad, and particularly to China, he made extensive purchases and a room in the apartment was devoted entirely to Chinese objects, some of which were very large.

For our work we met at the Curie Institute in a room in which Madame Curie's penetrating look kept us under surveillance. On one occasion I got stuck in the lift up there when it stopped. There was a small window in the outer door of the lift. We waved to arouse attention. People in the stairwell waved back cheerfully. People sometimes assume that everything is fine if it does not concern themselves.

Regarding the work, the Commission now discussed the task group's proposal regarding that which would become Publication 60, and this time particularly my proposal for an Annex C.

23.7. **BEIR V**

The American Academy of Science's BEIR Committee completed the 1989 report, 'BEIR V', with the title *Health Effects of Exposure to Low Levels of Ionising Radiation*. The summary that was issued alongside the publication read:

> This book re-evaluates the health risks of ionizing radiation in light of data that have become available since the 1980 report on this subject was published. The data include

> new, much more reliable dose estimates for the A-bomb survivors, the results of an additional 14 years of follow-up of the survivors for cancer mortality, recent results of follow-up studies of persons irradiated for medical purposes, and results of relevant experiments with laboratory animals and cultured cells. It analyzes the data in terms of risk estimates for specific organs in relation to dose and time after exposure, and compares radiation effects between Japanese and Western populations.

The primary reason for revising the dose estimates for the survivors of Hiroshima and Nagasaki was the report by Preston and Pierce of which I have given an account in connection with the ICRP meeting in Como in 1987 (see chapter 21). BEIR V was published in 1990.

23.8. **UNSCEAR's 38th session**

UNSCEAR's 38th session was held in Vienna on 8-11 May. The Chair of the Committee this time was Keith Lokan from Australia with Jean Maisin from Belgium as Deputy Chair. The Canadian E. Letourneau was rapporteur. The Swedish delegation consisted of Gunnar Bengtsson as representative, Lars-Erik Holm as the representative's deputy, and Jan Olof Snihs as expert, while Jack Valentin took part as Consultant for the Secretariat. I was able to take part in this meeting and in some of the forthcoming meetings as representative of ICRP and thereby avoided being brusquely dismissed from UNSCEAR's work.

The Committee discussed the direction of the work for the next few years. Among the subjects proposed were two new ones for the Committee – the impact of ionising radiation on plants and animals, and the perception of radiation risks.

The shortage of resources threatened the work. One consequence was that the translation of the work documents from English into the other five working languages (Arabic, French, Chinese, Spanish and Russian) had not been possible in advance, which led to considerable problems for the delegations concerned.

The following can be quoted Gunnar Bengtsson's report to the Ministry for Foreign Affairs:

> Questions about comparisons between effects of chemicals and radiation were controversial. There were clear tendencies towards some delegates wanting to develop this into comparisons between things such as risks from nuclear power and other energy sources, which was something which the majority were opposed to, and I intend to continue *against* it. However, at the same time I thought it was natural to speak in *favour of* attempts to exchange experiences between the different scientific disciplines which are involved with radiation and with chemicals which can harm the genes. Sweden and the Radiation Protection Institute have taken many initiatives in this field and there were already very interesting discussions in the document draft which dealt with mechanisms for cancer induction.
>
> The programme largely tallies with Swedish interests. However, my proposal to summarise ongoing studies of health effects following the Chernobyl accident was not taken on board. I also advised against the Committee dealing with ... the point about perception of risk since the Committee does not have suitable expertise. Other opinions won the discussion and great expectations were expressed for Sweden's substantial experience in this field (radon, Chernobyl, nuclear power) to be communicated.

Gunnar added:

> During the discussion I expressed my opinion that the Soviet principles for protection measures were well in line with the international recommendations that were also complied with in Sweden. I did not give my opinion on the actual dose levels that the Soviets had selected as a basis for measures, but said that the exact levels had to depend on local circumstances. As an example of local adaptation I gave the Swedish limits for food consumption (1 mSv per year in general and 10 mSv per year for adults, except pregnant women, who had presumably been informed and chosen to accept the

associated risk). It is highly likely that my comments will be quoted in what is now a very animated debate in the Soviet Union.

23.9. **Lars Högberg becomes DG of the Nuclear Power Inspectorate**

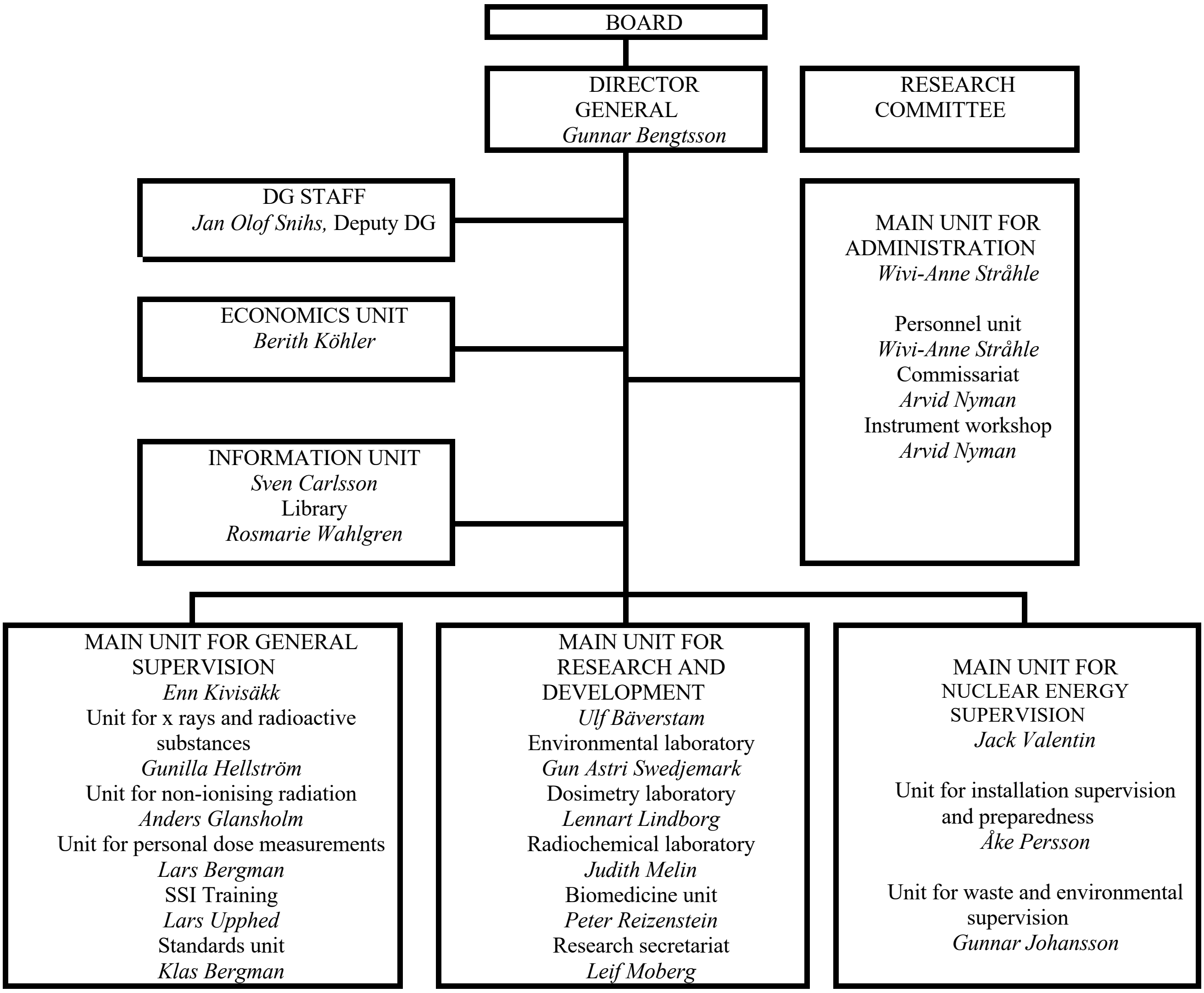
Olof Hörmander was succeeded by Lars Högberg as Director General of the Nuclear Power Inspectorate. I had suggested Lars when Ministry for Industry asked for advice in 1983. Six years went by before the advice was followed, but better late than never. Lars was head of the Nuclear Power Inspectorate until 1999. He was succeeded by Judith Melin in the year 2000. Judith, who had once been a chemist at the Radiation Protection Institute, remained in the post until 2008 before the emergence of the new Radiation Safety Authority (SSM). She then became Director General of the Swedish Coast Guard - an interesting career.

Lars was interviewed by the magazine *Ny Teknik* before departing. He was worried about the risk of a future shortage of competent personnel within nuclear technology. His answer to the question as to whether the Nuclear Power Inspectorate, the Radiation Protection Institute and the nuclear power plants were competing for the same competences, his answer was:

> We, the plants and *ABB Atom* are the main players competing within reactor technology. When it comes to the Radiation Protection Institute, they are more concerned about the research, a concern which we share. When it comes to the universities, they do not prioritise Professorships in the same way as they did 30 years ago. Professorships in reactor technology and radiation sciences used to be set up to a significant extent. Today, some of them are turned into Professorships in other subjects such as information technology, biotechnology, etc. There is a general decline in the nuclear field all over the world. We have said there is a need to study the question of future national competence.

23.10. **The way the Swedish Radiation Protection Institute is organised**

In 1989, Gunnar Bengtsson made a change to the way in which the Radiation Protection Institute was organised. The new organisation structure is shown in the following diagram:



It was now generally known within the Radiation Protection Institute that Gunnar Bengtsson expected Jack Valentin to succeed him as DG. The opinion was that Jan Olof Snihs, who would otherwise have been a natural alternative as Deputy DG, would probably be too old when Gunnar came to depart.

23.11. **The Congress of Radiology in Paris**

The 17th International Radiology Conference was held in Paris. I quote the following from my travel notes:

> The International Congresses of Radiology (ICR) have deteriorated latterly. Following the fiasco in Honolulu four years ago, one would have expected this year's Congress in Paris to be better organised, but it was also a disappointment.
>
> The Congresses of Radiology are held every four years. The 2nd International Congress of Radiology was held in Stockholm in 1928. That was when ICRP was formed.
>
> The oncologists are now in the process of breaking away from the diagnosticians. So, in reality, the Congress in Paris was therefore two Congresses, held in completely different places. Firstly an Oncology Congress from 1-4 July at *Palais des Congés* at Porte Maillot and then a Diagnostics Congress from 3-8 July in *Parc des Exposures* at Porte de Versailles, i.e., in a completely different part of the city.

The organisation of the Oncology Congress was acceptable, with interesting posters and sessions. The Diagnostics Congress was chaotic, an unavoidable consequence of the number of participants if the Congress is not very well organised.

The ICRU sessions were largely put in the Oncology Congress while ICRP – arbitrarily and together with other radiation protection ... had been put in the Diagnostics Congress.

...

Up until now, ICRP has had its work period and its members' mandate periods synchronised with the periods between the Congresses of Radiology. For example, members join and leave at the time of an ICR. The strengthening of ICRP's international position over the years towards greater independence means that relations with the ICR and the ISR over the years have been increasingly weakened while the contacts with other international organisations (such as IAEA, IRPA, OECD/NEA, UNSCEAR and WHO) have increased. The development of an ICR into divided Congresses is worrying for ICRP, which must now wonder how the relations will continue.

There is currently a worldwide campaign, largely covert, against the radiation protection endeavours which also take into account small doses of radiation when optimising protection. The campaign appears to have originated from the nuclear power industry's technicians, primarily in countries with plenty of industry which is annoyingly affected by the problems that nuclear power encounters in other countries, particularly Sweden. Their opinion is that the public's concern regarding nuclear power is exaggerated, which is no doubt true to a great extent, and their belief is that this caused by the assumptions of some authorities – and ICRP – regarding risks even at low doses of radiation.

Nuclear plant technicians 'feel' that there has to be threshold values for the radiation dose below which there is no risk. They are often supported by radiologists who think that the cautiousness of the authorities – and ICRP –also scare away their patients. Many of these radiologists 'know from experience' that nothing dangerous happens at low doses of radiation. All argumentation about probabilities, low risks, and only reasonable protection measures collapse in the context.

These groups think that the ICR-ISR should keep a tight rein on ICRP and that ICRP should perhaps be replaced by a smaller, less namby-pamby international radiation protection commission under the ILO or WHO. I was told that a motion was put forward during the Paris Congress' general conference (the diagnostics section?) stating that in future, the ISR wants to see all new ICRP recommendations in advance for approval. It will be annoying if this leads to a conflict. ICR defrays less than one per cent of ICRP's annual budget and the Commission remains under the ISR for sentimental reasons and to some extent practical reasons only. Those applying the pressure are actually being extremely silly, acting on the basis of their own interests. Making a martyr of ICRP would further strengthen the views that they perceive as dangerous. Not only that, there is doubtless more behind the fear of radiation than the simple explanation of intimidating authorities being cheered on by ICRP.

At the conclusion of the Congress (the diagnostics section), poorly planned, largely improvised, confused and pressed for time, I got to receive the Swedish Academy of Sciences' gold medal for radiation protection contributions, an honorary distinction which I hold in high esteem.

I was accompanied to the Congress dinner by Dan Beninson, but once we had arrived there we changed our minds and sneaked out to dine in peace and quiet at a small Parisian restaurant instead, and discuss the philosophy of radiation protection.

23.12. **The ICRP editorial group in Stockholm**

Right after the Congress of Radiology in Paris, the ICRP editorial group met in Stockholm, at the Haga Court of Justice to be precise, which the Radiation Protection Institute was now utilising. We sat in the big session hall. It was uncomfortably warm although it was only May, with poor ventilation. Dan was very irritated about the temperature and smoking ban. John Dunster still had substantial editorial work to do. We began to put together a final text for what would eventually become ICRP Publication 60.

23.13. **WHO experts to the Soviet Union**

In Belarus and Ukraine there was still concern following the Chernobyl accident in 1986, and the Soviet authorities asked WHO to send an expert group to the Academies of Sciences of these Republics to discuss the radiation risks. The experiences of the WHO group are given a vigorous description in Professor Ilyin's book *Chernobyl: Myth and Reality* (1995).* Both the events and Ilyin's description thereof are so unique that I have accordingly given them space below.

In 1989, a group of members of the Supreme Soviet approached Prime Minister Nikolai Ryzhkov and proposed that an international expert group be appointed to investigate the safety of the public in the areas that had been contaminated by radioactive fallout from the Chernobyl accident. Ryzhkov reacted immediately and gave two officials the task of setting up the investigation. One of them delegated the assignment, as Ilyin writes, in 'the usual bureaucratic manner'. The other was Health Minister Y. I. Chazov, who immediately contacted Professor Ilyin for advice. Ilyin said that since it was a matter of health problems, the Health Minister ought to write to WHO. But Chazov did not end up writing before Mikhail Gorbachev asked him 'When are the experts arriving?'

However, the contacts were made and three WHO experts arrived in Moscow two weeks later. They were Dan Beninson, Pierre Pellerin and Peter Waight. The latter-mentioned was responsible for the radiation protection matters at WHO. The next day they visited the Ministry for Public Health where a travel programme was set up, and then they visited the Russian NCRP where they discussed the situation and the protection measures that had been taken.

The most important question concerned the action level for the lifetime dose from the radioactive ground covering and contaminated foods. The WHO experts accepted the value, 35 rem (350 millisieverts), proposed by the NCRP. However, there were big information and communication -problems here. The proposed value referred to an *action level*. Such is usually higher than the *limit values* that authorities want to apply. This is difficult to understand if you do not realise that there is no major risk increase if the limit value is exceeded; there is instead a gradual increase in the likelihood of injury. A person who receives a radiation dose that is five times the limit value, for example, runs a risk increase that may be five times greater than the risk at the limit value. Since those who are responsible for protection want the risk to be very low at the limit value, the likelihood of injury is still low even at significantly higher doses.

It would not be reasonable or defensible to use the limit values as action levels. It would mean that measures were required which in themselves would lead to risks and also expenses of course in order to avoid very low risks. ICRP Publication 60 (1990) would end up recommending that the annual dose limit for general irradiation be lowered from 5 mSv to 1 mSv, a value which also, less clearly, had been recommended in Publication 26 (1977) when it came to long-term irradiation. The Russian NCRP had recommended 35 rem as an action level for the lifetime dose for the evacuation of affected areas or the rejection of contaminated foods. That corresponds to an average annual dose of 5 mSv.

The WHO experts were flown to Gomel in Belarus and driven from there by care to Chachersk, a town approx. 70 km to the north east. They were to meet doctors there and talk to the local population. The encountered an exasperated multitude and TV, radio and newspaper reporters. 'Green Activists' asked questions and accused the local authorities of withholding information about high levels of radiation and the increase in the number cases of cancer. Ilyin says:

> During the break, a good number of people came up to us, led by a very aggressive woman who angrily told us that the local authorities were misleading people by

* Leonid Ilyin has been a member of the ICRP Main Commission and Soviet representative of UNSCEAR.

> concealing the truth about the actual doses of radiation and that the radiation was killing children, etc. We understood from the subsequent talks that they were Green Activists who came from Narovl and had information on the result of independent measurements of levels of radiation and doses which were dozens of times greater than those mentioned by the experts. I finally succeeded in asking her:
>
> 'Who took the measurements and calculated the doses?'
>
> 'We did it ourselves,' she said.
>
> 'What do you work as?'
>
> 'That has nothing to do with it. In any case, we're not Professors; we represent the people,' said the female activist, feeling the approval from her friends.
>
> 'All right then. Here we have dosimetric data from Narovl (we had brought all available data with us from Belarus). Let's compare your figures with these.'
>
> 'I don't have our figures with me, but we're sure we're right.'
>
> 'Well, look at these figures. Are they different from what the measurements you have taken?'
>
> 'I don't remember… The people must know the truth.'
>
> 'I completely agree with you. If you don't mind, let's do as follows. Within one week, two dosimetry experts are coming to your town. They'll take all necessary measurements together with your representatives and calculate the doses of radiation for the residents in Narovl. They'll set up and sign an official record and we'll get the authorities to publish it in the local press a few days later.'
>
> M. Savkin, a brilliant dosimetry expert, who was head of the laboratory at our Institute and a person who stuck by his principles, came to Narovl with his colleagues. Neither the aggressive woman nor her companions turned up. Savkin and the Belarus specialists still took innumerable measurements and had the results published in the local newspaper. As might have been expected, the doses of radiation were within the area we had already noted in our data bank for Narovl.

The WHO experts, along with Ilyin and other representatives of the expertise in Moscow, continued to Minsk where they were to appear before the Belarus Academy of Science. They were greeted, fairly 'formally' according to Ilyin, by the Academy's President Platonov. There were more than one hundred Academy members and journalists and local TV reporters in the big conference hall. Beninson discussed – and defended – the 35-rem action level. Pellerin reported the knowledge situation regarding biological radiation risks and concluded that no increase in the incidence of cancer could be proven. The lectures aroused protests, fuss, and clapping. Ilytin writes:

> The discussion lasted for more than five hours without interruption. Those who blankly rejected the experts' argument won constant applause from the assembly. Finally, Beninson got up indignantly and said:
>
> 'I've been Chairman of dozens of scientific meetings in different parts of the world where very important and controversial problems have been discussed, but this is the first time I've taken part in a meeting of scientists, members of the Belarus Academy of Science as well, where scientific questions have not been settled in a professional manner, not with logic and discussions but with hand clapping. I cannot accept this and I cannot understand it.'
>
> The conference was concluded and our colleagues from WHO left the Academy of Sciences.

At four o'clock the next morning the experts arrived in Kiev to meet representatives of The Ukraine's Academy of Sciences at nine o'clock. The meeting was completely different from the one in Belarus. A small group of eight Academy members listened quietly to the experts but had no questions or comments. Ilyin writes that he did not understand why a meeting of the whole Academy had not been arranged.

After the visit to the Soviet Union the experts wrote a report to WHO. They found the proposed 35-rem action level for the lifetime dose reasonable and would also have seen fit to accept a higher value. At the meetings with the public and scientists who were not specialists in radiation protection they had found that the principles which applied were often not understood. The main misunderstanding concerned the difference between normal dose limits and action levels following an accident. There were also misunderstandings in the interpretation of disease and death statistics, particularly when there was inadequate evidence of the normal incidence. This has led to concern regarding and distrust of authorities and experts. Many scientists also felt there was a lack of information. However, the WHO experts were glad to have had access to all information and that measurement data was available to all Soviet scientists. Since many thought there was a lack of information, the experts advised their Soviet colleagues to create a procedure to disseminate information, e.g., through the Republics' Academies of Sciences.

However, Professor Ilyin was unhappy with the result. This is what he writes in his book:

> Unfortunately, I have to recognise that the experts' trip to the contaminated areas, the meetings and discussions during their visit and, finally, their official report to WHO signed by three specialists who assumed the full burden of responsibility for the objectivity of the assessments and the validity of the proposed recommendations – all this, with few exceptions, had not the slightest effect on those involved, including the upper echelons of power in our country. The reason was obvious: the views of the experts did not fit in with the socio-political and socio-psychological atmosphere which was constantly created by certain political circles when it came to the impacts of the accident. Also, certain scientists were engaged in an attempt to discredit the experts, scientists who attempted to redeem their failures in scientific work by assuming the thankless role of pseudo-refuter of international expertise, insisting that doses of radiation below the natural level were hazardous to the health.

23.14. **The Nordic Society for Radiation Protection in Visby**

The Nordic Society for Radiation Protection held another meeting in Visby. This time it was in cooperation with *Fachverband für Strahlenschutz* as one of their 'island meetings' (see Section 21.13). I was now Chair and Leif Moberg Secretary of the Society. Jack Valentin acted as joint meeting secretary and primary contact person towards the Fachverband. For the purpose of general comfort we had been allowed to arrange a pub for those participating in the meeting in a smaller building where Britt Hedberg-Vikström, Karin Lindell and Leif were responsible for serving beer and snacks.

23.15. **ICRP in Oxford**

ICRP met with its Committees in October 1989 at the Ladbroke Linton Lodge Hotel north of Oxford. The main subject was of course the impending new recommendations. Both Jack Valentin and Sören Mattsson were there and we took some difficult-to-navigate walks together while it was pitch dark. Hans Ringerz had not yet become part of Committee 3.

One day, Roger Clarke invited three of us (Angelina Guskova, Dan Beninson and me) to visit Bill Pochin who was said to be in poor shape and in need of encouragement. Roger gave us a lift to the place where Pochin was said to have been living since he had sold his family's villa after his wife had died.

When we arrived we were surprised. His home was a small chapel. Later on I asked Roger for more information and he emailed the following:

> I can see why you would be astonished about the old chapel* - yes, it really used to be a chapel. I believe he owned it as it was (and still is). It is not unusual for small chapels to be sold when they are no longer used. Bill's home was probably a Methodist chapel – it could not have belonged to the Church of England because they have big

* Roger also wrote: 'The Old Chapel lies in a village called Curridge and is just north of Newbury in Berkshire. As far as I can remember, the name of the residence was *The Old Chapel* and there was no street address'.

> churches. I am sure you know better than I that the Methodist church in the UK emerged around 200 years ago and many small chapels were built in England and Wales. These are now often sold and one in our neighbouring village, called Ball Hill, has actually been converted and sold as a residence at some stage over the past 15 years. So it is a common occurrence here. Churches are usually larger and are maintained even if they are not regularly visited.

Bill received us dressed in his dressing gown and appeared weak but happy to see us. Roger set about making tea and found some biscuits and we sat making small talk for a while. The good-natured Angelina combined her knowledge as a doctor and her warm-heartedness and told us she was very worried about Bill. And she had every reason to be - Bill died on 29 January 1990. Later on I asked Roger if he had been properly cared for. Roger's answer was:

> He was well cared for and was moved to a care home where he was under medical supervision – it was called Hollington House (it no longer exists as a care home – it is now owned by the Sultan of Brunei) and is approximately 400 metres from my villa so I used to go there regularly to meet him and I know he was comfortable and was well cared for.

23.16. **The Nordic Liaison Committee for Atomic Energy (NKA)**

In November 1989, the Nordic Liaison Committee for Atomic Energy (NKA) ceased to exist. It had been formed in 1957. In January of that year, a group in the Nordic Council led by the Danish Minister for Trade, Viggo Kampmann, had suggested that they ought to set up a permanent cooperation committee to deal with nuclear energy issues. The Nordic Council accepted the proposal and, at its 5th session in Helsinki in February of that same year, it decided to ask the Member States to set up such a committee. It went on to call itself the Nordic Liaison Committee for Atomic Energy Issues (NKA).

In 1967 the Dane Franz Marcus (whom many called 'Nordic Marcus') was asked to be Secretary of the NKA. As such he undertook innumerable trips between the Nordic countries and worked tirelessly in the interests of radiation safety. He has recounted the NKA's activity in an extensive book published by the Nordic Committee for Nuclear Safety Research (Marcus, 1997).

The Nordic Committee for Nuclear Safety Research (NKS) was set up under the NKA in 1975 and survived the latter after 1989. Torkel Bennerstedt, who used to work at the Swedish Radiation Protection Institute, was the Secretary of the NKS after 1993. Due to the pressure of external circumstances, the NKS expanded its area of interest to include radioecology, radioactive waste and emergency planning. This expansion met with mixed feelings on the part of the radiation protection authorities. It was certainly feasible to establish a new channel for research funds, but the responsibility particulars caused concern.

This concern was based on the appointment of members, two from each country except for Iceland, which had only one member. In Finland the President appointed members, but in the other countries this was done by the Ministry which dealt with atomic energy issues. This paved the way for a conflict in Sweden where the Ministry responsible since 1969 for nuclear power was the Ministry for Industry. The Nuclear Power Inspectorate belonged under the latter while the Radiation Protection Institute belonged under the Ministry for Agriculture until 1987. The Radiation Protection Institute therefore ended up 'on the outside' when it came to the activities of the NKA and the NKS.

Within the Swedish Radiation Protection Institute there were different reactions. Jan Olof Snihs had a pragmatic approach; here, the funds and the opportunity for joint research, investigations and other cooperation were given, including the arrangement of conferences on radioecology matters. All one had to do was to say thank you and acknowledge receipt. I had a more critical view of the matter and thought that the Radiation Protection Institute and its Ministry ought to share the responsibility.

Radioecology had been dealt with at the five meetings ('RIS' = Radioactivity in Scandinavia) during the 1960s at the initiative of Kurt Lidén and Jorma K. Miettinen. This activity was then stopped when the levels of radiation became very low at the end of the 1960s. However, the interest grew once again with the arrival of the nuclear power industry and a new series of the Nordic meetings was started with a seminar in Norrköping in November 1976. Then followed an active period during which Jan Olof Snihs played a leading role. Radioecology was represented at the NKS' first two programmes for 1977-1980 and 1981-1985, latterly with a seminar in Gol in the Norwegian mountains in 1985, but it was left out of the third programme (for 1985-1989), despite that Jan Olof's forceful argument was that they should continue the well-established cooperation. However, following the Chernobyl accident and in keeping with the many national research programmes which were then launched, a radioecology seminar was held (the fifth in the NKS' programme) in Rättvik in 1988, luckily organised by Snihs. A sixth Nordic radioecology seminar was then held on the Faeroe Islands in June 1992. The many Nordic radioecologists included Asker Aarkrog of Denmark, Anneli Salo of Finland. Erik-Anders Westerlund of Norway, and Ulf Grimås and P. O. Agnedahl of Sweden.

The NKS also discussed issues concerning radioactive waste, initially to a smaller extent during the 1970s and then with a new programme in 1981. Marcus writes:

> Alf Larsson, who was now head of SKi's waste department, was an eager participant. He led a project dealing with the management of waste arising from a postulated small reactor accident (AVF-1). This was prior to the Chernobyl accident and it required a lot of persuasion before the consultant, ASEA-Atom could agree to work on a scenario describing the consequences of an accident that appeared unthinkable. When the calculations were finally made it was evident that dealing with the waste from such a minor accident, although manageable, would present a major task.

It was soon realised that the NKS' resources were inadequate for substantial waste projects such as those that were underway in Finland and Sweden. The NKS therefore concentrated on smaller projects that could supplement the substantial national projects. A similar contribution was made by the Swedish Radiation Protection Institute. The aim was to improve and confirm models to predict the impacts of discharges of radioactive substances to ground or water. This aroused international interest and a desire to participate, and led to *the Biomovs Project* which was given high priority following the Chernobyl accident and led to a conference in Vienna in October 1986.

The radiation protectionists were eventually offered the option of participating in the NKA's meetings, but the apprehension still remained. Franz Marcus writes in his book:

> The radiation protection authorities had a network of working groups and contact groups, originating from the work with the Nordic Flag-Books (page 79). Then however, the work extended to other fields, some of which were common with NKS related project groups.
>
> The leaders of the authorities now participated in the Nordic Liaison Committee ('Kontaktorgan') meetings, but often gave the impression of being on guard to preserve their domain as independent authorities. There was a traditional scepticism between the radiation protection chiefs, under the leadership of Bo Lindell, and other participants in the Kontaktorgan meetings, most of which were related to the Ministries of Industry or Energy. The authorities preferred to keep a distance to underline their independence. This antagonism is said to originate from a discussion between the Danish physician Juul Henningsen and Niels Bohr who refused to divulge his politically sensitive knowledge, and to Rolf Sievert who was jealous of the large sums available in Sweden for the reactor programme.

Marcus forgets that the radiation protectionists' apprehension was also fuelled by the lack of insight that the others had, as reflected in the way Marcus misspells Juel Henningsen's first name and his description of him as 'the Danish doctor' without mentioning the fact that Henningsen, as Medical Adviser for the Board of Health, was immediately responsible for the nuclear power protection problems in Denmark. Marcus also writes that the cooperation among the radiation protection authorities originates from the work with the 'Flag book', while the successful Nordic cooperation organised by Juel Henningsen and Sievert with the support of the Nordic Council (mentioned earlier in the book) had been introduced fifteen years previously.

The events during the 1980s led to the dissolution of the NKA. Norway abandoned its nuclear power plans in 1980; Denmark followed suit after 1985. Sweden had its agonising referendum in 1980. The Chernobyl accident came in 1986. Only Finland stuck by nuclear power. The Brundtland report 'Our common future' with the buzzwords 'sustainable development' came out in Swedish in 1988 and gave no support for continuing to develop nuclear power. In 1989, Denmark declared itself unwilling to continue giving support for the NKS's research programme. Sweden then withdrew from the NKA but thought the work with the NKS was too valuable to be stopped. The NKA ceased in 1989 but in reality, its last functional event was its 68th meeting in Helsinki in October 1990. The NKS then continued independently, although its activity became too extensive it to be discussed here.

One additional acronym is worth mentioning: the NARS, i.e., the Nordic Task Group for Reactor Safety. This group was appointed in 1969 after being proposed by the NKA. It had two members from each of the four member countries. An arrangement between the governments was signed in July 1970 and extended in 1973. The NARS's recommendations were published in English through the Nordic Council of Ministers in 1974. No further arrangement regarding the NARS was ever made after 1974.

24. THE YEAR 1990

24.1. ICRP 'mission' regarding proposals for new recommendations

As part of the consultation which ICRP now found appropriate, in April 1990, a delegation from the Main Commission took a round trip to some of the most important international bodies which were responsible for radiation protection matters. The delegation consisted of Dan Beninson, Roger Clarke, John Dunster, Julian Liniecki, Bo Lindell and Hylton Smith and thus contained those who had the main responsibility for developing the new radiation protection policy. First of all we visited the OECD/NEA in Paris where we discussed the forthcoming ICRP recommendations with Ilari. We then continued to Luxembourg to meet Dr. Eriskat at the CEC. We then returned to Paris, this time to meet Professor Tubiana who represented the ISR, the International Society for Radiology.

The meeting with Tubiana was embarrassing. He referred to the radiologists' dissatisfaction with ICRP which, according to him, did not observe their interests and criticised us for exaggerating the health risks. We were surprised by his vehement criticism which we thought was unfair. After arriving home, I wrote to Tubiana and expressed my surprise at his failure to listen to what we had had to say. He modified the criticism after a few letters had been exchanged.

24.2. UNSCEAR's 39th session

UNSCEAR met for its 39th session in Vienna on 14-18 May 1990. Keith Lokan was Chair as he had been at the 38th session, with Jean Maisin as Deputy Chair and E. Letourneau as rapporteur. Dan Beninson was Chair of the physics sub-group and E. Letourneau of the biological sub-group. Gunnar Bengtsson took part as the Swedish representative, Lars-Erik Holm as his deputy, and the expert ('adviser') was Jan Olof Snihs and, for the first time, Lennart Sjöberg of the School of Economics and Business Administration, as behavioural scientist. Jack Valentin was consultant for the Secretariat and was therefore not part of the Swedish delegation. The work concerned drawing up an extensive new report which was estimated would be ready in 2-3 years.

In his report to the Ministry for Foreign Affairs, Gunnar Bengtsson wrote:

> The programme largely tallies with Swedish interests. Questions regarding comparisons between effects of chemicals and radiation are controversial and require further monitoring. Sweden and the Radiation Protection Institute have taken many initiatives in this area but we need to watch that it does not develop into organised comparisons between things such as risks from nuclear power and other energy sources. Sweden was the only country which had expertise (through Lennart Sjöberg) of the experience of radiation risks and it is essential that we continue to monitor this area to achieve nuanced treatment.

Gunnar's report hints at a shift in the attitude towards UNSCEAR's work. In the previous work, the Swedish delegation had worked largely with the objective of producing what would be a suitable report for the UN General Assembly with emphasis on the scientific work. Subsequent reports have begun to talk about 'Swedish interests' i.e., the work is being politicised to some extent. When Gunnar writes 'we' in his reports, you get the impression that he is referring to the Swedish delegation whereas our 'we' used to refer to the Committee. I took this as a subtle shift towards alienation.

24.3. **Capacity increase at Ringhals 1**

The output at Ringhals 1 was increased by 20 MW, from 730 to 750 MW.

24.4. **Ragnar Boge and Mats Holmberg**

The Radiation Protection Institute was severely affected when two of its most capable colleagues, Ragnar Boge and Mats Holmberg, died during the year. Their colleagues expressed their loss and deep appreciation of their contributions in many ways. Gunnar Bengtsson wrote the following about Ragnar Boge in the Swedish Radiation Protection Institute's personnel magazine *Curieren*:

> Ragnar came to the Radiation Protection Institute in 1963 having been trained in Norwegian nuclear chemistry research. He started at the old Nuclear Physics Department with radiation protection for work in laboratories and at hospitals. Eventually he got involved in the environmental issues of nuclear power and the growing problem of nuclear power waste issues. As a chemist, it was natural for him to be interested in the chemicals in all waste, irrespective of whether or not it was radioactive. He was involved in broadening the Swedish Radiation Protection Institute's work with waste to include views on other waste and on risks from chemicals in the environment.
>
> ...
>
> Ragnar had an unusually large international network of contacts. With his broad knowledge and substantial experience he became a rock in the Swedish negotiations regarding international Conventions on environmental matters, with the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, and the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area, as examples. He was also the driving force in the Swedish Radiation Protection Institute's major international project, BIOMOVS, regarding models for the distribution of radioactive and non-radioactive substances in the environment.
>
> ...
>
> My heart was warmed every time I saw Ragnar's small, round figure and his happy smile. A characteristic was that he was widely read. Many of us received articles which he thought could be of interest – it was such tips from Ragnar which made me pay attention to important matters regarding chemicals in the environment. The diligent reader Ragnar also gave us suggestions for conceivable and entertaining fiction.

Jan Olof Snihs, who cooperated closely with Ragnar, wrote a moving obituary from which I quote:

> … we last worked with the problems of how to solve the long-term issues in connection with the deposition of highly-active waste. How should we handle issues today which concern generations way into the future? What risks do we have the right to impose on the future? These are questions of general international interest. Ragnar was right up there among the issues. Internationally dedicated and respected. Full of ideas and suggestions. Ragnar and I did not always agree but I had no argument against his objectivity. I could do nothing but accept his clear logic, although it was sometimes in silent protest. I will miss his intellectual acuity, his sometimes biting but honest opinions and categorical conclusions which could infuriate me.

On his deathbed, Ragnar could take pleasure in the fact that the Radiation Protection Institute was to arrange a meeting in his name on the subject of long-term aspects of waste and comparisons of the handling of radioactive substances and harmful chemicals. The fact that the Minister for the Environment attended his funeral confirmed his importance.

Gunnar Bengtsson wrote the following in memory of Mats Holmberg:

> Mats embodied much of that which I take the greatest pride in regarding my Swedish Radiation Protection Institute colleagues: knowledge, independence and critical

> disposition. He was Doctor of Philosophy in both physics and radiation biology without being affected in the slightest when it came to exaggerated respect for academic titles. He worked hard to extend our knowledge of the harmful impacts of radiation. Mats enjoyed substantial international esteem for his fundamental work on damage to chromosomes, the bearers of our genes, and on methods to measure such damage. But he contributed much more to the Swedish Radiation Protection Institute's activity.
>
> ...
>
> Ever since my initial contact with Mats nearly fifteen years ago I have got on with him. We have bantered with one another and Mats has sent me small notes in which he has clearly spoken about things which have been wrong and which he wanted me to remedy. We had many discussions about how the doses of radiation from the Chernobyl accident would develop and how information should be provided regarding this. Mats was vehemently astute in such discussions. His only consideration was what the scientific truth was. We were like-minded in that it did not matter who put forth the argument. An unsustainable argument does not become any more sustainable because it is led by a King or a Director General. Luckily, the Radiation Protection Institute has plenty of critical people who call a spade a spade, but Mats was the leader among them and thereby made important contribution to the development and survival of the Swedish Radiation Protection Institute.

The things that Ragnar Boge and Mats Holmberg had in common were their integrity, honesty, competence and intellectual acuity. I often had long discussions with both, discussions where I could remain calm in the assurance that I would always receive honest points of view on my thoughts and proposals. They were no 'yes' men, and if on the rare occasion they gave way in a discussion I could be sure that it was due to conviction rather than out of politeness. Their death was a serious loss for the Radiation Protection Institute and a tangible personal loss of two real friends for me. I felt small in their company – but secure.

24.5. **ICRP in Bethesda**

The ICRP Main Commission met courtesy of the NCRP in Bethesda outside Washington DC on 18-22 June 1990. I was accompanied by Marrit since we planned a holiday with John Hursh and his wife Lydia in Arizona after the meeting. The Commission was now close to completing Publication 60, the new recommendations. We discussed the radiologists' criticism and disappointment with what they saw as 'their' Commission, but we did not want to leave the ISR since there was a risk that they would then set up a competing Commission.

The stay in Bethesda was not without its dramas. Marrit was witness to the fatal shooting of two men in front of our hotel. They had burgled a jeweller's on Wisconsin Avenue and escaped in a car but the store owner had a gun and shot at the car as it left and killed both of them - an excusable and unpunished killing in the USA.

John and Lydia had moved from their large villa in the winter coldness of Rochester to a small retirement community, Green Valley, just south of Tucson in Arizona. We flew from Washington to Los Angeles, hired a car and set off for the wilderness. It was the first time we saw a full forest of large wind turbines and it was the first time we were affected by real heat. When we reached Yuma in Arizona and stopped at a motel to stay overnight it was 122 degrees Fahrenheit, which is exactly 50 degrees Celsius. There was a bar approx. 400 metres from the motel and we set off in that direction to get something to eat. After having walked 200 metres we were almost panic-stricken and started to doubt whether we would reach our destination, and it would take just as long to get back. Our eyes stung and we had difficulty breathing. People are not created to withstand 50 degrees Celsius, but we reached our destination and once we had refreshed ourselves and eaten the evening was approaching and it became slightly cooler.

Green Valley is on US Highway 89 towards Nogales on the Mexican border, a route which surprisingly states the distance in kilometres rather than miles. A big saguaro, a tall cactus with 'arms', was growing in front of Hursh's Mexican-style villa.

24.6. **The Nordic Society for Radiation Protection in Ronneby**

The Nordic Society for Radiation Protection met in August 1990 at the *Ronneby Brunnshotell*. As usual, events outside the meeting programme stick in your mind. Abel González took part as observer for IAEA and Burton Bennett for UNSCEAR. Abel was indignant about not having heard about Ragnar Boge's severe illness, but a scientific problem outside the programme took up our discussions.

Most people were now starting to realise that 'risk' is a complicated concept and has components that describe both the likelihoods of various objectionable events and possible consequences of those events. Limits for the likelihood of different describable consequences were often discussed, but could limits be set for the consequences? Was there a purpose for setting such limits? Ought nuclear power plants to be banned because the worst *conceivable* impacts were so great? Was it possible to define a maximum permissible *conceivable* impact?

The problem is that every human action can theoretically have a tremendous impact. The concept of chaos shows that an insignificant change to the starting point ('the flapping of a butterfly's wings') can lead to completely different impact. You could play with the thought that a child playing with a ball could lead to a colossal disaster if you used enough imagination for the events that followed. The fact that such a likelihood of an imagined scenario could contribute to acceptability was because it was impossible to establish extremely small likelihoods.

I saw a conceivable way out in looking at the uniqueness of the impact. Were there other scenarios with other risks that could lead to equally great, or greater, impacts? How often do natural disasters have equal impacts? How unique is a nuclear power plant compared with a big dam structure or a dangerous chemical industry? Or a politician whose power has gone to his head? But we agreed that the problem was difficult and perhaps impossible to solve. What should be banned? The nuclear power plant? The child with the ball? I was glad that others had the formal responsibility. But it was little solace.

24.7. **ICRP drafting group in Oxford**

The task group that wrote Publication 60 met in Oxford for the last time. John Dunster's contribution cannot be praised enough. This self-assured man with a short fuse and strong views wrote the main text fully in accordance with the Commission's wishes and without attempting to enforce his own view. John could be insufferable in ordinary discussions but he was a genuinely honest man with a quick mind and sharp intelligence.

24.8. **'Effectance'**

ICRP Publication 26 (1977) defined the size of the 'effective dose equivalent' but it was not given that name until the arrival of the Commission's 'Statement' from the 1978 meeting in Stockholm. It was used by ICRP in publications and 'Statements' until the mid-1980s. However, a name consisting of three words was a bit of a tongue twister in compositions such as 'collective effective dose equivalent commitment' for example, something which I, despite helping to make the decision, made fun of in my farcical dinner speech at ICRP meeting in Brighton in 1977 (Contrarational Provision on Radiosensical Ignition, 11:16). The Commission therefore attempted to find a completely new name, preferably in the form of one single word. Dan Beninson proposed 'effectance' with reference to similar expressions in the other fields (capacitance and resistance).

In its 'Progress Report' in 1988, the Commission mentioned that it was considering changing to 'effectance' and its Statement from the meeting in Paris 1989 said that 'The concept of effectance, previously known as effective dose equivalent, has not been changed'. It seemed as though the change was *en route* to being accepted. However, in 1990 there was a turnaround in the final phase of the work with the new recommendations, Publication 60. When asked by David Sowby, the response from the Secretary of ICRP, Hylton Smith, on 10 January was that 'Until the new recommendations are published, effective dose equivalent is the official position'.

And the Commission introduced the new and shorter name ‘effective dose’ in Publication 60 at the same time as changing ‘dose equivalent’ to ‘equivalent dose’. Effectance had been near the mark but had not quite made it.

24.9. **What is a radiation dose?**

When I came to Rolf Sievert’s institution in the 1940s, ‘radiation dose’ was an unusual yet simple physical concept. It was complicated when it became obligatory to take biological factors into account and the radioactive substances in the human body and surroundings. This took place primarily in the 1970s and was given an adequate description in ICRP Publication 60 in 1990. Since then, generation changes among radiation protectionists have meant that the basis for the development has started to be forgotten.

When irradiating tissue or an organ, you have to remember that different types of radiation have a different relative biological effectiveness (RBE). This is taken into account by weighting the contributions to the basic physical size, the *absorbed dose*, with weighting factors for radiation, w_R. The sum of the weighted contributions is now called the *equivalent dose*. A further weighting is required to take into account the fact that different organs are different in significance to the total radiation risk. This is done with the help of a weighting factor for tissue, w_T (‘T’ for ‘tissue’). The sum of the contributions for all stated organs is called the *effective dose*.

The situation is simple if a person is exposed to short-term irradiation from an external source of radiation. It becomes more complicated if the radiation dose is caused by a radioactive substance that has been conveyed to the body and is in an organ and irradiates the whole of the body. It is then possible to calculate the effective dose rate, but to get the full radiation dose you also have to integrate (add up) over time and take into account the fact that the activity of the radioactive substances lessens because they decay and are excreted from the body. For radiation protection purposes, we generalise and anticipate a period of 50 years for adults and 70 years for children. The total dose is then called the *committed effective dose*; ‘effective dose commitment’ is something else (see below!). If it is a question of absorbing several radioactive substances, the contributions from each substance must be added. The total effective dose from external irradiation and the absorption of radioactive substances is then the sum of the effective dose from external irradiation and the committed effective doses from the radioactive substances.

In addition to the time variation of the effective dose rate due to the decay of the radioactive substances in the body, you also have to anticipate that the level of these substances also varies with time for other reasons. Some substances can remain for a long time in the skeleton, for example, while the other substances leave the body fairly quickly. This time variation must be taken into account when calculating the committed effective dose from a given intake.

However, it is often not a question of a one-off intake but of an intake which is ongoing for a longer period so that further summations are necessary over time. In such cases, you no longer relate the committed effective dose to the intake; instead, you relate it to the external contamination and, regarding a specific group of people, talk about the *effective dose commitment* from an *emission* of radioactive substances. If it is added up for whole populations, you talk about the total collective effective dose or the *collective dose commitment* from the emission.

The effective radiation dose is stated in *sieverts* (Sv). Collective doses are formally defined not as the sum of the individual doses but as the product of the number of people irradiated and their average dose. They are therefore stated in man-sieverts (cf. ‘man-hours’), *not* just in sieverts!

24.10. **A final report from Lars-Eric Larsson**

Lars-Eric Larsson turned 70 and was appropriately congratulated, which led to a thank you letter:

> Dear friend,

First of all, many thanks for remembering my birthday. I am replying using an old mechanical FACIT which I received as a thank you for the way I helped a good friend down here to paint. (...) Everything is going well for Inga and me. I do not feel anything that I can attribute to the heart attack seven months ago. The only thing that reminds me is one and a half tablets that I take every day. The doctors say I seem to have angina, but I do not feel it.

[...]

I have had some interesting news. I understood Rune [Walstam], whom I meet every summer, to say that you are heavily involved in the work with ICRP's new recommendations. I will write to the Secretariat and ask them to arrange for me to receive a copy.

[...]

Sir Bill's [Sir Edward Pochin] leaving is not really as surprising as that of Holmberg and Boge. I still have the letters from Bill in which he gradually became less formal with me without mentioning it. Perhaps good old Laurie [Taylor] still can dance a jig. He did it in Soho at Rolf's dinner when the London Congress was on in 1950. Apropos Rolf [Sievert], I also think the book is good.* It really makes you relive past times. It probably applies only to those of us who were there at the time. The best picture is the one of Robert [Thoraeus] cranking up the gramophone for the patients to enjoy.

I assume that my travel on behalf of WHO and IAEA has finished for good. The last time was 1987 when I was in Manila for a couple of months and then in INDONESIA for six weeks to help them fashion a programme to train medical physicists. I believe I have probably made myself useful in the Philippines, where I worked for a total of approx. three years. There was a full set of ICRP's publications there and they were used as study material. The reason for this was obviously Celia Anatalio, who is now retired. Their Atomic Energy Commission, which has also been pared down and has changed name, had some of IAEA's Safety Series publications, but I neither saw nor heard of them being used. Where there are people like Takahashi and Celia, the publications will be used, but not otherwise.

[...]

The darkness is falling early and it is raining this evening but the fire is crackling in the open grate so it is nice and cosy. We are now just waiting for the rest of the leaves to fall so we can rake them up. The best thing that could happen is for them to blow into the neighbour's garden.

24.11. **The Radiation Protection Institute celebrates 25 years**

The Radiation Protection Institute reached its 25th anniversary. This was celebrated on 18 October with a dinner for 250 people at *Nürnbergshuset* near *Mariatorget* in Södermalm.

24.12. **The Swedish Society for Radiobiology's 25th anniversary**

When the Swedish Society for Radiobiology held its annual meeting on 29 October 1990 and the Society was able to celebrate its 25th anniversary. The Chair was Mats Harms-Rindahl and it met at the Department of Pathology's lecture theatre at *Karolinska sjukhuset*. The Radiation Protection Institute hosted the programme. The invitation explained programme details:

As state authority which is responsible for radiation protection issues, the Radiation Protection Institute (SSI) occupies an important position between radiobiology research and those who make the decisions. It is therefore important for our members to be informed about the way in which the Radiation Protection Institute works, how the

* Hans Weinberger: *Sievert: unity and diversity* (1990).

channels between scientists and the Radiation Protection Institute are utilised, and which radiobiological questions the Radiation Protection Institute deems to be important.

The programme for the lectures includes:

15.00	SSI – a presentation	Jack Valentin
15:05	SSI and radiobiology	Ulf Bäverstam
15:35	SSI and the research surrounding non-ionising radiation	Lars-Erik Paulsson
16:05	The biological assumptions behind ICRP's new recommendations	Bo Lindell
16:35	The work within UNSCEAR	Jack Valentin

The participants included Arne Nelson, now eighty years of age but intellectually vital, although it was evident that his age was beginning to tell - he had difficulty moving around. He would still go on to live until May 1993, a pioneer within radiobiology and previously a well-known face at UNSCEAR's meetings.

Radiobiology has been an important frontier science for radiophysics both internationally and in Sweden. There have been large numbers of important radiobiologists and I remember my contact with Swedish scientists like Torbjörn Caspersson, Arne Nelson, Lars Ehrenberg, K-G. Lüning, Gunnar Walinder, Mats Holmberg, Mats Harms-Ringdahl and Synnöve Sundell-Bergman with pleasure, not to mention great international greats like H. J. Muller, L. H. Gray, Richard Doll, Austin Brues, Arthur Upton, Bill Pochin and Warren Sinclair.

24.13. **The ICRP MC at the NRPB in November: Publication 60**

The ICRP Main Commission met at the NRPB on 6-10 November 1990 to approve Publication 60. The radiation protection policy that was now proposed was basically no different from the one that had been proposed in Publication 26 in 1977, but it was better explained, particularly when it came to the choice of the dose limits. Roger Clarke gave a good 14-page summary of the publication in a supplement to the NRPB's *Radiological Protection Bulletin* no. 119 in 1991.

The need for a new publication had arisen because, following the publication of the 1977 recommendations ICRP had made several supplementary statements and recommendations and thereby created a demand for an update. A good example of the need is that the size of the effective dose had not been defined until after Publication 26 had been published. More space was also required for the assessment of the biological risks.

In Publication 26, the sum of the risk coefficients for the eight organ groups stated had become 1.65 % per sievert. In Publication 60, the Commission had stated risk coefficients for thirteen organ groups and, as well as the risk of death, also assumed a detriment[*] for having survived cancer. The detriment was assumed to be equal to the mortality fraction for the type of cancer in question, i.e., small for cancer of the thyroid and close to one for liver cancer. After calculating this detriment and with the risk coefficients that were now assumed, the detriment increased from 1.65 % per sievert to approx. 7 % per sievert.

Roger Clarke described the difference between an individual-related and a source-related risk estimate. I quote:

> Eventually, individuals are exposed to one or many sources of radiation. It follows that assessments of the effectiveness of protection can be related to the source giving rise to the individual doses (source-related) or related to the individual dose received by a person from all relevant sources (individual-related).

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[*] See Section 11.11.

A source-related assessment enables a judgement to be made as to whether the advantages it brings outweigh the disadvantages, including the radiation exposures. The source-related assessment will take account of the magnitude and probability of occurrence of individual doses from that source, but not other sources. It is therefore necessary to consider the individual-related assessment to see if the total dose or risk from all sources is too high.

The Main Commission of ICRP meet at NRPB in November 1990, to finally approve Publication 60. At the left end of the table, Hylton Smith and Henri Jammet. Others seated at the table, from left, Roger Clarke, John Dunster, Angelina Guskova, Bo Lindell, and Dan Beninson. Standing behind them, from left: Giovanni Silini, Charles Meinhold, Itsuzo Shigematsu, Deping Li, Julian Liniecki, Wolfgang Jacobi, Fred Mettler, and Warren Sinclair.
© NRPB.

ICRP has introduced the concept of constraint for dose or risk. Constraint is an individual-related criterion but is applied to a single source to ensure that dose limits or risk limits are not exceeded. A dose constraint should therefore be selected as a fraction of the dose limit as a limit term when optimising the radiation protection for the source.

In addition to the main text which had been written by John Dunster, Publication 60 had a number of Annexes. Of these, Annex A dealt with the quantities used within radiation protection. Annex B, which was written by Warren Sinclair, summarised Committee 1's conclusions regarding biological radiation risks. They were well aware that the risk estimates that had been made actually concerned only the populations that had been studied and possibly not other populations, and that they concerned an average individual in the population and may not have been at all suitable for a given, 'real' person.

One particular problem lay in the transfer of risk estimates from the population for which the estimate had been made to other populations. The simplest method was based on the assumption of a multiplicative dose-response relationship, i.e., that the risk increase due to extra radiation gives an added risk which is proportional to both the radiation dose and the background incidence of cancer in the irradiated organ.

I wrote Annex C about ‘Grounds for assessing the significance of radiation effects’ myself. It was probably my main contribution to ICRP’s radiation protection policy.

It was clear to us that, when assessing radiation effects, it was not enough to state ‘the risk of dying’ from the radiation. We agreed that ‘risk’ was a complicated quantity and did not simply mean the likelihood of an injury, but also covered the level of severity of the injury. The latter certainly follows implicitly if you talk about the likelihood of dying, but what does ‘the likelihood of dying’ from radiation mean? You can die immediately from a car accident, but if the cause of death is cancer caused by radiation, decades may pass before the injury makes itself felt, followed by years of suffering before the death occurs. Which is worse - suddenly dying from an accident while still young or dying later but painfully, as was wished upon me by ‘Christian nuclear power opponents’ (see Section 13:33)? What information would we need in order to perform a risk assessment? The likelihood of dying too early, the latency period and the expected age at the time of death? In what way would the passage of time be significant, which was preferable – surviving a specific number of years but then no longer being allowed to live, or having a chance of living longer with a specific likelihood of dying earlier as a price?

In order to present the risk situation I used the Gompertz-Makeham formula (see Section 22:19):

$$\frac{dS}{du} = A \cdot e^{Bu} + C$$

where u states the age.

This formula can be used as a reference to state the total ‘normal’ risk-adjusted mortality rate due to all causes of death before the studied the radiation arrives. The age-independent term C used to dominate in the world when accidents, starvation and epidemics affected many, more or less irrespective of age. In Sweden in the 1700s it was as big as 1% per year and is still just as big in the poorest countries. The formula shows the risk of adults; for children, the term in the poor countries is still much greater. The term C is approximately equal to the age-specific mortality rate in the age group where the risk is the lowest, i.e., around the age of ten. There, it is approx. 0.01% per year for women for the ‘safest’ countries (Finland, Iceland, Japan, Norway and Sweden) and more than 0.1% per year for countries like Egypt and Guatemala. The value of C is, roughly calculated, inversely proportional to the gross domestic - product (GDP).

Factor B in the exponent is approximately 0.1 year^{-1}. This means that the risk-adjusted mortality rate after around the age of 30 is doubled for around every seven years. Factor A is comparatively constant and is between 25 and 30 millionths per year. Factors A and B are the ones that Gompertz associated with ageing. Term C is the one that can be influenced by protection measures and improved healthcare. The formula must not be given any biological significance; it is empirical and describes fairly well the situation in most countries. In many countries, the risk-adjusted mortality rate for men due to greater risk-taking shows a peak at around the age of 20.

In 1988 I was invited to give the ‘Taylor Lecture’ at the NCRP’s annual meeting in Bethesda near Washington DC (see Section 22:8), which was entitled *How safe is safe enough?* There, I stated an expression for an ideal reference risk where all risk sources that can be influenced had largely been eliminated (i.e., C = 0) and where the values of A and B corresponded to the lowest observable risks due to ageing according to Gompertz (A = 0.000026 year^{-1} and B = 0.09 year^{-1}). I thought that a total added risk which did not involve more than a doubling of the reference risk would be individually negligible since it would just be equivalent to moving from the safest countries (see above) to other ‘safe’ countries such as Austria, Belgium, Canada, Denmark, France, Germany, the Netherlands and the United Kingdom). The corresponding criterion is used in ICRP Publication 60.

The question of a limitation of the ‘lifetime risk’ was also discussed. Unfortunately, the Gompertz-Makeham formula showed the ‘conditional’ risk-adjusted mortality rate, i.e., dS/du if you lived long enough to reach age u and experience the risk. The integral of the risk rate would be immense since it was never assumed that you would die. It became necessary to multiply the conditional probability by the probability (at birth or at a given age T) of achieving various later ages u. The result was a curve which showed the probability of different mortality ages. The area below the curve was <u>one</u>, i.e., the total probability of dying. If you performed the corresponding manipulation for the probability of dying from a specific radiation dose, you obtained a curve which could be compared with the total risk of death without the radiation and also showed the ages at which you ran the risk of dying thereof.

From all this information I was able to calculate different relevant details such as the total probability over a lifetime of dying of a assumed radiation dose, the average number of life years which were lost if you died of cancer from the radiation, the annual added probability at the age of 70 of dying due to the radiation, and at what age the risk of death from the extra radiation dose was greatest in relation to the total risk of death. All this information was relevant when discussing the choice of dose limits.

Many of us will not acknowledge the normal annual risk of death and that it is as high as approx. 1% at around the age of 50, although we ought to understand it when we see the obituaries in the newspapers. I felt some uncertainty myself where I was sitting calculating in the Haga Court of Justice. Had I calculated correctly? A mistake in that which was to be stated in ICRP Publication 60 would be embarrassing to say the least. However, the British at the NRPB who may have been equally concerned did an independent recount and luckily got the same result.

25. THE YEAR 1991

25.1. ICRP course on the Radiation Protection Institute

In January I held a course on ICRP's new recommendations for the personnel at the Radiation Protection Institute.

25.2. Generational change for radiation protection

The pioneers of radiation protection (Binks, Bugnard, Failla, Holthusen, Mayneord, Morgan, Sievert and Taylor) were born around the end of the 1800s and start of the 1900s and were active until the 1960s. The achievements of the next generation culminated at the end of the 1980s with the emergence of ICRP Publication 60 in 1990. Then came a third generation which wondered whether it was time for yet another paradigm shift.

The end of the 1980s saw the last the contribution from the second generation. Dan Beninson had been Chair of UNSCEAR from 1983-1984 and Bo Lindell from 1987-1988 (Professor Kumatori was Chair between these two). Bo Lindell was Chair of the ICRP from 1977-1985 with Dan Beninson as Deputy Chair. Beninson was then Chair with Henri Jammet as Deputy Chair from 1985-1993. Jammet was Chair of ICRP Committee 4 from 1962 until 1985, whereupon John Dunster succeeded him from 1985-1989, so radiation protection in the 1980s was controlled by a few people.

However, in 1987 the third generation made its entrance when John Dunster retired after five years as head of the British NRPB and was succeeded by Roger Clarke. Clarke then became Chair of the NEA's Radiation Protection Committee, the CRPPH. Two years later, he also succeeded John Dunster as Chair of ICRP Committee 4. Clarke was Chair of the CRPPH from 1987-1992 and of ICRP Committee 4 from 1989-1993, so for three years for both of the Committees. In 1993 he succeeded Beninson as Chair of ICRP and would remain Chair thereof right up until 2005. These events resumed the discussion regarding the radiation protection policy.

In order to understand the way in which events developed, you have to look back to the infancy of radiation protection, when it was a matter of protecting people who could be exposed to tangibly dangerous radiation. It was a matter of *deterministic* injuries, i.e., radiation injuries which required enough cells to have been killed in order for a tissue or an organ not to be able to function normally. This could happen only if the radiation dose exceeded a specific threshold dose, but the injury was then in principle inevitable, i.e., deterministic.

When during its initial period the ICRP aimed the protection exclusively at deterministic injuries[*], its members, who then consisted mainly of physicists and radiologists, had no sense of being involved in social or ethical considerations. It was a matter of establishing which doses of radiation exceeded the threshold values and ensuring that such doses could not arise. Radiation doses below the threshold values were not thought to be dangerous. Abel González has consistently designated the management of such knowledge as *epistemological*; it concerned only knowledge rather than the opinions. In the meantime, ICRP was still criticised for using the term Maximum Permissible Dose. Permissible – by whom? ICRP was referring to the national radiation protection authorities.

[*] When the genitals were irradiated, the aim was to prevent sterility; hereditary injuries were not yet being spoken about.

However, from the 1950s an increasing feeling of uncertainty began; was it really totally without danger below the dose limit? The uncertainty was rapidly expressed in the ICRP recommendations. The problem was knowledgeably discussed in Professor Failla's preface to Publication 1 (1958), the first of the Commission's series of booklets. The Commission therefore recommended 'that all doses be kept as low as was practically possible and that every unnecessary exposure be avoided'.

In the next comprehensive recommendations, Publication 9 (1965), ICRP had come to terms with the fact that the nuclear power industry could generate global radioactive contamination in the long term, but that risk estimates – for leukaemia and hereditary injuries in the first instance – required assumptions regarding the absence of threshold doses and a linear dose-response relationship which they had still not dared to assume other than as a precautionary measure. They repeated that unnecessary exposures should be avoided and that 'all doses be kept as low as was readily possible with regard to economic and social considerations' (paragraph 52).

The next ICRP recommendations, Publication 26, came out in 1977. For the first time, the Commission now made a clear difference between deterministic and *stochastic* (random) radiation effects and thereby definitively introduced a scientific reason to assume injuries below the dose limits as well. It was now necessary to interpret the previous paragraph 52. The interpretation was given in ICRP Publication 22 (1973) and led to the demand for radiation protection to be optimised, through the cost-benefit analysis for example.

It began to become obvious that in addition to epistemology, i.e., the scientific accumulation of knowledge, the radiation protection activity also included choices and decisions that had ethical meaning. Here, ICRP could not continue to maintain that there was a mandate for considerations. This meant that the task group which formulated the next recommendations, ICRP Publication 60 (1990), introduced an extensive consultation procedure for the first time which included other international organisations and a number of interest groups.

The task group was appointed at the ICRP meeting in Como in 1987. The meeting aroused international attention, with German television on site and petitions from a number of environmental organisations, including Friends of the Earth, and critical scientists such as Alice Stewart and John Gofman.

Sievert's and Taylor's generation had frowned upon openness during the work with recommendations. It was partly a consequence of the customs of that time but partly also a result of poor experiences. On several occasions the Commission's work documents had been published by others after having gone astray before the recommendations had been established. This caused confusion which they wanted to avoid. However, ICRP 60 was drawn up during Gorbachev' *Glasnost* period and views on consultation and openness had changed. There was also an increasing need for consultation with different interest groups.

ICRP's consultations with outside interests led to a thousand or so proposed changes which were dealt with by the author of the text John Dunster and the Secretary Hylton Smith. In 1990, a group consisting of Dan Beninson, Roger Clarke, John Dunster, Julian Liniecki, Bo Lindell and Hylton Smith visited the CEC in Brussels, the NEA in Paris, IAEA in Vienna and the ISR in Paris. In a letter to David Sowby I wrote 'Glasnost and perestroika have reached the Commission'.

ICRP Publication 60 summarised the radiation protection policy of the middle generation. The new generation came onto the scene when Roger Clarke started as Chair of ICRP in 1993. As already mentioned, at that time he had been Chair of both the NEA's CRPPH and ICRP Committee 4 for a few years.

It has been said that relations between ICRP and the CRPPH had previously been 'frosty' but I have not seen any evidence of this. On the other hand, from what I can see there may have been antagonisms between individuals rather than regarding the formal relations between the organisations. Things could heat up between Ilari and Dunster when the personal chemistry was not there and it is probably true to say that Dan Beninson had no enthusiasm for organisations which he thought were infected with bureaucracy (which may have been unfair specifically in relation to the NEA). Ilari made a major contribution to the contact between the CRPPH and ICRP but had little support from his Director

Generals. The situation improved for Ilari's successor *Ted Lazo* when the Spaniard *Luis Echávarri* started as DG in 1997 and showed significant interest in the radiation protection matters.

Initially, the ICRP dose limit was an operative tool (for purposes of planning and design), intended as a guide for both users and authorities, but increasingly became a guide for the authorities only, which would then give the operative instructions. Some saw the comprehensive dose limit as unnecessary. I personally thought it was incorrectly named; it was no longer operatively applicable – it was just information for the radiation protection authorities about which total doses ought to be avoided (the aim was still to achieve 'protection' rather than 'safety' - a defensive attitude). I appealed in vain for a reverse strategy: rather than working on the basis of a dose limit (which was worryingly high and not intended to be applied directly), start at the other end. The limits that the authorities allowed to be operative (installation-related constraints and limits derived following protection optimisation) were the ones that ought to be called 'limits'. The comprehensive guide to prevent the totality from going haywire ought to be called something other than 'dose limit' – that is actually just epistemological information. Where the public are concerned, in practice it is also impossible to measure individual people's doses, which goes to demonstrate that the 'dose limit' can be used only as a planning tool when authorities set the actual source-related and derived limits which are monitored.

Roger Clarke's ambition as Chair of ICRP and in the work with forthcoming recommendations was based on the experience he had of the cooperation with the CRPPH and the exchange of information between the CRPPH and ICRP Committee 4. Important components were openness, information and consultation. This is where Roger made a substantial and important contribution. Another significant contribution was his concentration on source-related limits, primarily those which ICRP had rather unfortunately named 'constraints', a word which in many languages proved difficult to translate.

Unfortunately, he came into conflict with some of the older generation, primarily with me and Dan Beninson, by maintaining that a situation was acceptable from the radiation protection point of view if every individual was satisfied with *his own* protection.* This meant that he prioritised the limit values and the protection for individuals and did not consider protection optimisation such as that based on collective doses to be equally important. When we tried to convince him that adequately protected individuals were not everything you should be looking for – you should also be interested in what overall damage a source of radiation causes, he did not agree with us. We quite simply did not understand one another and Roger's view of the matter had the advantage of being more pragmatic and easier to understand.

25.3. UNSCEAR's 40th session

UNSCEAR met in Vienna on 13-17 May for its 40th session. The Chair was now Jean Maisin from Belgium. Dan Beninson was still Chair of the physics sub-group and E. Letourneau of the biology sub-group. The Swedish delegation, whose representative was Gunnar Bengtsson, was made up of the same people as it was at the 39th session. Jack Valentin was consultant for the Secretariat. The work on a new, extensive report continued, which was expected to be published in 1994.

25.4. The international Chernobyl project

The week after UNSCEAR's meeting, an official, exhaustive report was given during a week-long seminar in Vienna about the international Chernobyl project. This had been produced at the initiative of the Soviets in autumn 1990. In the project, IAEA had performed a mammoth task in a few months with the help of experts from all over the world. 200 experts from 20 countries took part in 40 technical expeditions to the Soviet Union. During the project, three seminars were arranged and 8,000 personal dose measurements were taken, 10,000 whole-body measurements, 3,000 medical examinations were

* See the Section on 'Controllable Dose', 33:07 (1999)

carried out and 1,000 environmental samples were taken. Within the Soviet Union, 30 institutions took part and there were 4 assisting experts from Sweden.

Initially, IAEA had realised that being responsible for the project could have led to distrust. The project was therefore organised with seven international organisations in cooperation (the CEC, FAO, IAEA, ILO, UNSCEAR, WHO and WMO) and scientists from ten countries in an international advisory committee. The Chair of the latter and leader of the project was the respected Japanese Professor Isuzo Shigematsu, Director of the Radiation Effects Research Foundation in Hiroshima.

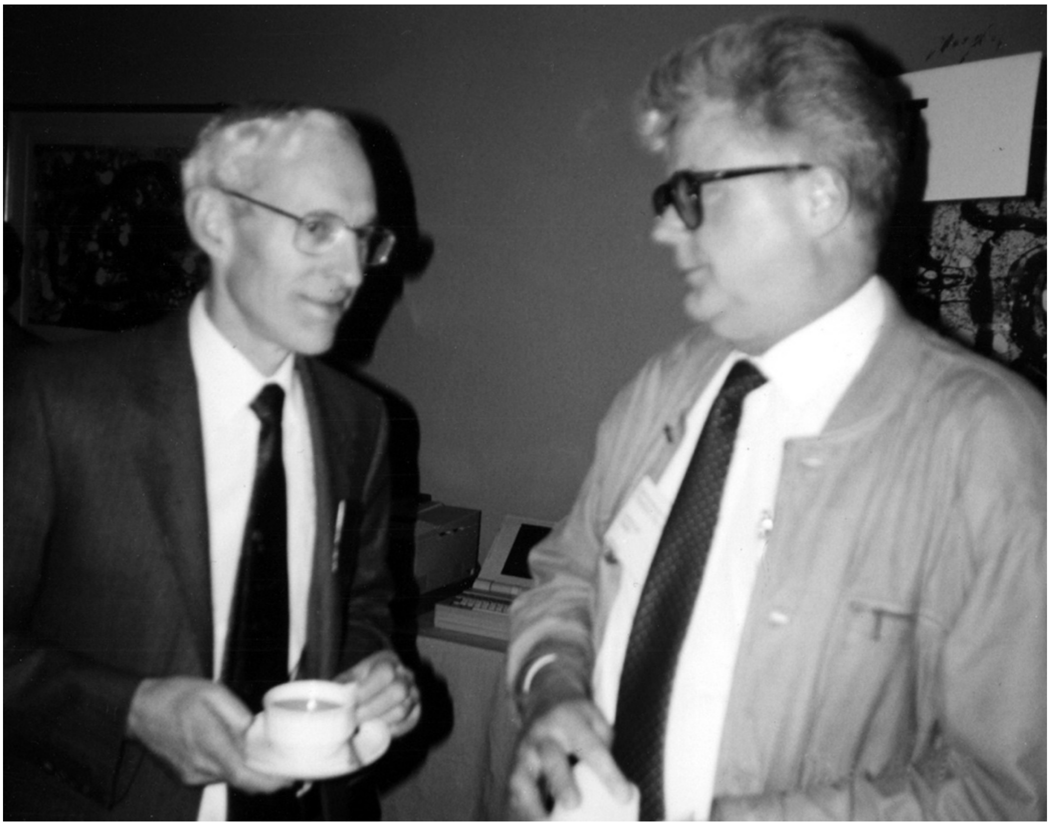
As well as Shigematsu, two other people also took on particularly substantial workloads. One was head of radiation protection at IAEA, Abel González, and the other was the Chair of ICRP Committee 3, Fred Mettler from Albuquerque in New Mexico, who was effectively responsible for the project's medical group.

Although the initiative for the project had been taken by the Soviet Union, disagreements arose when it came to approving the project group's recommendations. The political game in this context within Russia and the Ukraine has been given a spirited description by Professor Ilyin in his book (the English edition from 1995) *Chernobyl: Myth and Reality*.

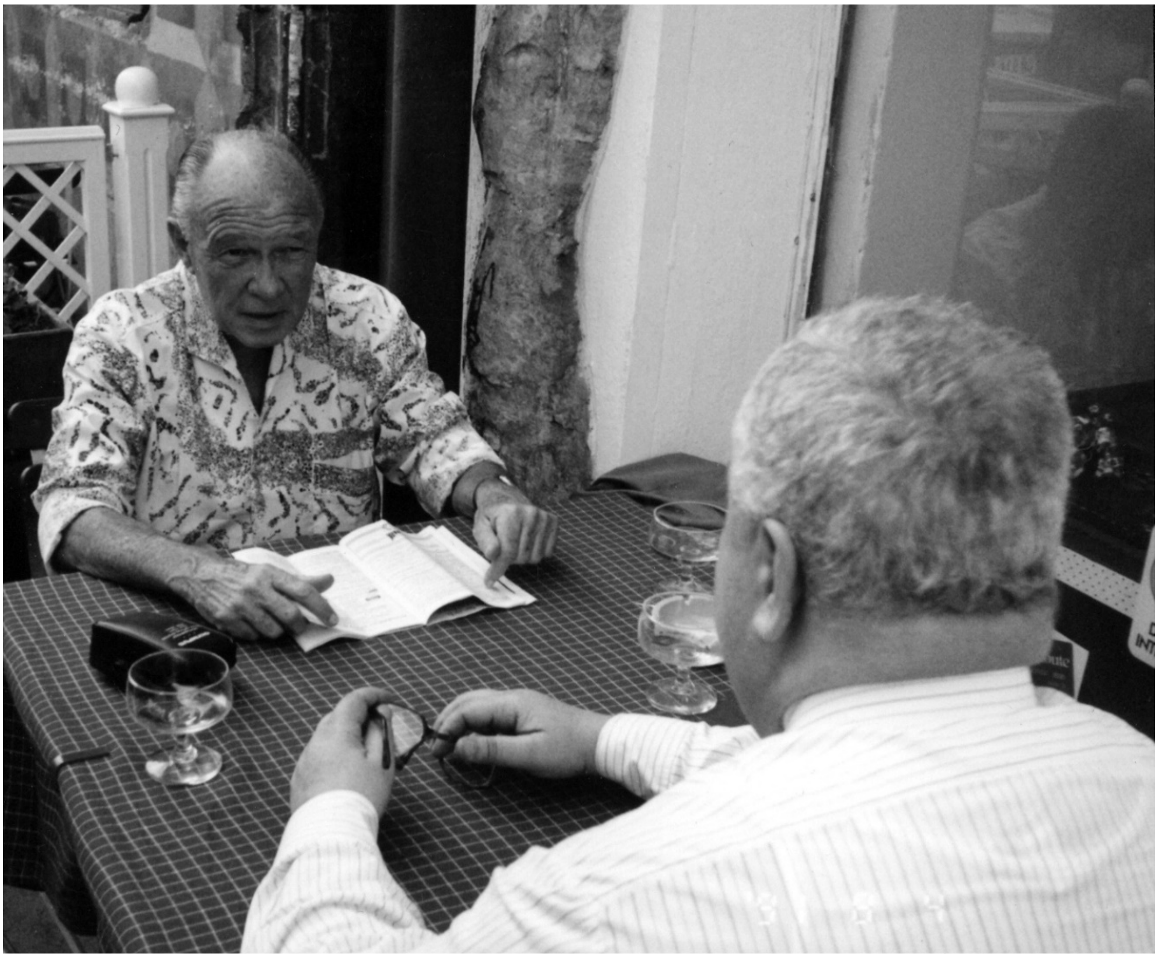
25.5. **Tolba's proposal for UNSCEAR**

On 28 June, in his capacity as Swedish representative of UNSCEAR Gunnar Bengtsson wrote to the Ministry for Foreign Affairs about the head of UNEP Mostafa Tolba's proposal that UNSCEAR ought to expand its business to also include carcinogenic chemicals. He started his letter with:

> I hereby give some background according to previous private contact. At the same time, I suggest that Sweden take the initiative towards a thrust at the UN General Assembly for an experimental broadening of UNSCEAR's work assignments for the approximately 5-year period for which work will start to be discussed at UNSCEAR's 1993 session.



Silini's successor as the Scientific Secretary of UNSCEAR, Burton Bennett, in conversation with Jan Olof Snihs during the 40th session of UNSCEAR, 1991.



Henri Jammet and Dan Beninson at an outing to Budapest
during the UNSCEAR meeting in Vienna, 1991.
Photo: Bo Lindell.

Tolba had suggested such a broadening to the Committee in letters in 1989 and 1990. He proposed two types of broadening - that UNSCEAR should also study the impact of radiation on flora and fauna, and that the Committee should also extend the activity to include not just radiation but also carcinogenic chemicals.

Gunnar gave reasons to support Tolba's proposal:

> Radiation and cancer-initiating chemicals have many similarities. In low doses they cannot be picked up by the senses, they can cause cancer and hereditary injuries and it is reasonable to assume that these also occur at very low doses of radiation with no threshold. Sweden has done a lot of work to create views on radiation in relation to hazardous chemicals. Swedish scientists such as Lars Ehrenberg have produced new methods for comparisons which have been complied with internationally. Birgitta Dahl has initiated two international meetings arranged by the Radiation Protection Institute which have dealt with waste containing radioactive substances and hazardous chemicals. No doubt the same interest as Dr. Tolba's, i.e., finding ways to benefit from coordination, are behind this.
>
> In my opinion, another reason for broadening out is that it could vitalise the Committee. The latter has now been working in the same field for 35 years. Although very valuable data appears in several of the sub-areas dealt with by the Committee, [it is natural] that the law of diminishing marginal benefit will make itself felt. I believe the Committee could make a very interesting contribution if it got involved in the surrounding areas.

I did not share Gunnar's views and thought he had misinterpreted the right of UNSCEAR to exist. In 'The Labours of Hercules' I attempted to describe UNSCEAR's task:

> You might wonder why the UN's General Assembly has a Scientific Committee and whether or not UNSCEAR's scientific work could not be done equally well by an International Committee under UNESCO or WHO, for example. In doing so you forget that the reporting, which was the objective of the activity in the first few years, has become a by-product in recent years, no matter how important. The most important thing about UNSCEAR has been the fact it *existed*. There is an established forum for scientifically assessing a sudden threatening situation with comprehensive radiation risks such as a reactor disaster or a nuclear war. At UNSCEAR you can analyse what the scientists agree on and remove this from political discussions to give the politicians an agreed platform from which debates can be led. Suddenly setting up a credible group of scientists in a crisis situation is difficult. With UNSCEAR, such a group is already established, which is of great value.

In my opinion, UNSCEAR was not a Committee that was justified by a need for scientific research. When Dr. Tolba proposed expanding the activity in line with UNEP's interests, there was a risk that inadequately-informed UN bureaucrats would start asking themselves what the General Assembly's interest in this was, and allow UNEP to take over the Committee in the way it was already responsible for its Secretariat. The General Assembly's interest in UNSCEAR is its existence in the event of nuclear warfare or other situations involving the global distribution of radioactive substances. UNSCEAR's work with its reports is secondary. UNSCEAR's expertise concerns only effects of radiation because advice to the General Assembly in situations involving extensive radiation effects is the primary task of the Committee.

However, Gunnar saw UNSCEAR mainly as a research organisation and wrote about 'Feelings within UNSCEAR':

> So far, UNSCEAR has displayed an extremely negative attitude to broadening its subject area. Its main argument is that the Committee's competence does not cover the chemicals field. The national delegations from 12 of the Committee's 21 participating nations have 3 or more members. Replacing one of the members of these with another who has competence that is suitable for a broader work area should not pose too much of a problem. For example, we have included a psychologist in the Swedish delegation since one of sub-areas that are relevant at the moment concerns experience of radiation risks.
>
> Another argument is that the mandate from the UN is not compatible with broadening. This view was evidently not shared by Dr. Tolba. If the General Assembly could recommend an experimental broadening activity, this would negate any objection.
>
> However, the mood at UNSCEAR is turning, partly in that the delegations have been renewed in recent years. Having put out my feelers privately to Australia, Belgium, France, Germany, Peru, Poland, Sweden and the Soviet Union, i.e., 8 out of 21 nations there is now support for broadening the scope. The USA's delegate is positive in principle but the USA will not support anything that involves new UN undertakings. Canada may be in favour of broadening. Argentina and possibly the United Kingdom. Of 9 other countries that I have not sounded out, the majority are probably in favour of broadening.

It seemed to me to be more likely that the new delegates did not understand UNSCEAR's task rather than the renewal having refreshed the manpower. The fact that only the weightiest, most experienced delegates Dan Beninson and John Dunster were negative ought to have been an eye-opener for Gunnar. But he proposed to the Ministry for Foreign Affairs that Sweden should take the initiative of proposing to the UN General Assembly a statement on the value of broadening the activity.

However, the big broadening of activities never came to fruition. On the other hand, work with radiation effects on the environment did. One consequence of Gunnar's view of UNSCEAR's assignments was that the Swedish delegation's reports, which used to be sent to the Ministry for Foreign Affairs, were now sent to the Swedish Radiation Protection Institute's Ministry, the Ministry of the Environment. Therefore, none of these are in the Ministry for Foreign Affairs' archive until the time when Gunnar's successor began sending reports to the Ministry for Foreign Affairs. They could not be saved at the Ministry of the Environment, nor in the Swedish Radiation Protection Institute's archive. Diaries were not kept diligently in the 1990s.

25.6. **The phase-out decision is torn up**

The phase-out decision from 1988 and Birgitta Dahl's 'irrevocable' viewpoint had aroused strong criticism which increased as time went by. The Moderate (conservative) Party and representatives of industry thought the phase-out of nuclear energy would lead to an increase in the price of electricity which, in turn, would damage the competitiveness of the industry. The situation became unsustainable for the government when four leading LO representatives also joined in with the criticism. Birgitta Dahl had to leave the energy issues in January 1990. The Social Democrats began negotiations with the Centre Party and the Liberal People's Party and an agreement was reached in January 1991 which tore up Swedish Parliament's decision from 1988. Rather than starting to phase out nuclear power with two reactors in 1995-1996, the economy, employment, welfare and the environment should be the factors to determine when the phase-out could begin. The Ministry of the Environment and Energy was transformed into a Ministry of the Environment and Natural Resources and Olof Johansson succeeded Birgitta Dahl as head of the Ministry.

25.7. **What price for our life?**

A conference whose subject was 'What price for our life' was arranged by the National Audit Office in May. A 60-page leaflet subsequently summarised the conference's conclusions. It started as follows:

> ... the value of a risk reduction differs very considerably depending on whether the responsible authority which sets the price of the increase in safety is the Radiation Protection Institute, *Vattenfall* or a healthcare unit.
>
> This came out at the National Audit Office's conference on risk assessment in May 1991. At the request of the National Audit Office. Bengt Mattsson, Assistant professor in Economics in Karlstad, has drawn up a report, 'The price for our safety', which discusses methods, results and instruments to assess risks of injury, illness and death. The report was a basis for the conference and for the National Audit Office's and other authorities' continued work with safety and risks.
>
> In its introductory address, Director General of the National Audit Office Ingemar Mundebo maintained that people were nearly always exposed to risks of being injured, becoming ill or dying: 'Sitting in this hall is not completely without risk. However, the risks were greater on the way here, and when you go out into the traffic later on you increase the risk exposure once again.' Government, Parliament, governmental authorities and municipal bodies have made decisions on a number of rules within traffic, the physical environment, settlements and the work environment with a view to protecting life and health. We are constantly facing issues regarding the way in which we will minimise the risks and what we are prepared to pay to minimise them.
>
> The National Audit Office is also assisting with the work since it supervises the legislation in accordance with the limitation regulation. The National Audit Office is working with methods and models to present a decision basis to the public sector within this field.

Mundebo emphasised out the following questions as the most important for the conference:

- How will risks within and between sectors be valued?

- How should we weigh up different perceptions of the way in which we value risks?
- What price are we prepared to pay for our safety?

In his report, Bengt Mattsson proposed that the price of a saved life should be the same in all parts of society. The Swedish Road Administration applied the price of 7.4 million Swedish kronor. Mattsson maintained that the surveys to which he referred indicated that the public saw 20-25 million Swedish kronor (1989 prices) as reasonable (according to the willingness to pay) and thought that the Swedish Road Administration's price was too low; the price really ought to be between 15 and 20 million Swedish kronor. I said that the Radiation Protection Institute reckons on a price of between 5 and 10 million Swedish kronor.*

During the discussion it became clear that one reason for the large spread between the observed values was due to an incorrect observation method. You cannot quite simply divide the sum of money that, in a specific context, has been spent on protection by the number of human lives which it has been used to save. It gives a relevant result only if the money has been spent for the *purpose of saving human life* and nothing else. One scary example was the measures against formaldehyde which had been taken to prevent mucosal irritation but which had the side effect of saving few human lives. The great expense divided by the few lives saved gave a very high apparent value, although this was irrelevant since the main purpose of the measures taken was not life-saving.

During the discussion, I emphasised that it was not possible to dimension the protection efforts according to the calculated reasonable cost - you also had to ensure that no individuals ran excessively high risks.

As an alternative to the number of saved human lives, the concept of 'Qualy' was mentioned, i.e., the quality-adjusted life year.

Inga-Britt Ahlenius (budget director for the Ministry of Finance at the time) thought the level of discussion at the conference was too abstract. She said:

> I am not sure it is appropriate to have such a high level of rationality. Decision-makers are people with all failings into the bargain. You must therefore be very clear as to what the instrument involves when looking at this risk assessment matter.

25.8. **SIUS***

The acronym 'SIUS' stands for Radiation Protection Institute International Development Cooperation. Jan Olof Snihs started it all off in the early 90s and initially called the activity 'Project Radiation Protection East'. It began with the Radiation Protection Institute hearing that the Nuclear Power Inspectorate had received money to support reactor safety in Lithuania. Snihs contacted the Ministry of the Environment to find out any options for equivalent support in the radiation protection field. Following a government decision in 1991, the Radiation Protection Institute received money (approx. 2 million Swedish kronor) to start the activity by visiting the three Baltic States, which Jan Olof and Curt Bergman did along with personnel from the Nuclear Power Inspectorate (the head of the SIP (*Swedish International Project*) at the time was *Jan Nistad*) and with respective Swedish ambassadors. The grant then increased rapidly and, after a couple of years, the Radiation Protection Institute received 18 million per year to be used as support in all fields where there was activity with radiation and

* It was interesting to observe that the sum of money which is reasonable to pay to save an (anonymous, 'statistical') human life is rather closely confined between two extreme values. One is the 'utility value' of a human life that would constitute an economic loss to society to fall below (the 'human capital approach'). The other is the highest value that society's economy could allow before you ended up paying so much to save the life that society cannot afford to exist. This means that the reasonable value must be somewhere between 5 and 30 million Swedish kronor per life if all lives are valued equally. The heads of the Nordic radiation protection authorities have agreed that a reasonable value when optimising protection for the Nordic countries is 20 000 US $ per man-sievert.

* The description is based on details from Jan Olof Snihs, to whom I am extremely grateful.

radioactive substances, and natural radiation. As well as Jan Olof and Curt, Torkel Bennerstedt worked for Project Radiation protection East as technical consultant, Heléne Sundewall as economic administrator and Sten Grapengiesser as project administrator for hospital projects, specific EU projects and assistance with administrative matters.

After Jan Olof had retired in 1997, Gunnar Johansson became head until the year 2000 when he was succeeded by Åke Person who, upon retiring in 2007, was succeeded by Maria Delvin, although she finished after one year. SIUS activity has continued and been successful and now covers Russia, The Ukraine, Belarus, Georgia, etc., eastern states, sometimes in EU-financed projects. The support for the Baltic States ceased after they joined the EU and the support for Russia will probably be reduced.

The most important inputs in Estonia concerned Paldisci, a Russian plant which trained submarine personnel for nuclear submarines with such a life-size submarine on land and with all necessary service installations, storage for reactor fuel and radioactive waste, etc. within the support organisation (PIERG - Paldisci International Expert Reference Group) with 9 countries and 3 international organisations, of which Jan Olof was Chair throughout its existence from 1994-2000, technical and financial support was organised for the plant to be wound down, with the responsibility and presence of the Russians also being phased out at the same time. The Swedish Nuclear Fuel and Waste Management Company made a substantial technical contribution to the support activity for Paldisci. In all, through the Radiation Protection Institute, Sweden invested approx. 20 million Swedish kronor in the Paldisci endeavour.

Another major and important contribution in Estonia was the improvement of the uranium waste plant in Sillamäe, a plant which was also the result of a Russian activity. The Radiation Protection Institute did surveys of the external environment with regard to uranium and radium and their decay products through Project Radiation Protection East along with experts from Studsvik and the Finnish Radiation Protection Authority. A support organisation (SIERG – the Sillamäe International Expert Reference Group) with 7 countries plus the CEC was formed in 1997 with Snihs as Chair. It was operational until the year 2000. The results of the activity then constituted the basis for an application from Estonia for contribution from the EC, Denmark, Finland, Norway and Sweden for a recovery project of a total of 200 million Swedish kronor to which Sweden contributed 5 million.

Waste was also an important problem in Latvia, as was the phase-out of Salaspils, a research reactor. In Lithuania the Ignalina reactors were of course also the biggest problem when it came to radiation protection and radioactive waste.

Common issues for the Baltic States were setting up radiation protection authorities, legislation, control instruments and control methods, radioactive waste, the protection of personnel from radiation, preparedness and protection against natural radiation.

Russia has been involved right since the time immediately after 1986 (the Chernobyl year) when Johan Baarli, Karl-Johan Johansson, Sören Mattsson, Judith Mehlin, and Jan Olof Snihs travelled to St. Petersburg and Kiev to discuss and make decisions on cooperation, in the first instance regarding problems following the Chernobyl accident. This then led to a number of projects for the impacts of the accident.

The SIUS then had sporadic cooperation projects with the Russians regarding nuclear power-related projects, particularly on waste. All the cooperation that took place between a large number of western countries and Russia at the start of the 90s following the fall of the Soviet Union led those who were active within the Project Radiation Protection East unit to initiate a coordination mechanism to know what was going on and to avoid double work. In 1995, IAEA organised a conference through the Ministry for Foreign Affairs' involvement in the Nordic countries, which led to the formation of the coordination group CEG (Contact Expert Group) which had 15 or so member countries and international organisations. Jan Olof was its first Chair for 2-3 years and was then in the Swedish group until 2007.

The work within the CEG was aimed at supporting the Russians by solving the waste problems ashore in north-western Russia (Andreeva Bay and Gremikha), phasing out reactor-driven vessels, disposal of spent nuclear fuel, etc. The big countries invested hundreds of millions in relief efforts while Sweden was only able to make smaller yet equally important contributions such as preliminary studies, safety analyses, strategies and administration. The biggest contribution was channelled through the Nuclear Power Inspectorate with the Swedish Nuclear Fuel and Waste Management Company as an important player.

As well as its work through the CEG, the Radiation Protection Institute has cooperated directly with and supported Russia through Project Radiation Protection East and then the SIUS, primarily in the waste area, including RADON plants for radioactive waste from activity other than nuclear power, but also for the protection of personnel from radiation at nuclear power plants (ALARA, dosimetry, etc.), preparedness, emissions issues, cooperation between authorities regarding rules and provisions, inspections, medical radiation protection, radioactive lighthouses, natural radiation, etc.

At a later time, the SIUS built up a programme to train those who worked at the waste plants in north-western Russia. This was primarily in the noughties. Although there is a great deal of money and knowledge in Russia, not that much goes to those who are most in need of support. Western countries are also often superior when it comes to technology. The cooperation and assistance from the west are therefore both necessary and appreciated by the Russians. As with all international cooperation, substantial consideration has been given to the integrity and points of view of the cooperation partner when implementing various projects. The Russians have chosen not to abandon this of course.

It feels good that Jan Olof's achievements in the cooperation with the eastern states have met deserved approval. In 2006 he was awarded the Estonian Order of the Cross of Terra Mariana and the Lithuanian Service Medal by the countries' Presidents for his contributions.

25.9. **ICRP in Vienna**

ICRP's four Expert Committees met in Vienna on 29 July-2 August. The Main Commission then met on 5-7 August. Since I had an APEX ticket I could not return home immediately, but I was invited to take part in a meeting with ICRP's contact group for the work with new international Basic Safety Standards which took place on 8 August. All the meetings were held at the Vienna International Centre which I also visited on 9 August for discussions with IAEA experts.

A main subject for Committee 1 was the report from the Human Respiratory Tract Models task group. The task group which was led by Dr. Bair was made up of Committee 2 and had the task of assessing what happens to radioactive substances that are inhaled and which doses of radiation they can cause. Since they also wanted to calculate the effective dose, they required a definition of the tissues for which the ICRP organ weighting factor 0.12 for 'lungs' was used. Committee 2 had therefore asked colleagues in Committee 1 to state which cells were relevant to the risk of lung cancer.

Committee 2 also discussed the lung model and had a joint meeting with Committees 1 and 4 regarding the matter. Professor Jacobi and Dr. Clarke were worried that the proposed lung model would estimate more cases of cancer than it would be possible to observe in reality.

Committee 3 appointed two task groups. One, with Sören Mattsson as Chair, would investigate potential medical irradiation. The other concerned irradiation in biomedical research.

Committee 4 discussed potential irradiation. A task group in which Lars Högberg was involved would discuss issues at a meeting in December. A proposal to disregard all very low probability scenarios was accepted only regarding individual risks, not for disasters where the existence of a realistic scenario should always require a review because estimates of very low probabilities can be unreliable.

At the Main Commission's meeting it was observed that a worker under the age of forty who was exposed to the dose limit for skin would almost definitely get skin cancer. However, the situation is special bearing in mind that according to the report, the mortality for the occurrence of basal cell carcinomas is just 0.01 % and 1 % for squamous cell carcinoma.

It was ascertained that ICRP was not making ends meet but that one explanation for this could be the many meetings during the work with Publication 60. However, there was unfortunately a clear trend that the Committee members essentially preferred to request travel expenses from ICRP rather than their employer.

25.10. **Lecture in Barsebäck in November**

In November I held a lecture about ICRP's new recommendations for the Barsebäck Plant's personnel.

25.11. **Postponed nuclear power phase-out**

The previous decision to phase out nuclear power had been postponed by the Social Democrats with the support of the Centre Party and the Liberal People's Party:

> The energy system, along with the safety requirements, must be adapted with regard to the need for electricity to maintain employment and welfare. When the phase-out of nuclear power can start and the rate at which it can take place are determined by the results of the management of electricity, the supply of electricity from environmentally-acceptable power production and the options of retaining internationally-competitive electricity prices.

25.12. **Task group in Monaco**

IAEA had called a task group for 'potential irradiation' to a meeting in Monaco in December. The consultant for the follow-up was Richard Cunningham from the NRC in Washington DC. In the group I was joined by Lars Högberg from the Nuclear Power Inspectorate. We flew to Nice and continued to Monaco by helicopter. The group also included Abel González, Bert Winkler and Don Cool.

Bert Winkler told me about the plans to invite me and Geoff Webb to visit Southern Africa next year.

25.13. **Crown among the Best**

In 1991, the Radiation Protection Institute was designated 'Best Value – Total Quality Management for Local Government' by the government. This was a result of the work by a Committee called 'The Crowns among the Best' which had been set up in autumn 1990. Four authorities were appointed as 'Crowns', i.e., the National Board of Public Building's western region, the National Board of Student Aid, the Chemicals Inspectorate and the Radiation Protection Institute. The result was reported in a book, *Kronorna bland Verken* ('The Crowns among the Best'), published by the Swedish Agency for Public Management in 1991. I quote from the book's preface, written by County Governor Ingemar Eliasson who was Chair of the Committee:

> The Committee began by seeking firm criteria for which requirements ought to be set for well-functioning authorities. We worked on the basis of the targets that had been established for each individual authority's activity and asked ourselves to what extent these had been achieved.
>
> To that we added the cost of fulfilling said targets.
>
> The way in which the costs of the authority develop, *the productivity development*, the share of internal administration, etc. was used to assess the way in which the resources had been efficiently utilised. *The quality* of the services and the *service* are assessed on the basis of the quantity of the complaints, the accessibility of computer systems, the speed of execution, the result of service surveys, etc. We set strict requirements regarding the documentation of these different criteria.
>
> More difficult to document – or in any case to quantify – was *the capacity of the criteria to change* and *new thinking.* An efficient authority must be able to adapt itself to changes in its surroundings and new political prioritisations. We thought the Swedish Radiation Protection Institute s capacity to quickly reorganise the activity during the Chernobyl accident and the CSN's capable use of computer technology are two example of such a capacity for change.

Gunnar Bengtsson had reason to be proud of himself. The distinction was evidence of the organisation's efficiency.

26. THE YEAR 1992

26.1. Trip to Southern Africa

I had received an invitation to go to Southern Africa with Geoff Webb from the British NRPB to talk about ICRP's new recommendations. I had never been to Africa and was very curious. However, Southern Africa did not have the best of reputations at the start of 1992. Thoughts were turning towards apartheid, police brutality, starving children and a withered Africa. I asked friends at the Ministry for Foreign Affairs whether my visit could be misused because of my past as a civil servant. The answer was no, unexpected things now no longer occurred - not if everything continues to move in the right direction.

Geoff Webb and I had been invited by the Southern African radiation protection society, the South African Association of Physicists in Medicine and Biology. Bert Winkler turned out to be the Society's President who was now about to depart. We were to give lessons about ICRP in a Summer School which was held outside Pretoria two days before the Society's Congress.

On the plane from Zürich to Johannesburg I happened to be sitting next to a Swedish engineer from Asea Brown Boveri. He had been to Southern Africa many times and I took the opportunity of asking him about the racism problems.

'You'll never see them,' he said. 'You'll be moving in an all-white world. Apartheid means that you live in different worlds. You'll meet only white people - and if you meet only white people who are technicians, engineers or academics, you won't meet anyone who advocates apartheid either.'

Something that I found surprising was that Johannesburg and Pretoria, which are about as far apart as Stockholm and Uppsala, are at an altitude of 1 700 and 1 400 metres respectively in the northern part of the country. We later flew the approximately 1200 km to Cape Town on the south coast.

Our first stop was the newly-established Congress Centre, the ESKOM Training Centre, at Midrand halfway between Johannesburg and Pretoria. ESKOM is Southern Africa's *Vattenfall* but it leases out the centre for all sorts of conferences. One central building contains dining halls and conference halls. There are buildings with guest rooms throughout. Everything was new - we were the first guests.

The thing that struck me throughout the trip, even during our later visit to Krugerparken, was the conspicuous lack of insects. There were neither flies, gnats, wasps nor beetles. There were scorpions on the other hand. No insects were gathering around the lanterns in the gardens. That was the benefit of drought, they told me. But it was March – maybe that made a difference.

Apart from Bert Winkler, the person who primarily took care of us throughout the visit was *Phil Metcalf*, the person in charge of the Standards Division at the CNS (Council for Nuclear Safety) of which Bert Winkler was head. The CNS came under the Ministry of Mineral & Energy Affairs. Phil was an efficient and helpful colleague. We had also been allocated a cheerful, accommodating young man called *Sean Mac Curtain* to help us.

To the north, Southern Africa's borders are with Namibia, Botswana and Zimbabwe and with Mozambique in the east. Two independent small states are encapsulated in Southern Africa: Lesotho and Ngwane (Swaziland). Areas such as the Transvaal, Natal, Orange Free State and the Cape Province are provinces, i.e., parts of the country. The Apartheid system meant that the black people were only allowed to live in designated areas known as Bantustans or homelands. Some of these had been declared independent but the UN had chosen not to approve this because it could have been interpreted as acceptance of the Apartheid policy.

The population of Southern Africa was 28 million in 1991. Of these, 68 % were ‘blacks’, 17 % ‘whites’, 11 % ‘coloureds’, i.e., Indians and 3 % ‘Asiatics’, i.e., Chinese, Japanese and Koreans. Of the white people, just 39 % spoke English; the majority spoke Afrikaans, i.e., the old, diluted Dutch of the Boers. Of the black people, just 0.2 % spoke English at home. Otherwise, they spoke Bantu languages, the most common of which was Zulu (38 %), Northern Sotho (15 %), and Xhosa (12 %). The leader of the largest party, the ANC (African National Congress), and the primary spokesperson for the black people, *Nelson Mandela*, spoke Xhosa. There were many examples of highly-educated, intelligent black people. For example, an article in *The Star* newspaper described *Gabriel Ramushwana*, Regent of Venda (a homeland) as a man who spoke nineteen Bantu languages as well as Afrikaans and English, and relaxed by listening to Beethoven. I felt ashamed for thinking this was strange.

We heard that a referendum among the whites regarding President *Frederik de Klerk’s* plans to put an end to the Apartheid policy would take place on 17 March. The President represented the Nationalist Party, the leading party of the Boers, which was a condition for success.

‘Apart from the idiocy of voting no from the purely self-preservation point of view,’ said Bert Winkler, ‘I cannot understand why so many people have such little sympathy and understanding where the blacks’ problems are concerned. I hope there will be at least 60 % who vote YES; a pipedream would be 65 % and then de Klerk really would be able to act.’

On the critical day, Sunday 17 May, Geoff and I went with Bert Winkler and Phil Metcalf to visit some vineyards near Cape Town. At Stellenbosch, a vineyard which was managed by a childhood friend of Bert, we were invited to lunch in a basement where the walls were completely covered by stacked, horizontal wine bottles – there could have been eight thousand in all.

The lunch was a strange experience. The results from the referendum among the whites started to flow in and our host received ongoing reports at the lunch table. The result was completely surprising in that the number of yes votes for President de Klerk’s policy was much greater than expected and amounted to almost 69 %. Our host and his colleagues at the lunch table were beside themselves with happiness, as were Bert and Phil. We toasted the success, firstly with champagne, then with white wine, red wine – with everything that had been put on the table. The tears of joy flowed. The black waiters who had not been able to vote were less enthusiastic, experience perhaps giving them lower expectations. but their faces made a show of being pleased anyway.

‘De Klerk took a big risk,’ said Bert’s friend. ‘I admire his courage, but his decision proved to be correct. If he’d waited, he might not have been able to get the majority of the whites on his side – the majority are Boers after all.’

The next day, the morning papers were jubilant about the result of the vote. One reason for the big election success for the yes voters may have been that the papers, black and white, had been almost completely against no votes. No doubt many of the blacks disapproved of a vote which they had not been able to take part in, but they certainly did not disapprove of the result.

Before we flew to Cape Town, Bert Winkler had driven Geoff and me to the Southern African Nuclear Energy Commission’s research centre, Pelindaba, where we were to give presentations about ICRP. Pelindaba is some 70 km west of Pretoria in what is otherwise an undeveloped area in hilly terrain with grassy mounds. A small research reactor (SAFARI-1), a 20 MW thermal power pool reactor, had been there since 1965 to produce isotopes.

The Pelindaba plant was originally erected as a research station around the small reactor. In the 1970s, expert assistance from the Germans had helped them start experiments with uranium enrichment with electromagnetic molecular beam separation with a view to being independent under the increasing isolation (due to the Apartheid policy) from the outside world. Since there were also substantial uranium deposits, this allowed them to gain control of the whole of the fuel production and become independent of foreign pressures regarding the nuclear power programme. Since, like Israel, Southern Africa was outside IAEA’s safeguard inspections and many thought it was interested in developing nuclear weapons, its enrichment technology was a sensitive matter.

The enrichment plant consisted of 47 isotope separation modules with a molecular beam of uranium hexafluoride. Every module required more than 2 MW of power. In 1989, 54 tonnes of uranium hexafluoride enriched to 3.33 % had been delivered to the Atomic Energy Commission’s neighbouring fuel factory. At the start of 1990, the AEC delivered a full set of fuel elements for one of the reactors in the Koeberg nuclear power station outside Cape Town. At the same time, production was stopped at the enrichment plant because by then, enough uranium had also been reprocessed to supply SAFARI-1 for a good number of years to come.

The AEC also had a plant to convert yellowcake to uranium hexafluoride with a stated capacity of 1 500 tonnes per year. However, due to a limited demand, only 428 tonnes had been processed during the 1989-1990 financial year.

From having been a national authority for nuclear energy research and development, the original 'Atomic Energy Commission' had now become the commercial Atomic Energy Corporation of South Africa.

The AEC also ran the commercial national waste station, Vaalputs, which is 600 km north of Cape Town. Vaalputs covers an area of 10,000 hectares. The place where the waste is deposited is a layer of sand a few metres deep, a layer of clay 15-20 metres deep and granite beneath that. Solid, low-level activity waste from Koeberg is compacted into metal drums while intermediate-level waste such as ion-exchange resins is mixed into concrete in concrete cylinders. 1 500 metal drums and 500 concrete cylinders were transported from Koeberg to Vaalputs every year.

Spent fuel elements are stored for ten years in pools of water at Koeberg. They are then transported to Vaalputs for intermediate storage for another few decades before expecting to send them abroad for reprocessing. They then expect to receive in return approx. 5 tonnes of highly-active waste per year to be deposited in Vaalputs.

When Geoff and I repeated our lectures at Pelindaba we were invited to visit the irradiation plant for foods, one of five plants with cobalt-60 as its radiation source. 55 different foods such as bananas, strawberries, chicken, onions, papaya, potatoes, asparagus, mushrooms and meat were irradiated. I said that we in Sweden had a largely negative attitude towards the irradiation of foods, mainly because it was wrong to save an unhygienic product rather than ensure that the product was handled hygienically to start with. The manager agreed, but said that people in Africa had particular problems which we did not have in Sweden. One was pests in fruit such as papaya and mango. Another was the durability of supplies for the army in the hottest parts of the country.

In the general market, the main items that had been irradiated were fruits and berries such as strawberries, but the doses of radiation were low for these. All irradiated foods had a special label attached and scarcely anybody objected to buying these items.

We were visiting Cape Town to see the Koeberg nuclear power station which is approx. 25 km north of Cape Town on the other side of Taffel Bay with the famous Robben Island and its prison buildings. From Cape Town you could see the reactors on the horizon in a similar way to seeing the Barsebäck plant from Copenhagen.

The Koeberg plant had two pressurised water reactors, each with 920 MW of electric power, supplied by French *Framatome* and commissioned in 1984. The safety checks at the power plant were very strict. Geoff and I gave our lectures to twenty or so listeners at the visitor centre. After the lectures, we visited the preparedness organisation's leadership centre in a bunker underground with a special ventilation system. According to the preparedness plan, the power plant's head of operations was responsible for the preparedness decisions such as typhoon signals and barriers, but my guess was that other partners would not be able to remain inactive if something were to happen – those such as the Mayor of Cape Town, the public doctor, the governor of the province, the government authorities and the company's management.

I moved in Anglo-Saxon circles only. That is where I came across understanding of the problems and sympathy for the black people. I never got as far as the larger Boer circle. I also had no contact with the black people's circle and their dormitory suburbs or homelands. I thought that visiting places like Soweto as a tourist with camera in hand without the time needed to create any actual contact would felt hyena-like.

What I can do is to wish the people of Southern Africa, 19 million black people, 5 million white people (the majority of them Boers) and 4 million Asiatic and 'coloured' people, all good luck for the future. Southern Africa is a country that has wonderful natural surroundings and substantial natural resources. I hope that many of us in Sweden can have good contact with our colleagues there and that Apartheid is buried and forgotten so that empathy and friendship can blossom on its grave.

26.2. **UNSCEAR's 41st session**

UNSCEAR met in Vienna from 15-19 June for its 41st session. I recall that I took part as observer for ICRP.

26.3. **The IRPA Congress in Montreal**

IRPA held its 8th Congress in Montreal from 17-22 May 1992. At the time, *John Lakey* was President of IRPA, Charles Meinhold Deputy President and *Chris Huysken's* Secretary. The most important event was the formal emergence of the ICNIRP (International Commission on Non-Ionising Radiation Protection) with a Charter that was signed by Lakey, Meinhold and Huyskens and Michael Repacholi who was Chair of the ICNIRP. This Charter was approved by IRPA's General Assembly on 20 May. This placed the ICNIRP in an independent position equivalent to that of ICRP, but it would have close working relations with IRPA.

Two types of non-ionising radiation were defined. One was electromagnetic radiation with wavelengths in excess of 100 nanometres (see Sections 8.11 and 8.13) and the other was acoustic radiation with frequencies in excess of 20 kHz (ultrasound) or with frequencies below 20 Hz (infrasound).

The Commission would consist of a Chair, Deputy Chair and 'up to' an additional twelve members, chosen by the Commission itself. The IRPA board and its society of members could suggest candidates. Like with ICRP, at least three and no more than five members must be replaced before each ordinary IRPA Congress. In 1992, the members included a Swede, *U. Bergqvist*.

26.4. **The Nuclear Power Inspectorate stops five reactors**

In September the Swedish Nuclear Power Inspectorate decided to demand the stoppage of five older boiling water reactors since the emergency cooling systems had shown that they were not reliable. The conversion took a long time; Oskarshamn 1 could not be restarted until 1996.

26.5. **ICRP in Albuquerque**

The ICRP Main Commission met in Albuquerque from 2-6 November 1992. Meeting in New Mexico was justified by an invitation from Commission member Fred Mettler who was a radiologist in Albuquerque and the American UNSCEAR representative. I took a holiday in conjunction with the meeting and, along with Marrit and Karin, visited our friends John and Lydia Hursh in Arizona. Karin drove us from there to Albuquerque. Dan Beninson was still Chair.

27. THE YEAR 1993

27.1. **ICRP in Bethesda**

The ICRP Main Commission met courtesy of the NCRP in Bethesda from 13-15 April. At this meeting it was decided that Roger Clarke would succeed Dan Beninson as Chair.

27.2. **UNSCEAR's 42nd session**

At UNSCEAR's 42nd session where Gunnar Bengtsson was Swedish representative, E. Létourneau from Canada was Chair and L. V. Pinillos-Ashton from Chile was Deputy Chair.

27.3. **Lars Persson at IAEA**

Lars Persson worked for Abel González at IAEA in Vienna from 1993-1996, González being head of the nuclear safety department at the time.

27.4. **ICRP in Bournemouth**

ICRP and its Committees met in Bournemouth from 20-24 September, followed by a meeting of the Main Commission at the NRPB in Chilton from 27-29 September.

28. THE YEAR 1994

28.1. The cork book

The group that had worked with non-ionising radiation at the Radiation Protection Institute had celebrated the emergence of new statutes since 1980. Those at the Swedish Board of Occupational Safety and Health had started a tradition of celebrating new instructions with coffee and cake. *Anders Glansholm*, who in 1981 changed over from doing the Swedish Radiation Protection Institute's general standards work to being in the 'IJS' group, thought the events were worthy of a more fitting tribute - champagne was required. In order to create a balance and not misuse the Institute's resources, it was decided that the immediate supervisor of each input would provide the champagne rather than the unit providing it. The corks were saved and stamped with a date as they were used. In 1984 a written record of the events was created – 'the cork book'. Initially, the head of general supervision also took part, so Gunnar Bengtsson, Sten Grapengiesser, Jack Valentin and Enn Kivisäkk have attended over the years. Gunnar took part 'after having ensured that there was a non-alcoholic alternative'. Anders Glansholm's comment at the time of my writing this is: 'It was all a bit facetious of course but, when the IJS group was asked12-13 years ago to provide some sort of retrospective long-term perspective activity report, the cork book was the most fruitful source.' Today (autumn 2006), the cork museum and the cork book live on and currently cover 84 editions since 1980, not only statutes but other noteworthy publications as well such as those in international magazines.

28.2. UNSCEAR's 43rd session

Warren Sinclair turned 70 at UNSCEAR's 43rd session (9 March). His birthday was celebrated with a dinner arranged by Waltraud Holzer at Lusthaus in Prater.

28.3. ICRP in Bethesda

The ICRP Main Commission met courtesy of the NCRP in Bethesda from 18-21 July.

28.4. Capacity increase at Ringhals 1

Changing the rotors in the low pressure turbines at Ringhals 1 increases the output by 40 MW.

28.5. The Congress of Radiology in Singapore

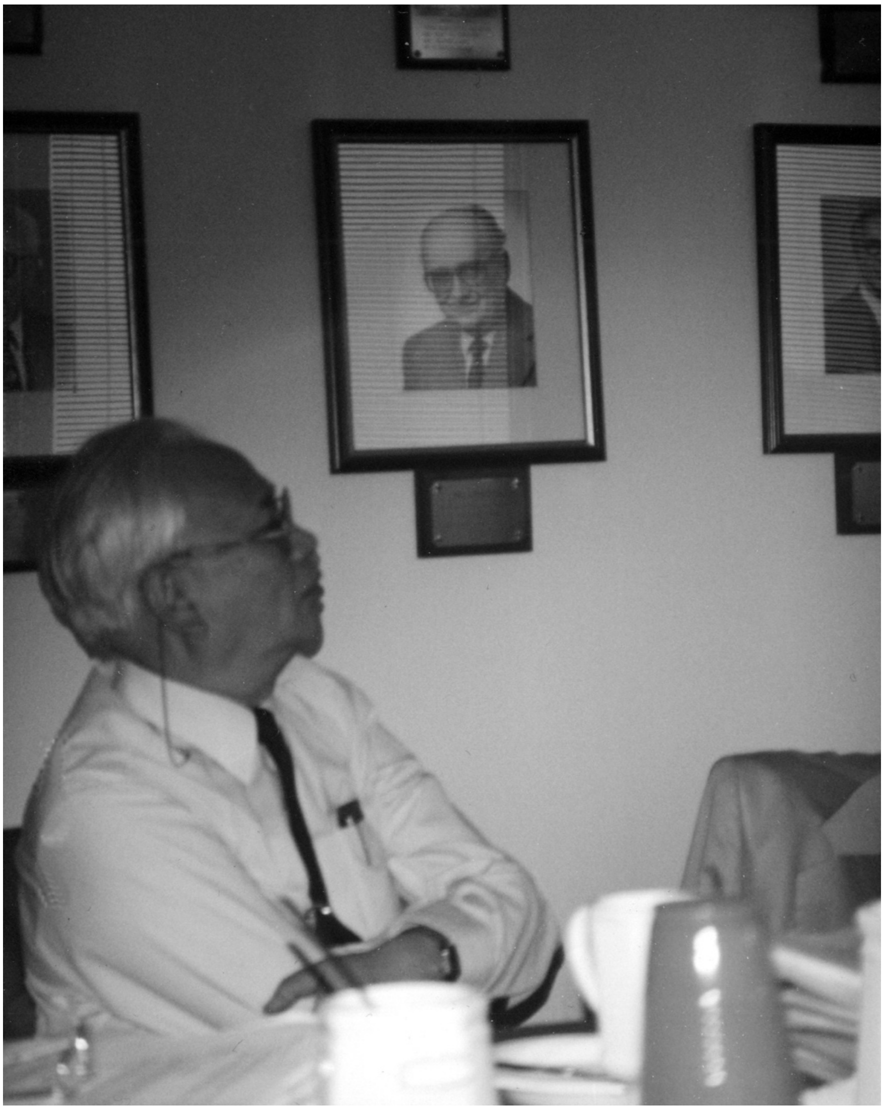
The 18th International Congress of Radiology, now without the radiotherapists, was held in Singapore. A dynamic radiologist, *Lennew Tan*, was responsible for the organisation. The Swiss Secretary General if the ISR, Dr. *Walther Fuchs*, was succeeded by the Finnish radiologist *Carl-Gustaf Standertskjold-Nordenstam*. In Singapore, it was decided that in the future, the Congresses would be held every other year and serve as radiological training. The subsequent Congresses were held in Beijing in 1996 and in New Delhi in 1998.

28.6. **The ethics of radiation protection**

Ethics and Radiation Protection is the title of a paper by Professor of Ethics at the Royal Institute of Technology, *Sven Ove Hansson* (2007). He gave the following summary:

> ... some of the major problems in radiation protection are strongly connected with those that moral philosophers have worked with since antiquity. This applies in particular to the problem of combining respect for individual rights with the furthering of collective interests. Since moral philosophy is about 25 times older than radiation protection, it might then be hoped that moral philosophy should have ready-made solutions that can be taken over and applied by radiation protectors. This is not the case, but some thought patterns and modes of reasoning that have been developed in moral philosophy may be useful in radiation protection. On the other hand, moral philosophers have much to learn from radiation protectors, not least when it comes to finding pragmatic solutions to problems that may be intractable in principle.

ICRP Publication 60 made a clear distinction between individual-related protection and source-related protection. In the *individual-related* protection it was a matter of ensuring that no individuals received doses of radiation that were too high. In the *source-related* protection it was a matter of ensuring that no plant or source of radiation caused injury that was unacceptable overall.



From the ICRP meeting in Bethesda, 1994. Dr Deping Li.
Photo: Bo Lindell.

In October 1994 IAEA arranged a conference in Paris entitled *Radiation and Society: Comprehending Radiation Risks*. The driving force within IAEA was *Morris Rosen* who occupied the posts of Assistant Deputy Director General and Director of the Division of Nuclear Safety. Rosen was a key person because it is said that he had good contact with the Director General Hans Blix. Rosen was worried about the public's lack of enthusiasm concerning nuclear power and was, like so many within the technical world, convinced that the worry about nuclear power and radioactivity was based on misunderstandings and lack of knowledge. He thought a big conference to clarify 'the way it actually was' would quell the concern.

IAEA ordered for the conference a work document with clarifying papers from a number of well-renowned experts. The order was sent to the Swedish Society for Risk Sciences, of which I was Chair at the time, and the staff were asked to choose authors, contact them and convince them to submit contributions to a work. The work would also be edited by the staff so it was ready for printing before the conference in Paris. It was entitled *Comprehending Radiation Risks*.

One of the lectures concerned radiation protection and ethics. The author, *Kristin Shrader-Frechette*, was a scientist and Professor at the University of South Florida in Tampa. She criticised both sides of the nuclear power debate and spoke spiritedly about 'environmental hypochondriacs' and 'industry cannibals'. But she explained to us which ethical rules we were actually following. It was the first time that we gained such an insight*.

The individual-related protection with the help of the limit values is an example of *deontological* ethics (from the Greek *de´on* = duty). The source-related protection is an example of *utilitarianism*. Ethics and morals are largely synonymous concepts but if you want to differentiate between them you say that ethics are the rules for your conduct and that morals are the way in which you act vis-à-vis the rules. Hitler had terrible ethics but possibly strong morals; he followed his rules.

The individual-related protection with the help of the limit values continues to be individual-orientated even though the limit values such as constraints are source-related; it is always a matter of deontological ethics. You see things from the individual's point of view even though the individual is a 'source-related individual'.

The source-related protection requires utilitarianism if you place the source rather than the individual at the centre. ICRP's justification must be assessed on the basis of the total injury and benefit to which the source or activity leads. ICRP's protection optimisation must also be based on the source and the benefit and the harm thereof.

This is the thing that is so difficult to get people to comprehend. I usually use a picture showing a nuclear power plant surrounded by a number of small humans who are partly green but who also each have a red patch. The green is their natural radiation dose and the small, red patch is the dose they also receive from the nuclear power plant.

For each individual you can compare the size of the red and the green. The comparison is relevant. Provided the red is small in the comparison, the individual's risk situation has not changed a great deal; he receives his main dose from natural sources of radiation. If the red becomes comparatively large, the deontology marches in and dangles a dose limit.

Let us now look at it from the source-related and utilitarianism point of view. In this instance we gather all the red and all the green in their respective piles where the red makes only a relatively small pile. It is a measure of the total injury that the plant, the source, causes. How are we to assess it?

We can do another comparison between the red and the green, but this time between the piles gathered up. The red one in the comparison is still negligible but it gives no new information. Since it is negligible for every individual, it must also be negligible in a collective sense. The comparison does not say anything new.

The relevant comparison should be made with the total net benefit provided by the activity once we have removed harmful effects other than those from radiation. It enables us to assess the defensibility. We can also find out how much of the red pile which we are advised to avoid, which optimises the

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* Kristin Shrader Frechette has since written about Ethical Problems in Radiation Protection (Shrader, 2001) along with Lars Persson.

protection. However, we have no reason to compare the total amount of red, i.e., the whole of the injury from the activity, with the total green, i.e., the unavoidable injury owing to natural radiation! We did the comparison for each individual already in the deontological examination of the individual protection.

The paradigm shift that ICRP sometime looked as though it wanted to introduce at the start of the noughties had involved sliding from source-related to individual-related protection. ICRP's success has been in its simultaneous application of both the deontological and the utilitarian ethics as a balanced mixture. However, the final result of ICRP's discussions was not a total paradigm shift - the balanced mixture has been retained with minor modifications.

28.7. **Travel report from Holland**

I quote from a travel report that I wrote in November 1994:

> On 30-31 October I was invited to the Health Council of the Netherlands (Gezondheidsraad) as an adviser. The Health Council is a government advisory body and consists of 175 experts appointed by the former. The Council has an available staff of 50, 20 of whom have scientific education and experience. The Chair of the Council is a Professor of Chemistry in Maastricht, *I. Ginjaar*. The Managing Director, *Dr. Wim Passchier*, is a physical chemist.
>
> The Minister for the Environment (the Ministry of the Environment is new and ambitious) has asked the Health Council to submit a report on the scientific aspects of the essential differences which the Council can identify between the radiation protection system described in ICRP 60 and the Dutch government's radiation protection policy. The latter is based on the general policy that the government has formulated for protection against health risks from instances of environmental contamination and accidents.
>
> [...]
>
> In order to be able to accommodate the government's request, the Health Council set up a task group of ten people with Ginjaar as Chair and Passchier as Secretary. The only foreigners in the group were me and American NCRP President Charlie Meinhold, although the latter was in China at the time of the meeting. The group met on 31 October at Moermond Castle outside Renesse on the coast of southern Holland, i.e., Zeeland, to discuss a fairly good draft report which Passchier had written after firstly having consulted the various group members; he was in Stockholm to interview me before the meeting.
>
> The group soon came to the conclusion that ICRP's reasoning was better scientifically supported than that of the Dutch government and that it was difficult to work on the basis of fixed limits for what was a not particularly well-defined annual mortality risk when you want to set dose limits. At any rate, you ought to talk about the risk that is *committed* per year rather than the one per year which is expressed. One of the members of the group, microbiologist *J. Blok*, thought that if a risk-based system were required out of necessity, it would be better to use an annual limit as a basis for the increase in the *relative* risk. The group members, i.e., the Dutch, were unusually judicious and knowledgeable and there were high-level discussions.
>
> Passchier will now travel to Washington DC (Bethesda) to discuss the revised report with Meinhold and the next version will then be sent to us in December, hopefully for final approval. The report will then be submitted to the Health Council for a go-ahead before it is sent to the Ministry of the Environment. It could be of interest to the Swedish Radiation Protection Institute as well.
>
> Chris Huyskens, who was part of the group, asked me to give his best to Jan Olof [Snihs] and ask for all possible help for him, as Secretary of IRPA, to be able to have contact with people in the Baltic States so that they can be represented at IRPA.
>
> The weather in Holland (Zeeland to be precise) consisted of rain, rain, rain and a 12 m/s wind. Passchier took me on a round trip among the fields towards the sea and the impressive system of sluice gates which, in normal weather, allow a free flow of water

into the bays and the estuaries but which, when there is storm, can be lowered to withstand the assault of the sea. Moermond Castle was a pretty small castle surrounded by a moat which you associate with a saga, with five towers and steep steps but had a good meeting room and good food. Our bedroom was in an annexe and was fairly cold, and outside the wind whistled in the trees whose leaves, in Zeeland, had not yet started to turn yellow. To get to said castle from Sweden you needed to take a flight, a train (approx. 150 km from Amsterdam), a bus and then walk for quarter of an hour in the pouring rain, which was an adventure in itself. The fact that you then found yourself below sea level added that extra something. Passchier pointed out that the authorities with the latest moat and sluice gate system consider the risk of flooding disasters to be zero. ‘As if there could be such a thing as zero risk in real life,’ he added with a sigh in the face of the technological optimism.

29. THE YEAR 1995

29.1. UNSCEAR's 44th session

UNSCEAR held its 44th session.

29.2. ICRP in Würzburg

ICRP and its Committees met in Würzburg on 3-11 September. It was now 100 years since Röntgen had made his epochal discovery, and this was obviously marked at the meeting. Since the dissolution of the Soviet Unions in 1991 'Russia' had become the Russian Federation with Boris Yeltsin as President. The upheavals in Russia made their mark on our Russian colleagues who became increasingly candid and talkative. The member of ICRP Main Commission, Professor Leonid Ilyin, who had previously had problems when the KGB prevented him from taking part the UNSCEAR meetings despite the government having appointed him as Soviet representative, was now happy and jovial and gave me his recently-published book enthusiastically.

Dan Beninson and I had dinner with Lars-Erik Holm who in a couple of months would be appointed head of the Swedish Radiation Protection Institute. Dan's curiosity was the reason for our dinner together.

29.3. Steam generator replacement at Ringhals 3

It took 90 days for the German-French Siemens-Framatomic consortium to replace the steam generators at Ringhals 3.

29.4. Extension of the Non-Proliferation Treaty

At a meeting in New York on 11 May 1995, those signing the NPT[*] decided to extend the agreement indefinitely. The dissolution of the Soviet Union and the NATO sharing agreement to place nuclear weapons in Member States created new interpretation problems. However, Southern Africa's voluntary abandonment of its nuclear power programme was a ray of hope, as was the same decision which was then made by Libya. The major problems that remained primarily concerned North Korea and Iran, while countries like India, Israel and Pakistan had developed nuclear weapons.

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[*] Non-Proliferation Treaty

30. THE YEAR 1996

After 1996, my possibilities of actively taking part in the international radiation protection work also lessened. My portrayal as the text continues is therefore more rhapsodic and is largely unable to give a fair idea of the activity at the Radiation Protection Institute. Most of my time was now taken up with my work with writing the history thereof. However, I did follow with interest and concern the development within ICRP and the international radiation protection debate in which I still took part.

30.1. ICRP in Bethesda

The ICRP MC met courtesy of the NCRP in Bethesda from 19-22 March.

30.2. UNSCEAR's 45th session

UNSCEAR's 45th session was held in Vienna from 17-21 June 1996. The meeting gathered participants from 20 nations (except for Sudan). The Chair was Luis Pinillos-Ashton from Peru with Alexander Kaul from Germany as Deputy Chair. The Swedish delegation consisted of Lars-Erik Holm as representative with Jan Olof Snihs as deputy and Jack Valentin as expert.

The following can be quoted from the report:

> One important success from a Swedish point of view was that the Committee decided to approve and publish the document on impacts of radiation on the environment, thereby finally opening the door to develop radiation protection from health to the environment. The work with other documents went well. The possibility of publishing these collectively as a report, 'UNSCEAR 2000', at the end of the millennium was discussed. Regarding technical issues, Swedish points of view were received sympathetically as usual and the Swedes taking part in the meeting were utilised for different assignments of responsibility. However, as regards time we were unfortunately less successful since the next year's UNSCEAR meeting was also established for the Midsummer week.

The following was written about the work:

> [The documents] had reached varying stages of development and it seemed unlikely that a traditional, comprehensive UNSCEAR report could be published in 1997 or 1998 which would have been the intention. One possibility would be to publish a few documents each year. The United Kingdom instead launched the idea of holding off with the next publication until the year 2000 and then in return be able to produce something extra good. The idea was well received. Reading between the lines there was a hint of some concern on the part of the Secretariat. Both the Scientific Secretary Burton Bennett and the Administrative Secretary Waltraud Holzer retire in 1998/99 and would themselves, for both practical and personal reasons, have chosen to have completed the pending report, something which may have required an unlikely exemption from the UN's retirement rules.
>
> Owing to the UN's resources being stretched, UNSCEAR, with its limited budget and three employees, has also been asked to make various savings. Completing a report with the two big employees retiring may be a temptation to close down the whole

> Committee, which would not benefit the protection of health and the environment against the harmful effect of radiation. UNSCEAR enjoys absolute confidence in various camps, which is its great strength.

30.3. **Earth radiation**

On 11 June 1996 I completed a 16-page report which should have been included in the Swedish Radiation Protection Institute's published report but was not; it is therefore difficult to get hold of. I quote the introduction:

> With some lack of caution I have promised to review the phenomenon of earth radiation which has once again been paid attention over the past six months in the daily press, magazines and on TV. The articles have particularly concerned alleged, mysterious grids which have an impact on people's health in the sense that staying too long above the grid's power lines is claimed to cause illness, primarily cancer. This has worried many, particularly because the articles had been presented as though they concerned well-established facts. The Radiation Protection Authority has thereby ended up in a situation in which questions sometimes have to be answered. It would therefore valuable if the 'earth radiation' could be investigated so that the Institute's representatives know what they are talking about.
>
> The instinctive reaction from each person who has been educated in natural science and who has a critical disposition is that the earth radiation is a myth and not worthy of any discussion. But actually, this is not exactly a scientific attitude. Before you reject something, you have to know what it is you are rejecting. A quick look through the literature shows that the issue runs deeper than you might think. The instinctive reaction may lead to ignominious consequences since those advocating the existence of earth radiations can easily show that the person with the instinctive reaction has not looked at the issue in enough detail.
>
> According to the representatives, the mysterious, health-hazardous grids, named after German doctors who maintain the danger thereof (incl. Manfred Curry and Ernst Hartmann) can be shown only using a divining rod or a similar instrument. For established science, this further suggests that it is more about belief than knowledge.
>
> ...
>
> There are at least three instruments to detect phenomena relevant to the issue of earth radiation, i.e.:
>
> (a) The divining rod
> (b) Angle pin ('the pointer')
> (c) The pendulum
>
> All three of these 'instruments' work on the basis that they notify you of almost unnoticeable movements of the wrist. All speculations regarding mysterious capacities of the actual instruments to be influenced by external 'forces' are superstition and the professional users also refer to them as superstition. The instruments therefore do not need to be made of any special material.
>
> ...

The divining rod [the Y-shaped rod] must be held with the tip outwards and with the palms of your hands facing upwards in a grip known as the 'reverse grip'. With this grip, the equilibrium becomes unstable and the divining rod begins to move at the slightest turn of the wrists. With the 'natural' grip, anyone who is not used to using it and who tries to stop the movement will instead that increase it, giving the impression that an external force is turning the Y-shaped rod.

The angle pin is an L-shaped metal wire which, with an appropriate grip, is an alternative to the divining rod. The pendulum consists of a weight at the end of a string and is generally speaking a popular tool for mystics.

The divining rod has been used for several centuries to search for valuable objects or ore deposits in the ground but also to search for water veins. Established scientists (including myself) consider the use thereof to be superstition. Where its use has been successful, that success is explained by lucky guesses on the part of experienced users. However, there are highly-educated people who are convinced of the capacity of the 'divining rod'. The premier French radiation protectionist, Henri Jammet, was surprised that I had not thought about it, but I was not surprised at his conviction because I knew that he would not sit in his car until he had walked around it three times.

The mysticism which culminated in the 1990s had it that it was possible to observe and avoid the Curry and Hartman lines using a divining rod. However, despite promises of rewards in the millions, nobody has succeeded in convincing the sceptics.

30.4. **Lars-Erik Holm becomes head of the Radiation Protection Institute**

The new head of the Radiation Protection Institute was Lars-Erik Holm, the young radiologist whom I had convinced to join in with ICRP work. Many of us had hoped that Jack Valentin would get the job but that was not to be, although I do not know why. Lars-Erik was still welcome; he was a friendly and knowledgeable man and we were spared from a politician. Jack had to settle for being Secretary of ICRP, an important and responsible task which he performed with vigour and with contributions which brought him world-wide renown. He was a worthy successor to David Sowby and Hylton Smith, but he took on a heavy workload - ICRP became more important over the years.

But it was surprising that Jack did not get the job of head of the Radiation Protection Institute. Perhaps it was an instinctive reaction to our expectations. Perhaps we were too strongly in favour when we proposed Jack. On 15 September 1995, Sören Mattsson (as Chair of the Royal Swedish Academy of Sciences' National Committee for Radiation Protection Research) and I jointly wrote to the Ministry of the Environment and Nature Conservation. I quote:

> In the next few years, the Radiation Protection Institute will face a number of issues which will place great demands on the competence and capacity of the person in charge to explain the course of events, policy and decision. An all-round insight into all lines of activity is important for the purpose of coordinating and prioritising different sections of the activity.
>
> Valentin has unique qualifications. With his biological fundamental education in genetics and a very good ability to give a balanced and comprehensible idea of the radiation risks, he has just the background and abilities needed for contact with the public and the media. From what we have seen he has good relations with all major interest groups (medical radiologists, the nuclear power industry, the environmental movements and the media) and his judgement is generally respected.
>
> Valentin also has broad experience of and knowledge within the Institute's most essential activities. His scientific background means he can easily acquaint himself with the research matters in which the Institute is involved. He has been in charge of the general supervision and has for the UN's Scientific Committee (UNSCEAR) written an Appendix on radiation doses from the medical use of radiation. Leading radiologists have expressed firm wishes to have Valentin as head of the Swedish Radiation Protection Institute. However, Valentin's substantial contribution within the Radiation Protection Institute concerns his position as head of the units that deal with nuclear power's radiation protection problems (personnel protection, the limitation of emissions and discharges, waste issues and preparedness in the face of reactor accidents). In the event of a reactor accident, the head of the Radiation Protection Institute is expected to lead the advice and will, like Gunnar Bengtsson following the Chernobyl accident, face great demands for comprehensible information for County Administrative Boards and politicians as well as the public.
>
> Valentin also has broad experience of international cooperation within the EU and UNSCEAR and the International Radiation Protection Commission (ICRP) where he is on the Committee which makes recommendations for the application of ICRP recommendations. He has encountered respect and appreciation in all of these contexts.
>
> In our opinion, Valentin is such an obvious choice for the job that people would be shocked and stunned if he did not succeed Gunnar Bengtsson.

No decision had yet been made on 30 November that same year (1995). I then wrote (possibly an unwise move) a letter to the Minister for the Environment, Anna Lindh. I referred to the letter that Sören Mattsson and I had written nine weeks previously. At the end of the letter I wrote:

> It is of course to your credit that the details of the job and the demands that the person in that position would face are being thoroughly reviewed, but the very long time that this has taken has caused a stir and led to questions as to whether people are trying to pass over Valentin for some reason.

On the same day I wrote an angry letter which I had intended to send to the Prime Minister's office. I wrote:

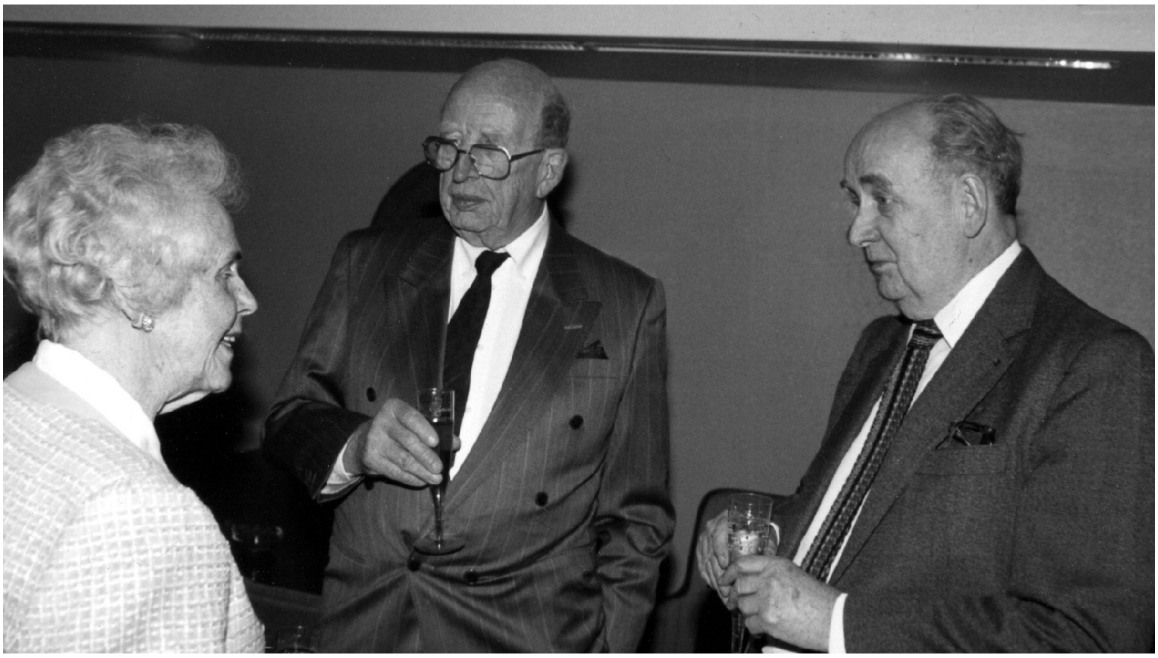
> I find it difficult to understand why it has taken 18 (!) weeks to deal with filling the supervisory position. The almost total silence of the Ministry of the Environment for this long period constitutes a casual attitude bordering on impertinence towards the Swedish Radiation Protection Institute's personnel and has caused irritation and a number of unfortunate rumours. Many are asking whether the Ministry definitely wants to pass over Valentin for some unknown reason and has therefore taken great pains to search for an alternative candidate with appropriate competence. I hope this is not the case, but why Valentin – which is the way it seems – is being avoided is a mystery as far as I and many others alongside me are concerned.

Writing the letter got it off my chest, but I never sent it. Not because I did not dare - I was a pensioner and beyond reach - but I realised that the letter could have made the situation even worse for Jack.

So, in the end, Lars-Erik Holm was appointed Director General of the Radiation Protection Institute in 1996. We received this news with mixed feelings. However, despite our disappointment, we found some comfort in still having a scientifically-qualified person as our boss. I wrote to Lars-Erik on 17 December 1995:

> Everyone at the Radiation Protection Institute is now looking forward with great expectation to cooperating with you. As you may well know, I and many others alongside me had expected Jack Valentin to get the job and, as far as I understand it, Gunnar Bengtsson has always said this as well due to Jack's broad, in-depth knowledge and experience of the whole of the radiation protection field. I understand that Jack must be deeply disappointed, but the Ministry has clearly not attached any great importance to these qualifications.
>
> I imagine that your being aware of this may cast a slight shadow over your pleasure and make your feel uneasy. If that is the case, you should know that no-one at the Radiation Protection Institute, including Jack and myself, feel any reason to let this impede you. You are absolutely not to blame, particularly since you contacted Jack and said that you had been asked right from the start. You will find that we are all very anxious to have good cooperation and are convinced that you will do a good job. We know you have good abilities, so you are not coming as a stranger but as a good friend with whom we are all looking forward to working. From your time on the Swedish Radiation Protection Institute's board you have no doubt felt the good atmosphere and familiarity which have prevailed since Sievert's days. You must also have noticed how respected the Radiation Protection Institute and its representatives are at home and abroad. Welcome to this circle.
>
> My own view [as a pensioner] on the Radiation Protection Institute – to be useful without interfering – is something that I would like to discuss with you early on. Old bosses are not always fun to come across – please be assured that I will not disturb you.

I had already poked my nose in through my letter to the Ministry as a self-appointed spokesperson for the personnel but, after having been in 'this circle' for almost fifty years I felt a certain responsibility for how the future could pan out.



From the 'old-folks get-together' at the Swedish Radiation Protection Institute, 1996.
Upper frame: Rolf Sievert's secretary, Torborg Hammarberg; Lars-Eric Larsson; and Bo Lindell.
Lower frame; Kerstin Lundmark and the skilled engineer Nils Hagberg. In the background: Torborg Hammarberg.

From the ‘old-folks get-together’ at the Swedish Radiation Protection Institute, 1996.
The newly employed Director General, Lars-Erik Holm, and the Institute’s Research Director, Kay Edvarson. In the background, the engineer Chris Wilson and Lars-Eric Larsson can be glimpsed.

30.5. **ICRP in Paris**

The ICRP Main Commission met in Paris from 4-8 November 1996 in a hotel near the Eiffel Tower.

30.6. **The IRPA Congress in Vienna**

In 1996, IRPA held its big Congress in Vienna. Unfortunately, as usual, I do not clearly remember the negotiations at the meeting. On the other hand, I do remember my meeting with Merril Eisenbud, who was around eighty and who was moved by his memory when he saw me. Eisenbud had been an important member of the American UNSCEAR delegation. He was a knowledgeable healthcare provider but had also been a tough debater when it came to defending his home country’s nuclear weapons testing. We had had many controversies over the years but when looking at me now, his memories made him nostalgic. As with so many ageing people, he felt lost among the youngsters and he clearly saw me, despite the fact that I was seven years younger, as a reassuring soulmate. ‘There aren’t many of us left who remember the way it was,’ he said, gripping my hand. I was struck by his moved state and, despite everything, felt some solidarity with him.

30.7. **Record year for Ringhals nuclear power station**

During the year, Ringhals produced 25.3 billion kilowatt hours (25.3 terawatt hours) with an availability of 90 per cent. The total electricity production in Sweden at the same time was 140 terawatt hours. All types of power sources were included.

31. THE YEAR 1997

31.1. ICRP in Albuquerque

The ICRP Main Commission met again at the Sheraton Old Town Hotel in Albuquerque from 21-23 May.

31.2. UNSCEAR's 46th session

UNSCEAR's 46th session was held in the Midsummer week which annoyed the Swedish delegates. At this meeting, Alexander Kaul was Chair and Lars-Erik Holm Deputy Chair. The rapporteur was Joyce Lipsztein from Brazil.

31.3. ICRP in Oxford

ICRP with Committees met in Oxford from 7-13 September 1997. Lars-Erik Holm was now a member of the Main Commission and deservedly appreciated. We ate meals together in the small, typically British hotel which Lars-Erik declared he liked so much.

31.4. New guidelines for the energy policy

The following is quoted from the joint brochure, 'Perspectives on Nuclear Power', from the Nuclear Power Inspectorate and the Radiation Protection Institute (2003):

> In 1997, the Centre Party, the Social Democrats and the Left Party agreed new guidelines for the energy policy. The decision was to remove 2010 as the final year for nuclear power, that no final date should be given for when all reactors should be phased out, and that nuclear power should instead be phased out at the rate that was possible with regard to the electricity supply and the possibility of using electricity produced by environmentally-friendly means. It was also decided that Barsebäck's two reactors should be closed down.
>
> In order for it to be possible for the State to close a nuclear power plant, Swedish Parliament adopted the *Law on the phasing out of nuclear power* that same year. The law gave the government the right to decide that the right to run a nuclear power reactor should cease at a time determined by the government.

The law was first applied in 1998 to one of the Barsebäck Nuclear Power Plant's two reactors.

31.5. The Swedish Academy's gold medal

The changes to the organisation of the Congresses of Radiology meant that the radiologists showed less interest in the Swedish Academy of Science's gold medal. It was therefore decided that the medal would be awarded at the IRPA Congresses in the future and the regulations were changed to facilitate this. The first medal to be awarded at an IRPA Congress was awarded to Angelina Guskova in the year 2000.

32. THE YEAR 1998

32.1. The closure of Barsebäck

Based on the Law of the phasing out of nuclear power, the Government decided that also Barsebäck 2 was to be closed, and that this would take place on 1 July 2001, provided that the loss of electricity production could be compensated through supply of renewable electric power and reduced use of electricity.

32.2. Provisions regarding solariums

During the year, the Radiation Protection Institute issued provisions on solariums (SSI FS 1998:2). These were made public in a couple of information sheets, 'About Solariums' and 'Regulations for those who run tanning salons', from spring 1999. The first leaflet contains a warning:

> The National Radiation Protection Institute advises against tanning in a solarium. People with light and sensitive skin such as children and young people under the age of 18 should avoid using solariums altogether. Nor should you get a tan if you have a lot of brown moles. Using a solarium more than ten times a year is considered to increase the risk of skin cancer.

32.3. ICRP in Southern Africa

The ICRP Main Commission met in Cape Town from 27-30 April. This was the first time that I was not welcomed, but I did not put this down to the Chair being unwilling to welcome Emeritus members. Instead, I saw it as a natural outcome of the substantial expense that it was unreasonable for either the Radiation Protection Institute or ICRP to pay and which I could not afford myself. Abel González was concerned about personal safety in Southern Africa, but I comforted him by referring to my visit six years previously. I had not felt any danger.

32.4. UNSCEAR's 47th session

UNSCEAR held its 47th session in Vienna from 25-29 May. Alexander Kaul was Chair with Lars-Erik Holm as Deputy Chair and *Joyce Lipsztein* (Brazil) as rapporteur. The Swedish delegation consisted of Lars-Erik Holm with Ulf Bäverstam as deputy and Leif Moberg and Wolfram Leitz as advisers.

The Committee discussed eleven documents that would constitute the basis for the report in the year 2000. The reports were:

> *Exposures from man-made sources of radiation*. Leif Moberg had spent a year working as a consultant for the report. The delegation thought far too much importance was being attached to the fallout from nuclear weapons testing in relation to instances of contamination from nuclear reactors.
> *Medical radiation exposures*. Wolfram Leitz helped to complete this report.
> *Occupational radiation exposures*.
> *Dose assessment methodologies*.

Epidemiological evaluation of radiation-induced cancer. So far, risk assessments had been made for individual organs but the consultants were also to relate the risk assessment to the effective dose ready for the next session.

DNA repair and mutagenesis.

Hereditary effects of radiation. Risk assessments were still lacking but were expected to be included in the next version. People reckoned that the estimated value of the risk would be lower than before.

Combined effects of radiation and other agents.

Radiation effects and risk assessment at low exposure levels (the final report was called *Biological effects at low radiation doses*).

Exposures and effects of the Chernobyl accident. The previous consultant had been replaced by two Scandinavians, Swede Per Hall and Dane Hans Storm to develop the section on epidemiology and clinical studies.

32.5. **ICRP in Stockholm**

The ICRP Main Commission met at the Radiation Protection Institute in Stockholm from 11-14 October. Unlike previously, I had not been invited to the Commission's preceding meeting. I had not thought it strange - I would have had difficulty paying for the trip to Cape Town anyway. However, it now turned out that, unlike his predecessors, the new Chair, Roger Clarke, did not see Emeritus members as an asset. Roger, who had always been an outspoken person, likened them to 'vultures' and made it clear that they would not be invited in the future. There were two of us in Stockholm, John Dunster and I. There were special reasons for inviting us to this particular meeting* and it would probably have been difficult to refuse to allow me to participate in meetings in Stockholm. However, Roger was not backward about coming forward with his gibes, and when we had something to say in the discussions, his invitation for us to join in was 'So let's now listen to John and Bo rambling on!' I would not have taken offence had it been in a discussion among ourselves, but I wondered what members from Japan and China thought of it all. But then maybe rambling was not part of their vocabulary.

On 13 October, the Commission would invite everyone to dinner at Hasselbacken and I had been asked to give a dinner speech about the history of ICRP. However, before dinner we were to visit the Wasa Museum. I invited Roger for a cup of coffee in the vicinity of his hotel in the Old Town. He had already previously put forward the theory which led to us having differences of opinion for several years afterwards. He thought that if every individual who had been irradiated was so well protected that the personal risk was negligible, the irradiation situation was also completely acceptable. But Dan Beninson and I thought the collective radiation dose could still require protection measures if it was large enough to probably lead to stochastic injury. Roger either could not or did not want to comprehend that collective risks can lead to a need for protection even if the personal risks are acceptable. We see the same circumstances within many areas. As individuals we accept the traffic risks but not the fact that many die on the roads. Dan and I understood that what we accept depends on many factors as well as the personal likelihood of being injured, but we could not let go of the idea of some responsibility for what, irrespective of how small the risks is, can still occur at collective level.

I discussed this with Roger over a cup of tea but failed to convince him otherwise. Could I be wrong myself? I did not think so and therefore continued our discussion while we were walking from the Old Town to the Wasa Museum.

At Hasselbacken I talked about the history using a number of slides. Jack Valentin's wife *Cecilia Torudd*, the well-known draughtswoman, was in a group of musicians who entertained us. Everything went without a hitch. This was the last time I saw my best friend, Dan Beninson.

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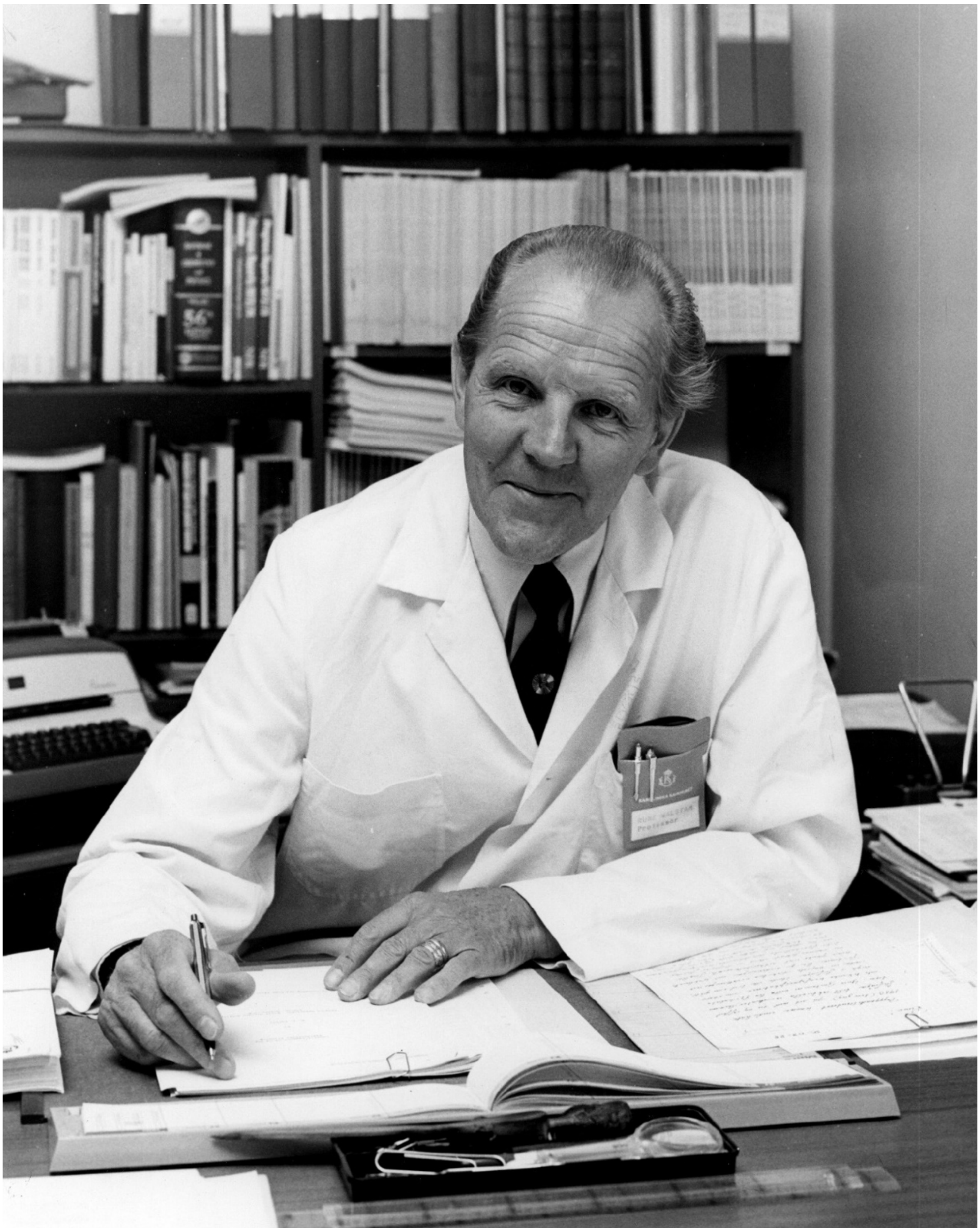
* John and I were in the process of writing an information leaflet about ICRP which was published in 1999. It summarised ICRP's policy at the time. A table showing the membership from 1928 until 2001 is particularly interesting. The leaflet had no edition number but it did have the usual blue cover and was entitled *International Commission on Radiological Protection: History, Policies, Procedures*.

32.6. **Axel Berggren passes away**

Over the years, the inventive Rolf Sievert employed a number of skilled engineers who realised his ideas. The first was Paul Haglund (1904-1983), Sievert's first colleague. The second was Axel Berggren (1901-1998). Another two were particularly important: Bengt Håkansson (1925-) and Rune Walstam (1923-2002). The latter was unique in that his continuous training and gaining of qualifications meant that he inherited Sievert's Professorship.

Axel Berggren was my first colleague at Sieverts Institute in the work with the high voltage hall. For me, he was a mixture between a father figure and an older brother. He was in charge of the Institute of Radiophysics' workshop and was active there well into old age. He died in 1998 and I missed him.



Professor Rune Walstam, Rolf Sievert's successor as Professor of Radiation Physics, at his desk at the Department of Medical Radiation Physics

33. 1999 ONWARDS

33.1. ICRP in St. Petersburg

The ICRP Main Commission met in St. Petersburg to discuss new recommendations. This was the first time that the Chair decided not to include the Emeritus members.

Dan Beninson was now on the way to his 70th birthday (2001). Despite his diabetes, narcolepsy, lack of caution where diet was concerned and previous cigar smoking, he would be older than Sievert and died on 21 August 2003. I would not be seeing any more of him. He had planned a visit to Stockholm in connection with a trip to Vienna at the start of 2003, but rang me and said that he could not come. All I could say was that I understood. Either he was not capable or he did not want me to see him in the state he was in either. Later, Waltraud Holzer said that he and others had visited her in Vienna but that she would never forget how wretched he looked when she opened the door to him.

I lost my best friend and the world lost its leading radiation protectionist. His role as leading creator of ideas in Argentina had been taken over by Abel González.

33.2. UNSCEAR's 48th session

UNSCEAR held its 48th session in Vienna from 12-16 April 1999. All delegations took part except for that of Mexico. Lars-Erik Holm was Chair of the Committee with Joyce Lipsztein (Brazil) as Deputy Chair and *Yasuhito Sasaki* (Japan) as rapporteur. The Swedish delegation consisted of Lars-Erik Holm as representative with Ulf Bäverstam as deputy and Leif Moberg and Wolfram Leitz as adviser. I quote the following from Holm's report (which was still submitted to the Ministry of the Environment):

> This year's UNSCEAR session was the 48th in a row and it was the 44th year since the Committee had been set up. Last year the General Assembly reviewed the Committee's role and future. Both IAEA and WHO were asked their opinion on this. The basis for this was the consideration of whether or not advice to the General Assembly on such a high-level technical subject as radiation should come from the special UN organisations that deal with issues concerning health and nuclear energy. UNSCEAR's unique role regarding the assessment of radiation sources and radiation effects in a global context, along with the benefit of obtaining its independent, objective points of view, was a weighty argument when the General Assembly decided to retain UNSCEAR's status as it had been so far. So, the General Assembly's resolution A/RES/53/44 has renewed the Committee's mandate to continue its work. A copy thereof had been distributed to all representatives.
>
> Many parts of the world are concerned about the risks of ionising radiation. There is generally concern with regard to risks with activities using ionising radiation and a lack of knowledge regarding the risks of natural radiation. The Committee therefore faces expectations to report both actual and perceived dangers and to do so objectively and reliably in order to be able to contribute towards a greater understanding of ionising radiation and consequences of exposure to such radiation.
>
> This year's meeting discussed twelve scientific documents, all of which represent the Committee's current work. This was the penultimate gathering before the publication of the UNSCEAR report for the year 2000. As usual, this will be published as a book of around 1000 pages with an executive summary aimed directly at the

General Assembly, and the rest are the scientific Appendices that form the basis for and which constitute the goldmine of information for which UNSCEAR has been so internationally esteemed. ...

As I have already mentioned in last year's travel report, Burton Bennett will cease to be Scientific Secretary on 31 July 1999 when he retires. The Administrative Secretary Waltraud Holzer is retiring as early as May 1999, but will return to work when the report for the year 2000 is being completed. The Committee has previously expressed a desire for the Scientific Secretary's job to be extended until the year 2000 to facilitate the completion of the work. I therefore wrote to the head of UNEP in November 1998 in my capacity as Chair requesting that his employment be extended. I have still not received any reaction from UNEP, and nor does any work seem to have started there to prepare adverts for the post of Scientific Secretary. At the previous week's meeting, at the request of the Committee I also wrote to Deputy Secretary General Connor in New York and reported the problem, hoping that the process could be accelerated. I have also been in contact with the Ministry of Foreign Affairs (Richard Ekwall/GS) because Sweden is also responsible for preparing the UNSCEAR matters for the Fourth Committee in New York.

I asked Lars-Erik Holm how come the Swedish UNSCEAR delegation no longer reported directly to the Ministry for Foreign Affairs as it had done in Sievert's and my time. The led to our computers exchanging letters:

[Holm:] As I recall, Gunnar Bengtsson began reporting to the Ministry of the Environment, which also reported the Swedish participation to UNSCEAR. I continued in the same way. On the other hand, I contacted the Ministry for Foreign Affairs in Stockholm and New York on my own initiative at the end of the 1990s in the face of the year 2000 report. I presented the report to the UN's Fourth Committee in October 2000 and it really irritated The Ukraine and Belarus who did not accept the conclusions about Chernobyl at the time. They now support the conclusions as UNSCEAR has started cooperation with their scientists for the production of the next report. This has also meant that they now have a different understanding of the way in which the Committee works. I am now in regular contact with the Ministry for Foreign Affairs and always send a copy to *Elisabeth Hellström* and, for the past two years, to the representatives in Vienna as well. ...

[Lindell:] Thank you for your answer! What has worried me regarding UNSCEAR is the slide in the understanding of the Committee's primary task which started when Gunnar began to consider it to be a Scientific Committee which could equally well have come under UNEP or WHO. He seemed to think it was natural for the Radiation Protection Institute to be involved as a regular work assignment whereas I saw the Swedish UNSCEAR delegation as a separate institution under the Ministry for Foreign Affairs. From the General Assembly's point of view, the value of UNSCEAR lies in its existence rather than its ongoing work, which must instead really be seen as maintaining competence. If something big happens such as the use of a nuclear weapon or global reactor accidents, UNSCEAR is a treasure trove to the General Assembly; an equivalent committee could not be set up on an *ad hoc* basis. It is almost an extra bonus that the General Assembly can also see the usual scientific reports, but these are not exactly an adequate reason for the Committee to exist. That is why my eyes are opened wide when I see the delegation reporting to the Ministry of the Environment rather than the Ministry for Foreign Affairs. Do you agree?

[Holm:] Absolutely - I completely agree with you! I also think it is a good thing that the General Assembly receives a report directly from the Committee each year. A condition for UNSCEAR's reports to be able to continue is to retain its independent status and not just be any old scientific committee. When it comes to assessing the effects of Chernobyl, the role of the Committee also points to its key role in communicating information with high a high level of credibility. This was also something which Kofi Annan pointed out at the time of the 50th anniversary. ...

33.3. **John R. Horan dead**

On 16 April 1999, John Horan died of a malignant brain tumour. John was born in Chicago in 1923 and had a BSc in physics and underwent one of the first lots of formal training in radiation protection under the auspices of the Atomic Energy Commission (1950-1952). He spent most of his professional life as a radiation protectionist in Idaho, firstly at the reprocessing plant in 1952 followed by the Navy' reactor station from 19531957 and finally as head of the Atomic Energy Commission's radiation protection programme at the National Reactor Testing Station. The AEC loaned him to IAEA in Vienna for a while where he was responsible for the radiation protection unit.

I first met John Horan in 1956 when I visited the reactor station in Idaho and, like my fellow countrymen, was slightly embarrassed about his name (pronounced 'Hor-an' in Swedish, which means 'the whore') but impressed by his level of knowledge and enthusiasm when he showed me around. My subsequent contact with him was at IAEA and IRPA where he, like me, was a member of the board for a while. By then he had grown in both size and presence. He was almost religious when it came to integrity and sticking to his principles, and you felt you were acquainting yourself with the holy when facing his tall, domineering (yet friendly) figure. His eagerness in searching for an active monastery during a trip around Hungary came as no surprise.

John was Chair of the Health Physics Society from 1966-1967 and Secretary of IRPA from 1970-1976.

33.4. **Karl Z. Morgan passes away at the age of 91**

Karl Ziegler Morgan ('KZ') died on 8 June 1999, apparently from a ruptured aneurysm. Morgan is best known for having created the International Radiation Protection Association (IRPA) and for having spent twenty years as Chair of ICRP Committee II (later called '2'). As the head of radiation protection at Oak Ridge National Laboratory, he and his colleagues have produced the extensive tables of MPC (Maximum Permissible Concentration) values for radioactive substances.

Karl Morgan was born in Kannapolis in North Carolina and spoke a southern dialect which we Europeans initially had difficulty understanding. He was an early member of the Manhattan Project* and was finally placed at Oak Ridge. Before devoting himself to radiation protection he spent time in North Carolina running research into cosmic radiation. During his time at Oak Ridge he was met with respect and wonder, the latter because of his integrity and stubbornness. 'It will take an act of God to change Morgan's mind,' was the regular sigh from Failla. From 1972 until 1982, Karl Morgan was Professor of nuclear technology at the Georgia Institute of Technology. He was no nuclear power opponent but became a bitter enemy of the Federal authorities. At the end of his life he was engaged as an expert for the prosecution in a number of court cases. KZ was a great friend of Rolf Sievert whom he often highlighted as a role model. His skirmishes with Lauriston Taylor in various courts were followed with astonishment and melancholy by radiation protection colleagues.

33.5. **BEIR VI**

In 1999, the American Academy of Sciences' BEIR Committee published its sixth report, BEIR VI, the subject of which was now *The Health Effects of Exposure to Indoor Radon*. The following can be quoted from the press release:

> This report from the National Academy of Sciences (NAS) is the most definitive accumulation of scientific data on indoor radon. The report confirms that radon is the second leading cause of lung cancer in the U.S. and that it is a serious public health

* See 'The Sword of Damocles'.

problem. The study fully supports EPA estimates that radon causes about 15,000 lung cancer deaths per year.

An additional BEIR report, BEIR VII, was published in 2006. It was an update of BEIR V from 1990 and gave risk data not just for mortality but also for morbidity where cancer from low doses of radiation was concerned. The following can be quoted from a press release (from the Institute for Energy and Environmental Research - the IEER):

> Contrary to the beliefs of many in the nuclear industry, the BEIR VII report reaffirmed the conclusion of the prior report that every exposure to radiation produces a corresponding increase in cancer risk. The proportionality of risk means that at low exposures the risks are small, as the NAS report points out. The average risks to the population are estimated to be 10 to 15 percent higher than the reference value now used for radiation protection of the general population (565 cancer fatalities per million rem exposure in BEIR VII compared to 500 typically cited in the literature on radiation protection). While this average risk is in the general range of uncertainties and values reported previously, it indicates an increase of risk overall.

33.6. **Gunnar Walinder's criticism**

Gunnar Walinder, who is undeniably a prominent radiobiologist and cancer scientist, had for a long time and in many contexts criticised ICRP's adoption of a linear, non-threshold dose-response relationship ('LNT'). He summarised his criticism in an article in *Strålskyddsnytt* (Radiation Protection News) (Walinder, 2000). The criticism was also aimed at Sievert and me. He wrote:

> In the 1950s there was a very animated debate at the Institute of Radiophysics at *Karolinska Sjukhuset* in Stockholm about how radiation risks should be calculated. Owing to my youth and associated defects I behaved more like an attentive listener than someone who was taking part in the discussions. Rolf Sievert and Bo Lindell were convinced of the following two axioms:
>
> 1. Radiogenetic cancer and genetics were the factors that determined the MPD (Maximum Permissible Dose).
> 2. The incidence of cancer was randomly related to the radiation dose, i.e., the risk was stochastic. There was therefore no need for detailed biological knowledge when calculating the radiological risk – it could be seen as a purely statistical problem.
>
> Both Sievert and Lindell realised that it was not possible to assess the risk for an individual. The sensitivity to radiogenic cancer varied too greatly for this to be possible. ... However, the stochastic nature of cancer made it possible to talk about a risk to the population, i.e., a collective risk. Bo Lindell therefore introduced the concept of collective dose as a basis for the risk assessments.
>
> This has to be the main reason why he reacted so strongly to Professor Roger Clarke's familiar Controllable Dose proposal. ... Based on the given condition that radiogenic cancer is a stochastic phenomenon, I agree with Lindell and I would therefore call Roger Clarke's proposal half-baked.

However, Gunnar Walinder did not believe in the condition. He continued:

> However, as far as I am concerned, it is extreme to maintain that the risk of radiogenic cancer does not require knowledge of what cancer is and of the conditions for the occurrence thereof. This approach is probably what has led to failure to follow the development within tumour research and thereby failure to realise that our current knowledge of the way in which cancer can arise completely precludes the idea that its occurrence and development can be stochastic, i.e., independent of other, often unforeseeable factors.
>
> Gunnar Walinder also wrote:

> Anyway, the Sievert-Lindell ideas made a rapid breakthrough internationally, which was probably because they tallied with the general and very simple perception at the time of the way in which cancer occurs. People were convinced that specific individual genetic injuries could transform a cell into a malignant phenotype overnight.

Gunnar was probably slightly unfair. Many prominent biologists and cancer scientists have played a part in the conclusions drawn by ICRP and UNSCEAR regarding a reasonable dose-response relationship. It is not as though the results of tumour research have remained unknown to them. But Gunnar is confusing a random initiating event and the complicated course of events and unforeseeable impacts which then occur following the initiating event. These events, which make it impossible to predict the outcome of an individual case, influence how great the risk of cancer is but do not need to mean that the likelihood of radiogenic cancer ceases to be proportional to the incidence of the original genetic injury.

Gunnar Walinder is of course right when he says that you could make yourself look ridiculous 'in believing that this makes it possible to reduce the dose-response relationship for all these forms of cancer to a common straight line (a first degree equation) which is valid for all populations without regard to their different living conditions'. However, ICRP is not suggesting this. Instead, it has given a *nominal* dose-response relationship which is intended only for radiation protection technical measures, just like we have clear-cut speed limits for motor vehicles without thinking that this involves the same risk for all motorists. In Publication 60, ICRP has a long report on the way in which the risk factors for different organs vary from country to country, between the genders and with age and advises against using the nominal connections for actual risk assessments.

Gunnar wrote also:

> More recently, modern tumour research has shown that many genetic injuries were required in different places in the genes for it to be possible for a cell to be transformed into a malignant phenotype. It is easy to show that a low radiation dose could not cause all these genetic changes on its own, so the malignant cell transformation could no longer be seen as a stochastic consequence of the radiation since this consequence was also dependent on a number of other genetic changes having occurred or which were definitely going to occur.

But it certainly could. If radiation were the sole cause of genetic injuries and a number of such genetic injuries were required to initiate cancer, the dose-response relationship, as Gunnar wrote, would not be linear. If on the other hand there are causes other than radiation which are also competing for genetic injuries, the dose-response relationship for malignant cell transformations becomes linear at low radiation doses. I showed that this was the case in a simple but not unreasonable model in an article in 'SSI News' in 1996 (Lindell, 1996b).

One important reason for Gunnar's objections was his concern regarding the imbalance between radiation protection and protection against toxic substances if only the radiation protection is based on an LNT assumption. The concern was justified but now feels less warranted. Since the international meeting of scientists at *Karolinska Institutet* in March 1977, many biologists have also accepted the LNT relationship for injuries from genotoxic substances and, contrary to what many radiation protectionists envisage, the authorities' protection ambitions are now greater for a number of chemicals than for ionising radiation.

Gunnar published his objections in the year 2000 in a book entitled *Has Radiation Protection become a Health Hazard?* (Medical Physics Publishing, Madison, Wisconsin).

33.7. **Controllable Dose**

In April 1999, Roger Clarke gave the first description of his proposal for a change to ICRP's radiation protection policy in a Guest Editorial in the American Health Physics Society's *Newsletter*. He wrote that the proposal, called Controllable Dose, was his own but that the ICRP Main Commission had asked him to invite people to comment for subsequent discussions at the Commission. This took place through IRPA referring the proposal to its member associations. A more detailed version would be published in the June edition of the *Journal of Radiological Protection*.

In my view it was unfortunate that Roger's proposal was so widely disseminated before having been seriously discussed by ICRP. It would not have mattered so much had it concerned technical details, but it now clearly concerned rejecting ICRP's former philosophy and the recipients could have difficulty seeing the difference between Roger's personal views and his statements as Chair and spokesperson for ICRP.

The editor of the HPS' *Newsletter* had asked for comments from two people. One of those was the Canadian Richard Osborne, who was Chair of an ICRP Committee 4 task group for advice for the Committee and then the Commission regarding the proposal. The second was the Chair of the Health Physics Society, *Keith Dinger*.

Osborne showed some concern regarding changes that were too drastic and wrote:

> I believe that source-related assessments will still be needed for both general and professional irradiation. It could no doubt be a good thing to improve and explain the recommended radiation protection system so that the application of the dose limit for the public is not misunderstood and that individuals among the public better comprehend how insignificant very small changes to their total exposure are.

Dinger was more positive, writing:

> I am very encouraged by the underlying principle in this proposal. In his contribution, Professor Clarke says that the principle is: 'If the risk of health injury to the most irradiated individual is insignificant, the overall risk is insignificant – irrespective of how many people are irradiated'.* It means that the proposal eliminates the unreasonable burden of regulations resulting from using collective doses consisting of 'microdoses to megapopulations'. I believe it would be a considerable step towards fundamental regulations for radiation protection allowing reasonable provisions. Collective dose calculations which include trivial doses to large populations and resulting in health effect predictions constitutes the misuse of extrapolated radiation risk assessments since they do not include the uncertainty of the assessment. As I understand Professor Clarke's proposal, this abuse would be eliminated and I think it is encouraging.

Roger Clarke's proposal was thus supported by the American opinion that was prevalent within the Health Physics Society where they did not believe there were risks from small radiation doses.

33.8. **Harold H. Wyckoff passes away at the age of 89**

Harold Wyckoff died of a heart attack on 6 May 1999. Harold's size, white hair and friendly face had made him a conspicuous person, and I cooperated with him on a long-term basis within ICRP, ICRU and UNSCEAR. He was born in 1910 in Traverse City, Michigan, but his higher education was at the University of Washington in Seattle (B.S. 1934 and Ph.D. 1940). After his doctorate he moved to Washington D.C. and was taken on by the National Bureau of Standards in 1941.

Two years later, Wyckoff was 'loaned' to the American Army's 9th Bomb Squadron to serve in its operation analysis division. Lauriston Taylor was already there as Colonel and Deputy Commander. There were prominent scientists and engineers who analysed operational problems and gave advice to the Flying Squadron Generals. Following the invasion of France the group was required to work near

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* See the section called 'The Ethics of Radiation Protection' (1994).

the front line. In 1945, President Truman presented the ‘Bronze Star’ to Wyckoff, the highest military distinction that could be presented to civilians.

Following his return to the NBS Harold Wyckoff was firstly head of the agency’s x ray standards section and then head of the NBS Laboratory for Radiation Physics and deputy manager of the Department for Radiation Physics (Lauriston Taylor was the head). After retiring from the NBS in 1966 he was Scientific Director of the US Armed Forces’ Research Institute for Radiobiology until 1971. He then worked as a consultant, firstly for the Bureau of Radiological Health and then for himself after 1974 while also continuing his international assignments.

Harold was a member of the ICRU and was Secretary thereof from 1956-1969. He then became the Chair of the Commission from 1969-1985. From 1972 he was part of the American delegation to UNSCEAR. He lived the last ten years of his life as a recluse and no longer had the energy to meet his many friends. Lauriston Taylor ended his obituary for Harold with what he no doubt saw as particularly appreciative: Among his many other talents, along with his doctorate, he was a crackerjack good engineer.

33.9. **Closure of Barsebäck 1**

Continuing the quote from the Ringhals website (see previous chapter):

> The Supreme Administrative Court’s verdict was publicised on 16 June. The verdict means that the government’s decision to close a reactor shall stand. Closing Barsebäck does not contravene the Swedish Constitution. *Sydkraft’s* inhibition application in the competition case on 5 November. On the same day, *Sydkraft* appeals against the decision at the Court of Appeal. Barsebäck 1 is closed on 20 November 1999. In order to retain its competence, Barsebäck’s employees are given an employment guarantee. As a consequence of the arrangement between the government, *Sydkraft* and *Vattenfall*, Barsebäck is made a subsidiary of Ringhals AB on 1 August 2000; through the agreement, *Vattenfall* will own 74.2 per cent of Ringhals and *Sydkraft* 25.8 per cent. Ringhals and Barsebäck jointly form the Ringhals Group and the cooperation starts to develop.

Barsebäck 2 continued supplying electricity. According to the deal made by the Social Democrats, the Centre and the Left Party in 1997, Barsebäck 2 would wound down before 1 July 2001 but the preconditions (production of renewable energy and savings) were not satisfied. The power plant therefore continued to run without any new phase-out decision having been taken until 2004. Then, the Social Democrats, the Centre and the Left Party agreed that Barsebäck 2 should be closed in 2005. Therefore, on 16 December 2004, the government decided that it would be closed on 31 May 2005 and that is indeed what happened at midnight of that day.

33.10. **Stakeholder**

In gambling or betting, a stakeholder is a person with whom monies are deposited until the outcome is clear. At the start of the noughties, lack of enlightenment led the word to be used as a synonym for ‘interested person’, i.e., someone holding a stake in the significant interest in something. To start with, many of us older people did not want to know about the use because the word already had another meaning, but we were forced to accept that the use of language changes with the times. The first time I searched ‘stakeholder’ using Google I got 17,400,000 hits, so the new meaning is now established. So, ‘stakeholder involvement’ is used when you want people other than experts and decision-makers to influence radiation protection decisions.

33.11. **Skin cancer from the sun and solariums**

In 1999, Swedish Parliament made decisions on 15 national ‘environmental goals’, of which the Radiation Protection Institute was made responsible for ‘Safe Radiation Environment’. This included a sub-goal regarding sun and UV radiation which read: ‘By 2020, the number of cases of skin cancer per year caused by the sun must not exceed the number in the year 2000’. This led to support for the Radiation Protection Institute’ perception that it is what the population does in the sun that constitutes the most serious threat from non-ionising radiation.

33.12. **Electromagnetic fields**

One general concern regarding electric and magnetic fields was documented in the mass media at the end of the 1990s and continued into the next millennium. This book does not actually cover the noughties, but I am making an exception for these problems. I have found a few publications from 2000-2003 to which I think may be worthwhile referring in order to conclude the non-ionising radiation discussion.

In the year 2000, five authorities (the Swedish Board of Occupational Safety and Health, the National Board of Housing, Building and Planning, the Swedish National Electrical Safety Board, the Swedish National Board of Health and Welfare and the Radiation Protection Institute) published a reader-friendly 17-page pamphlet entitled ‘Magnetic Fields and Possible Health Risks’. In response to the question ‘Are there any limit values for magnetic fields?’, the pamphlet says:

> No, Sweden currently has no limit values for static or power-frequent magnetic fields either in the work environment or for the public. However, both the Swedish Board of Occupational Safety and Health and the Radiation Protection Institute are preparing provisions and general advice for such limit values. In other countries such as Germany, authorities have allocated maximum permissible levels for the fields. The EU Commission has also adopted recommendations regarding the limitation of the population’s exposure to electric and magnetic fields.
>
> All of these provisions tally with guidelines issued by the independent International Radiation Protection Commission (ICNIRP) in 1998. Following a thorough review of all scientific literature in the field, the ICNIRP has decided on a system of limit values based on known, acute health problems from fluctuating magnetic fields.
>
> The flows that can be created in the body by such fields must not exceed 2 mA/m^2 (milliamperes per metre squared). This maintains a safe distance to the values where nerves can be stimulated and muscle cramps can occur. Translation of this current value into 50 Hz magnetic fields results in a limit value of 100 µT for exposure of the public.[*] With regard to any long-term injuries, such as a greater risk of cancer, the ICNIRP does not think that available data is adequate for establishing the limit values, although epidemiological studies have given some indications of possible connections between longer-term exposure to weak fields and cancer. ...
>
> The suspicions of connections between magnetic fields and cancer mean that we in Sweden recommend practising some caution. The following should therefore be observed when planning and building communities if possible with regard to reasonable expenses.
>
> ♦Endeavour to design or lay new power lines and electric plants so that exposure to magnetic fields is limited.
>
> ♦Avoid locating new homes, schools and kindergartens, etc. close to existing plants which generate high magnetic fields if there are alternative locations.
>
> ♦Endeavour to limit fields which deviate strongly from that which can be considered normal in existing homes, schools and workplaces.

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[*] Remember that the Earth’s magnetic field is approx. 50 µT but is constant rather than fluctuating.

The Radiation Protection Institute later (6 December 2002) published the ICNIRP's (and thereby the EU's) recommendations on the 'limitation of the public's exposure to electromagnetic fields', (SSI FS 2002:3).

33.13. **Mobile telephony and radiation**

In 2001, the National Institute for Working Life compiled a five-page information leaflet on 'Mobile telephony and radiation' with *Kjell Hansson Mild* as the contact person. The leaflet answers 24 questions, including the following examples:

> What sort of radiation does a mobile telephone emit?
>
> ... a mobile telephone emits microwaves, i.e., electromagnetic waves with frequencies between 450 [and] 2450 MHz, e.g., a GSM 900 telephone emits microwaves of 900 MHz, i.e., 900 million fluctuations per second. The electromagnetic wave has a wavelength of approx. 3 dm.
>
> What is an SAR value?
>
> This is a concept that we will be hearing a great deal about in the future. SAR stands for Specific Absorption Rate and it tells you how much energy per time unit and unit of mass we absorb in different parts of the body. Regarding the European limit values, the SAR in the head must not exceed 2 W/kg over 10 g of tissue. When it comes to GSM 900 MHz, the radio waves penetrate the head approx. 2-3 cm before being fully absorbed. The highest SAR value is received in the outermost layers*.
>
> How much do cordless telephones emit?
>
> The cordless telephone also emits microwaves, but here with a constant output of approx. 10 milliwatts during a conversation. You do not have the control function that a modern GSM telephone has, and in some situations the GSM telephone therefore has a lower output (approx. 1 mW) than the cordless. Measurements of the SAR values also show that those for the GSM can actually be lower than those for portable ones at the same output.
>
> How much do aerials radiate?
>
> A base station actually has no more power than a hand-held telephone because you gain nothing from sending out higher signals than those the telephone can send to reach back. ... Measurements show that the signal strength at a normal distance from a station is of the same magnitude as that which we already have in our environment from radio and TV broadcasts. The level of the signal rapidly falls as the distance from the aerial increases.
>
> How are humans injured through [short-wave] radiation?
>
> The only known output is the heat output, i.e., warming and biological effects associated with the temperature increase. All international limit values are set on this basis. A mobile telephone can never lead to warming effects, i.e., the direct warming of parts of our heads; its output is too small for that. A theoretical calculation performed says that there would be a temperature increase of 0.1 ^{o}C at the very most. But this is how it is with things we do not know; can you get cancer? Will I get a headache if I use the telephone? Can you be injured without warming taking place?
>
> Is it better to use hands-free from the radiation point of view?
>
> Of course it is. With a hand-free – earpiece and microphone on the cord – you have approximately 10-20 times less radiation to your head. ...
>
> How can I protect myself against radiation?

* Note that the designations here are starting to look similar to the dose concepts for ionising radiation. There, the rate of absorbed dose is Gy/s, i.e., W/kg. 2 W/kg for ionising radiation therefore corresponds to 2 Gy/s which, owing to the ionisation, is an incredibly high dose rate. However, for microwave radiation, it is thought that only the heat output which is significant and relatively large outputs per time unit can therefore be absorbed without danger.

> Well, the first thing you can do is start by choosing a telephone with low SAR values; you can have longer conversations using a normal telephone or - best of all – change over to using hands-free equipment.

33.14. The Minister for the Environment responds to those who are oversensitive to electricity

On 24 October 2003 the then Minister for the Environment, Lena Sommestad, responded to a critical letter in *Miljömagasinet* (‘the Environmental Magazine’). I have chosen to quote the following from the response:

> In a letter in *Miljömagasinet* on 12 September you offer hard criticism of the government’s environmental policy, particularly regarding electromagnetic fields and non-ionising radiation. You claim that by expanding 3G, digital TV, digital radio, etc., we are disregarding overwhelming, unanimous research indicating serious health effects.
>
> ...
>
> I have no doubts about the symptoms that you and many other people are suffering from. The living conditions portrayed by you and other people affected phase me no more than they do anyone else. However, in my opinion, more knowledge is needed to be able to put into action the correct measures which can have a positive influence on the situation of oversensitivity to electricity. We mainly have to feel ensured that the measures undertaken have the desired effect. I believe the latter-mentioned is something that both you and I can agree on.
>
> You claim that scientists largely agree that electromagnetic fields and non-ionising radiation, to the extent that they are permitted today, lead to a substantial health hazard. However, this is not the case. A large majority of scientists are behind the internationally-established limit values that we apply in Sweden. In addition, the radiations values that are actually measured are usually way below these limit values.
>
> A minority of scientists believe that electromagnetic fields (EMF) and non-ionising radiation lead to significantly greater risks than those that it has previously been possible to ascertain. However, these results have not won widespread support in the scientific community. New studies are being published continuously. And the minority may eventually be shown to be right, of course. Research is not about majority decisions. However, the Swedish government cannot choose to disregard the general consensus reached by the research world in an individual area based on tried and tested methods and in scientific discussions.

33.15. Harald Rossi dead

Harald Rossi, ‘the father of microdosimetry’, was a very intelligent man who was also very curious. He used to say that he did not understand how people could be so indifferent as to not be amazed by someone having landed on the moon. There was no doubt he was looking forward to the new millennium with great expectations. Maybe this was why he did get to experience it. He died on its first day at the age of 82 at home in Upper Nyack north of New York City.

Harald (who had not used to like being called ‘Harold’) was born in Vienna and studied at the university there before coming to the USA via the UK in 1939 at the age of twenty-two. He defended his thesis in physics at the Johns Hopkins University in Baltimore. He then came to Columbia University in New York where he became the closest colleague of Professor Failla, whom he went on to succeed.

Rossi introduced microdosimetry with an article in the *Journal of Radiation Research* in 1959 and made a strong contribution to its development in cooperation with *Albrecht Kellerer*. Microdosimetry concerns the conditions on a microscopic scale where the macroscopic connections (the mass effect) no longer apply. The energy delivered by radiation on such a scale is random, and for small volumes you have to talk in terms of the likelihood of a specific energy emission rather than state a dose value.

Lennart Lindborg and I wrote the following in an obituary about Harald Rossi:

> [We] got to know Harald as an unusually straightforward, clear-thinking person. The institution he built up with a mixture of competent physicists and biologists emerged [...] as an institution which was very close to ideal for radiation protection research. ...
>
> In addition to his scientific achievements which are reflected in several hundred scientific articles, Harald will be remembered as a vivacious member of the ICRU and its Committee on quantities and units. It has been said that a Committee was never insipid or boring with Rossi around. Many of us also remember Harald's powerful contributions at the meetings of UNSCEAR and other international groups, when he endeavoured to, and succeeded in, training those who were insufficiently rigorous in dealing with quantities and concepts.
>
> During his final years, Harald Rossi was a sharp critic of incautious action in the assumption of a linear, non-threshold dose-response relationship and also conducted himself in that capacity in 'SSI News'.

Around the end of the millennium many deaths occurred among noteworthy radiation protectionists, including Rossi and Wyckoff, the duo who Dan Beninson emphasised his pronunciation when addressing them 'Har**á**ld and Har**ó**ld' respectively. I became a close friend of Harald in the 1950s when I was working at UNSCEAR's Secretariat in Manhattan and lived with the family in White Plains. When we were to travel home to Sweden I sold our Chevrolet to Harald, who in turn sold his old car, called Bouncy, to an acquaintance for a bottle of bourbon every month for as long as the car ran.

Lennart Lindborg was not the only one who took part in Rossi's research - Gunnar Bengtsson did too.

33.16. **Sigvard Eklund dead**

I quote the obituary that I wrote in the Swedish Radiation Protection Institute's 'Radiation Protection News':

> The former Director General of IAEA, Sigvard Eklund (PhD) died in Vienna on 30 January [2000]. He was born in Kiruna in 1911. Eklund worked as a physicist for Manne Siegbahn at the Nobel Institute, Frescati, Stockholm from 1937-1945, whereupon he was employed as Assistant professor at the Swedish Defence Research Establishment (FOA). He defended his thesis in Uppsala in 1946 and became Assistant professor in nuclear physics at the Royal Institute of Technology (KTH). One of his first assignments was to design a van de Graaff generator. In 1949 he wrote a memorandum regarding an initial reactor to be built on Drottning Kristinas väg by the new *Atombolaget*. He was generally an advocate of heavy water reactors over graphite-moderated reactors as being suitable for future power production. At around the same time he presented a report on the conditions for Swedish nuclear weapons. He found that it would not be financially unreasonable to produce five atomic bombs per year, but he also expressed disapproval of the military's attitude towards the bomb.
>
> In 1950, Sigvard Eklund became head of research at *Atombolaget*, i.e., *AB Atomenergi*. He designed the R1 reactor on Drottning Kristinas väg and was the Swedish physicist who could best cooperate with Lise Meitner, the prominent physicist who was otherwise poorly treated in Sweden.
>
> In December 1953, President Eisenhower gave his famous Atoms for Peace speech before the UN General Assembly. In 1955, this led to the first Atoms for Peace conference in Geneva. There was now so much openness for the first time regarding nuclear reactors that the private power industry could start planning nuclear power plants. This influenced *Atombolaget's* position and orientation in Sweden. Eisenhower's initiative led to IAEA being set up in 1957.
>
> The first Geneva conference was so successful that it was followed by another Atoms for Peace Conference in Geneva as early as 1958. This time, Sigvard Eklund was asked to be President of the Conference.
>
> In 1961, right in the middle of the antagonisms of the cold war, Eklund was chosen to succeed the first Director General of IAEA, Sterling Cole. In so doing he took on an

assignment for which he would go on to be re-elected four times, so he was Director General of IAEA for twenty years until 1981 when he retired at the age of seventy. He was then honoured with the name Director General Emeritus and was given a special workroom and secretarial assistance at IAEA. Its important task of checking compliance with the Non-Proliferation Treaty from 1968 was developed while he was head of the organisation.

Sigvard Eklund was a friendly man and an adroit diplomat who, in discussions, had the benefit of his great expertise. After he had retired, he was happy to see visiting Swedes as guests in the Emeritus room where he enquired about the latest development within the nuclear energy field with great interest. He was indifferent to the Swedish nuclear power debate - he warmly supported the development of nuclear power but was also fully aware of its risks.

33.17. **Rune Walstam dead**

It was painful to hear that my good friend and colleague, Rune Walstam, with whom I had cooperated since the 1940s, had passed away in September 2002, mourned by his wife Anne-Sophie and son Thomas. It was also surprising because I had heard him present his history of the activity at *Radiumhemmet* just a few weeks previously. I reproduce my obituary from *DN* of 3 January 2003:

> Rune Walstam was educated by the Swedish pioneer of radiation protection and medical physics, Rolf Sievert, at the latter's famous Radiophysics Institute at *Karolinska Sjukhuset*. After Sievert's death, Walstam succeeded him as Professor of Clinical Radiophysics at *Karolinska Institutet* and head of medical physics primarily at *Radiumhemmet*. Just before his death, Rune had the pleasure of seeing his extensive report on the radiation treatment at *Radiumhemmet* in print – his preface is dated 20 August. However, this contribution was the thing that sapped his strength.
>
> Rune Walstam spent his childhood in Krylbo. He took the long road from his technical compulsory school qualification to Doctor of Philosophy via a BSc which had to be supplemented with a grade in French (!) among others because Rune had no leaving-school certificate from secondary school. After various stints of engineering experience, he came to Sievert in 1947 and finally became one of the world's most prominent medical physicists.
>
> Rune had a fantastic ability to find ingeniously simple solutions to different problems. He developed ingenious dose planning methods before the computer epoch, saw through radical radiation protection improvements for the personnel at *Radiumhemmet* and designed different cunning devices, including the 'double chamber' along with Sievert, and aftercharging equipment which considerably improved the protection at work with gynaecological radium applicators. He was one of those who designed the 'cobalt guns' which replaced *Radiumhemmet's* outdated teleradium devices.
>
> There are many of us who will miss Rune Walstam terribly but who will remember him fondly. In addition to his professional merits, he made a strong impression on many through his friendliness, his congeniality and the interest he showed in everyone.

I have mentioned Rune's cooperation with Jerzy Einhorn in the Nairobi project before (Sections 1.3 and 2.6). It is worth adding that he belonged to *Karolinska Institutet's* Nobel Assembly for 22 years and was pleased that he had been President of a Nordic Congress of Radiology (in Stockholm in 1979), which no other physicist had been before him.

33.18. **The loss of Dan Beninson**

The thing that many of us had feared over the past few years occurred on 21 August 2003: Dan Beninson's heart gave up the ghost. I was devastated of course.

After his death, Dan was aptly described by Jack Valentin, and I quote:

All of the world's radiation protectionists are heartbroken – our friend and master Dan Beninson passed away on 21 August 2003 at the age of 72. He was on the road to recovery after having been seriously tormented by diabetes, but his heart could cope no longer.

Daniel J. Beninson, Dan to his many friends all over the world, got his doctorate from the University of Buenos Aires in 1954 where he initially taught Biophysics. From 1955-56 he did research at the E. O. Lawrence National Laboratory in Berkeley, California. After having done a doctorate in Applied Physics in the USA he was employed by Argentina's Atomic Energy Commission in 1958, initially as coordinator of the Department of Radiophysics and of researchers at the radioisotopes section. In the meantime he had already been working between 1956 and 1958 as Secretary at UNSCEAR, the UN Scientific Radiation Committee, a post which he again held between 1974 and 1979.

His first period at UNSCEAR served as the introduction to a life-long career alternating on the one hand between the Atomic Energy Commission (CNEA) and the Nuclear Energy Inspectorate (ARN) in Argentina where he advanced to the highest leadership positions, and on the other hand between the international radiation science organisations (UNSCEAR, where he was Chair from 1962-1964 [and 1983-1984], the UN International Atomic Energy Authority [IAEA], where he had innumerable expert assignments from 1959 onwards, the International Radiation Protection Association [IRPA] which he helped to found, and, the International Radiation Protection Commission [ICRP], which is perhaps the organisation with which he came to be most associated.

Dan was elected a member of ICRP Committee 4 (the application of radiation protection recommendations) in 1962 at the age of 31 – ICRP occasionally needs to be reminded that many of its important achievements were carried out by young people at the start of their career – and became a member of the Main Commission in 1969, advancing to become Chair of ICRP from 1985-1989. He remained a member of the Main Commission until 1997 as Chair of Committee 4 and until 2001 as a member. As of 2001 he was an Emeritus member of ICRP.

Dan also received many international distinctions, among them the 1996 Rolf M. Sievert Award from IRPA. He was an extraordinarily quick thinker and sharp analyst who was very mathematically gifted (his medicine teacher on the other hand appears to have strongly advised him never to become a clinician), verbally and linguistically gifted and fast as lightning in reply. Dan was a facetious person who was often bantering and teasing, but he was never mean.

On the contrary, the most abiding memory of Dan may well be that he was an incredibly generous person who never got on any 'high horse'. He always took heed of what was actually said rather than who it was who had said it, thereby creating self-confidence and drive among young, inexperienced people around him. He did not suffer fools gladly but he was happy to correct ignorance, and he was always prepared to listen and learn. His capacity to remember innumerable new, young novices all the over world was absolutely incredible.

I miss my friend and master Dan as many others do, but I am very glad I had the chance to meet him one last time in May 2003 in Argentina. Inquisitive and interested in food as he was, he took me, as was his wont, to what he described as 'the best Arabian restaurant in Buenos Aires'. He certainly knew what he was talking about, in that and all other respects.

I first met Dan in 1956 and was a colleague of his at UNSCEAR's Secretariat in Manhattan from 1957-1958 when, as a member of the Manhattan Chess Club, he was able to beat Bobby Fisher. Our cooperation thereafter was renowned both within and outside of ICRP. It is a shame that Dan (like John Dunster) was never awarded the Royal Swedish Academy of Sciences' gold medal for radiation protection contributions. This grieves me greatly, and the founder of the medal, Rolf Sievert, would have been very surprised. If anyone deserved it, Dan did.

33.19. **The conclusion of a century**

In the general confusion and uncertainty regarding what ICRP intended to do with Roger Clarke's proposed policy, became the Commission's former functionaries (Dan Beninson, Deputy Chair from 1977-1985 and Chair from 1985-1993; Bo Lindell, Secretary from 1957-1962, Deputy Chair from 1969-1977 and Chair from 1977-1985; David Sowby, Secretary from 1962-1985) were asked to write a Guest Editorial in *Radiation Protection Dosimetry* on *The Development of an International Radiation Protection Policy*.* We were the ones who had the main responsibility for the radiation protection policy which was now being questioned. We were concerned about the development and took the opportunity to say what we thought.

The most important sections read:

> It has been said [...] that the development has gone from protection of the individual to the collective and now again tends towards the protection of the individual. It has also been said that if the most exposed individual is sufficiently safe, then society, i.e., the collective, is also safe and that therefore no collective dose assessments are needed.
>
> However, none of this is quite true. It is a truism to say that society (the collective) is safe if the most exposed individual is safe; society is the sum of the individuals so this is undoubtedly true. But the fundamental question is not individual or collective; they are both protected to the same degree. The real problem relates to individual versus source. Collectives and individuals may both be protected well enough, but there may still be a cost-effective case for improving the source-related protection. Individuals may be protected well enough as regards their own risks, but they might still feel uneasy if they know that somebody else might be harmed by the practice. The important thing is that if the source causes global exposures, which statistically may be expected to cause a few deaths, and these deaths can be avoided at a reasonable cost, why should then this not be done?
>
> If we neglect the source-related protection and concentrate all protection requirements solely on the most exposed individual, we would turn the clock back and return to where we started. There would no longer be any inducement to avoid global pollution. Furthermore, the principle of optimisation has brought about an additional and beneficial by-product. The requirement to assess every operation, to check whether additional effort would be reasonable to reduce exposures even further, has engendered a culture of protection and a climate of good housekeeping. This culture of safety could well be diluted if protection were to concentrate on the most exposed individual.
>
> ...
>
> We have described the major attributes of the current international radiation protection policy and the reasons why they have been selected. We are aware of the fact that the present system is sometimes perceived as complicated. We also believe that, sometimes, certain aspects of the system have been applied in a different way from that intended by ICRP. However, the remedy should not be to abandon a system that has developed under continuous improvements over more than seventy years. The best solution would seem to be to keep the system in its essential parts and look for possibilities to facilitate its practical application.

The latter was recommended by many and was, overall, the final solution preferred by ICRP.

Roger Clarke's major contribution was thus not the actual content of in his proposal for a paradigm shift but the discussion he initiated at one stage when several of the international authorities were on the point of becoming disinterested in radiation protection. While Roger was Chair of ICRP, a system of consistent public referral procedures for all ICRP reports was introduced, and 2007's fundamental recommendations which ended up replacing Publication 60 from 1990 were preceded by a unique

* *Radiation Protection Dosimetry* Vol. 88, No. 2, pp. 115-118 (2000).

extensive consultation process where firstly the conceptual basis and later the detailed recommendations text were analysed and discussed publicly on several occasions.

Thanks to this discussion, initiated by Roger Clarke, radiation protection was revived and it is for this important result and for his continuous work to increase transparency and involvement that he will be remembered. Ironically enough, the discussion has also meant that many of those who were initially tempted by the pragmatic and easy-to-explain aspects of Rogers ideas for a paradigm shift eventually understood the nature of the proposal's shortcomings. In further developing ICRP's openness, Roger ended up putting the nail in the coffin for his own proposals. He is venerated in that he actually accepted this fact and accepted that the 2007 recommendations carry very few traces of his original ideas.

33.20. **John Dunster dead**

In the ten years surrounding the end of the millennium, prominent radiation protectionists have dropped like flies, and one of the greatest, John Dunster, the same age as me, died year in 2006. Here, I give you the obituary that I wrote together with Roger Clarke and Jack Valentin:

> Herbert John Dunster, Emeritus member of the ICRP Main Commission, died on 21 April 2006 at the age of 84 following a long and, until now, staggeringly successful fight against a series of strokes. These had certainly prevented him from driving in latter years, but his intellectual vitality did not appear to have been particularly affected and only a couple of months have passed since his latest short article (on dose constraints) was printed in the Journal of Radiological Protection.
>
> John Dunster graduated from the Imperial College of Science and Technology at the University of London while war was raging and was immediately recruited to the British Admiralty where he worked with acoustic research surrounding submarines and torpedoes. In 1946, John began working on the British nuclear energy programme at what would later become the UK Atomic Energy Authority. He performed emission calculations for the graphite reactor at Windscale (now Sellafield) which produced plutonium for the British nuclear weapons programme. In 1957, the first major nuclear accident in the western world occurred when a fire broke out in the Windscale reactor. An extensive milk-sampling programme was necessary owing to ion emissions from the accident. Restrictions and radiation protection criteria had to be introduced for the people living in the area, and John was one of the main people making the decisions.
>
> The Windscale accident led to the United Kingdom's renowned National Radiological Protection Board (NRPB) being set up in 1970, with John becoming head of department. In 1976 he was tempted over to the British Health and Safety Executive where he became Deputy Director General and head of nuclear safety. In 1982, John returned to the NRPB, this time as its head, and remained there until he retired in 1987, which meant that he was in the hot seat once again and once again made an invaluable contribution at the time of the Chernobyl accident in 1986.
>
> John had many international assignments, among others for the International Atomic Energy Authority (IAEA), for the UN Scientific Radiation Committee (UNSCEAR), for the EU and for the International Commission on Radiation Units and Measurements (ICRU). However, his big professional passion alongside the NRPB was the International Radiation Protection Commission (ICRP).
>
> John was elected onto what was then ICRP Committee V (radioactive isotopes and radioactive waste) in 1959. In 1962, ICRP's Committee structure changed and John moved to Committee 4 (application of the ICRP recommendations) where was he was involved in writing several reports, especially the epochal *Publication 22* (1973) on the optimisation of radiation protection and the role of the collective dose in that context. In 1977, John was elected to the ICRP Main Commission where he played a very active role in developing the radiation protection philosophy, and he was the one with the pen in his hand putting the texts together when 1990's recommendations from ICRP, *Publication 60*, were produced. When John left the Main Commission in 1997 he was chosen to be an Emeritus Member.

> John was an extremely quick thinker, talked just as quickly in both English and French and was a forthright debater which could at times be overwhelming for newcomers to the industry who may have expected some diplomatic twists before coming to the point.
>
> However, it did not usually take John's colleagues long to discover his absolute honesty, his great generosity and his unassuming modesty in terms of his own personal role. In John's and his wife Rose's modest but very hospitable home there was always a place for an extra teacup and a congenial discussion about a new radiation protection problem where John was always very prophetic.
>
> ...

It is painfully unfair that John Dunster, one of the world's leading radiation protectionists, was never rewarded with the Royal Swedish Academy of Sciences' gold medal. This may well have been because the Academy was cautious in rewarding members of the organisation (ICRP) who suggested candidates. I personally enjoyed very good cooperation with John and we completed a couple of extensive reports together.

33.21. **The Centre for Radiation Protection Research (CRPR)**

Although it falls outside the 1900s, I cannot neglect to mention the development that took place at Stockholm University at the initiative of Mats Harms-Ringdahl. When the research which took place in the Swedish Radiation Protection Institute's final year was cut, Mats changed over (but still with support from the Swedish Radiation Protection Institute) to the Institute for Genetics, Microbiology and Toxicology (GMT) at the University. An independent unit, the Centre for Radiation Protection Research (CRPR) was set up there in 2008 at which the new Swedish Radiation Safety Authority was financing three research posts. This injected a driving force into an activity which, in Sweden as in many other countries, had begun to fade. The Centre was headed by Mats as Professor at the GMT and the Chair of its board was Professor Eva Forssell Aronsson of Sahlgrenska University Hospital.*

33.22. **The Radiation Safety Authority (SSM)**

On 30 June 2008 the Swedish Radiation Protection Institute's flag was hoisted for a commemoration at the Institute's latest premises at Vreten next to Bällstaviken in Solna; the day after that, the National Radiation Protection Institute would cease to exist. Many would say that, at the time, the Institute was 41 years old because it was formed in 1965, but that would not be the whole truth; the activity paid very little attention to its official year of inception. The building below *Radiumhemmet* was certainly new then, but it was an extension of Rolf Sievert's Radiophysics Institute and both personnel and work assignments were largely the same as they were before 'the inception'. The radiation protection activity had been created by Rolf Sievert in the 1920s and run at his Institute. In the latter years before the Radiation Protection Institute came about, that which later came to be called the Radiation Protection Institute's board had been responsible for the activity under the name 'Radiation Protection Board'. The age of the Radiation Protection Institute was therefore difficult to determine and was not that far off the normal retirement age in Sweden.

The early radiation protection activity was pioneering work, and it was fortunate that it was run at a scientific institution. The first inputs consisted of supervising sources of radiation which consisted almost exclusively of x-ray devices and encapsulated radium. However, it was necessary for the supervision to have references in the form of work provisions and limits for radiation exposure. If the activity had been well-established on an international basis, such references could have been obtained from international recommendations and people would have known which requirements could be set.

* Eva is a prominent radiophysicist and was Chair of the Radiation Protection Institute's (SSI) research council.

The question 'what?' could have been directly answered and the answer would have constituted an instruction for the men doing the supervision – and yes, they were actually men; as late as the 1950s had Sievert refused to allow the knowledgeable medical physicist Inger Ragnhult to become a radiation protection inspector. Sievert thought it was against good morality for a woman to travel around the country with male colleagues.

However, the activity was not internationally well-established. The question 'What?' therefore had to be answered by Sievert and his colleagues. It required knowledge of radiation physics, the biological effects of radiation and the use of sources of radiation. The question 'What?' could not be answered unless the question 'Why?' could be answered as well.

It was this work which made Sievert's name famous all over the world - so famous that his international colleagues chose to call the unit for equivalent and effective radiation dose *sievert* (Sv) which made his Institute famous on a global scale. It also put Sweden in an influential position in the international radiation protection work, a position which also benefitted the Radiation Protection Institute.

Since Sievert's time, the answers to the questions 'What?' and 'Why?' have been worked out by the International Radiation Protection Commission (ICRP). Sweden's influence is reflected by the person chosen to be Chair of the Commission. After the Second World War, the Chairs have come from the following countries respectively: the United Kingdom 4, Sweden 3, Canada 1 and Argentina 1. Work on the questions of 'What?' and 'Why?' was also carried out at the Swedish Radiation Protection Institute when it came to non-ionising radiation.

The factor that has kept the Swedish radiation protection activity vital is that the officials have not just known what is required but also *why*. This is what has prevented the activity from becoming bureaucratic. A true 'bureaucrat' knows what is required but not usually why. If an authority knows what should be required but not why, that leaves no room for any flexibility that may be needed.

The fact that a national authority has reason to consider the question 'Why?' is not without its controversies, and this emerged at the start of the noughties. While Bo Lindell and Gunnar Bengtsson largely pursued Sievert's intentions, the third Director General, Lars-Erik Holm, changed tack. This is where his (unwarranted) feeling of uncertainty probably played a role. He expressed his aversion to having 'Sievert hanging over them' early on and appeared to want to strip away anything which was not seen as a refined authority function.* The personnel began to complain about 'having to keep your thoughts to yourself', and there was particular displeasure at the decision to eliminate ('butcher' in the vernacular) the Swedish Radiation Protection Institute's scientific library. Many were worried that the Radiation Protection Institute would continue to know *what* but no longer be able to answer the question *why*.

Ironically enough, the inertia of the system meant that the Radiation Protection Institute could continue that have considerable influence on the international radiation protection activity. Jack Valentin has been an exceedingly efficient Secretary of ICRP and Lars-Erik was elected as the third Swede to be Chair of the Commission, an assignment which he appears to have carried out to everyone's general satisfaction.

Over the years, the relationship between the Radiation Protection Institute and the Nuclear Power Inspectorate has been the subject of many discussions. A particular problem has been some of the Nuclear Power Inspectorate officials' views of the authorities' tasks. Some of the officials and, in his time, also the Chair of the board Gösta Netzén, held the view that the most efficient thing would be if

* Lars-Erik's aversion to having 'Sievert hanging over them' was probably caused by his fear that the authority could not work efficiently if it were a mishmash of supervisory authority and research institute. His predecessors (Sievert, Lindell and Bengtsson) thought a reasonable mixture of these functions led to a high level of competence and constituted a key to the exchange of knowledge with foreign institutions. Being named 'The Crown among the Best Value – Total Quality Management for Local Government' also showed that the Swedish Agency for Public Management thought that 'an efficient authority had to be able to adapt to changes in the surroundings and new political prioritisations. We realised that the Radiation Protection Institute's ability to rapidly reorganise its activity during the Chernobyl accident was an example of such a capacity for change'. For the majority at the Radiation Protection Institute, having 'Sievert hanging over you' was something to be proud about.

all matters regarding nuclear power, i.e., also radiation protection matters, came under one and the same authority and that the Swedish Radiation Protection Institute's activity within this field should therefore be moved over to the Nuclear Power Inspectorate. However, the view was not supported at political level. The main objection was that such an arrangement would lead to two authorities dealing with radiation protection matters and that a disagreement regarding the fundamental protection policy could arise. The experience of the American Atomic Energy Commission (AEC) was a deterrent.

Another possibility which has also been much discussed is the merger of the Radiation Protection Institute and the Nuclear Power Inspectorate to become one authority. This had advantages and disadvantages but was appealing at Ministry level. Previously, when the Radiation Protection Institute and the Nuclear Power Inspectorate came under different Ministries, a merger would have been more difficult. However, in 2007, a decision was made to merge the two authorities and a committee was appointed under the well-qualified lawyer *Ann-Louise Eksborg* (1947-), Director General of the Swedish Emergency Management Authority and the former Swedish Accident Investigation Authority.

The new authority, the Radiation Safety Authority (SSM) began its activity on 1 July 2008 with Ann-Louise Eksborg in charge. the Radiation Protection Institute thereby ceased to exist. Lars-Erik was given the important task of being Director General or the Swedish National Board of Health and Welfare, a job which he started as early as 1 March 2008. Carl-Magnus Larsson was appointed DG of the Radiation Protection Institute for its remaining lifetime. Of the old Swedish Radiation Protection Institute members, only Carl-Magnus and Leif Moberg still had high-up positions. Carl-Magnus has finally (2010) been honoured as head of the radiation protection authority in Australia and Leif Moberg has replaced Gustaf Löwenhielm as head of research at SSM.

As I write, a great deal is expected of the new authority. Will it continue the good traditions of the Swedish radiation protection activity and reactor safety and continue to ask the question 'Why?', or will it become an ordinary authority which contents itself with an answer to 'What?' and thus run the risk of being swamped by bureaucracy? Will they realise that 'Sievert hanging over them' is a concept of honour?

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The Toil of Sisyphus is the fourth and final volume of Bo Lindell's history of radiation, radioactivity, and radiological protection, a continuation of *Pandora's Box*, *The Sword of Damocles*, and *The Labours of Hercules*. It is aimed at persons with a general interest in radiation and requires no previous knowledge. The book deals with the 20th century after 1966, when the great Swedish pioneer Rolf Sievert passed away, and synoptically with developments during the first decade of the 21st century.

At Sievert's retirement in 1965, his radiation-science empire had been split into three parts: a university department of medical radiation physics; another university department of radiobiology; and the Swedish Radiation Protection Institute (SSI) which was both an expert organisation and a regulatory authority. The Institute's first leader was Bo Lindell, as its 'Professor and Manager' – a title that Sievert persuaded the government to stipulate in order to emphasise the scientific nature of the position. He retired from that position in 1982 but remained an emeritus adviser until 2008.

Professor Bo Lindell (1922-2016) had a degree in engineering physics and a PhD in radiation physics. He was Scientific Secretary and then Chairman of the International Commission on Radiological Protection (ICRP), and a leading member of the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) as the Swedish delegate, and, for a time, Chairman. He also participated actively in the work of other international and national organisations dealing with radiation. Through this central position, Lindell had full insight into the international development of radiological protection, and unique opportunities to influence this development, which he used to the full to ensure that proper account was taken of both ethical and practical concerns.

Lindell chose the title, *The Toil of Sisyphus*, as an analogy to the difficulties encountered by the nuclear power industry in its efforts to gain acceptance. However, the book is not limited to, or even primarily oriented towards, nuclear energy. It covers all aspects of radiation and radiological protection problems and issues during a period of significant political and societal upheavals around the globe.

The title turned out, as Lindell continued to write, to have many further connotations to the observations and issues he describes, and to his own work. It can also be seen as a fateful comment on the Swedish Radiation Protection Institute, which was born and nurtured in Lindell's hands, became a world-renowned entity through his and his colleagues' efforts, and in 2008 became a part of a new, bigger Radiation Safety Authority – with obvious economies of scale but also the peril of specific scientific expertise fading into a more conventional governmental agency.

Bo Lindell's personal narrative provides an eminently readable account of all salient events, spiced with many entertaining, and sometimes heart-rending, anecdotes. Covering the period when Lindell was deeply personally involved, this volume is formatted as chronological diary notes rather than the topic-oriented accounts in the previous volumes. In response to Lindell's own fears that it would be subjective, knowledgeable readers have instead described this book as even more colourful than the three previous volumes.

Lindell wrote this book series, his magnum opus, in Swedish. Aided by generous grants, the Nordic Society for Radiation Protection (NSFS) proudly presents this translation into English.