lucas heights 1971

Strict limits for exposure to all kinds of radiation
are set and applied worldwide in an attempt to ensure the safe
use of nuclear energy and nuclear techniques.
These limits are kept under constant review;
an important aspect of this work is the assessment of
radiation quality.
One of the goals of radiation physics and of radiation biology
is thus to obtain a description of everything
that happens when radiation of differing kinds strikes
living organisms.

This forms the essential background to the holding of an IAEA symposium on biophysical aspects of radiation quality at the Australian Atomic Energy Commission Research Establishment at Lucas Heights, New South Wales, earlier this year. The Australian Government served as host for the symposium, and gave generous help in providing facilities and supporting staff, which allowed the Headquarters supporting staff to be kept to a minimum.

In his opening speech Dr. Horst Eisenlohr, IAEA Scientific Secretary, recalled that although the Agency had held previously a very successful regional research meeting in Australia, this was the first major international symposium arranged by the IAEA in that country. The fact that it was attended by 68 participants from 16 countries "is in itself a tribute to our hosts and to the high level of scientific research in Australia".

Eisenlohr pointed out that the IAEA planned to hold a small meeting on micro-dosimetry in 1964, which had already developed to an important part of radiation biophysics. But when organization of that meeting began "it turned out that the number of scientists actually working in the field of microdosimetry was in fact very small". It was still felt that a meeting on this subject was due and desirable, so its scope was broadened to include other relevant physical and biological aspects of radiation quality. This wider theme was the subject of two panels held in Vienna in 1965 and 1967 which evidently had a considerable impact on the world-wide development of research into radiation quality and microdosimetry in particular. In 1967 Euratom was able to convene its first symposium on microdosimetry, at Ispra; since then, the subject had developed further and scientists in many countries had contributed much to a better understanding of the action of radiation on living systems.

The state of the art

Papers presented at the Lucas Heights symposium dealt with the whole range of the chain of events beginning at the physical process of absorption and micro-distribution of radiation energy, passing through the action of radiation energy at the molecular and cellular levels up to the reactions of a biological system as a whole and the modification of its sensitivity to radiation. Discussion included changes induced in cells as they develop, and the extension of the results of these investigations to changes induced in tissues.

Eisenlohr pointed out that the biophysical aspects of radiation quality had a considerable impact on the use of ionizing radiation in medicine, and on health physics. The connection between physical characteristics of ionizing radiation in its various forms and the "quality factors" defined for radiation protection work thus formed another topic dealt with at the symposium.

In all, 39 papers were presented, including three invited survey papers on particular aspects of the subject. It is expected that all will be published by the Agency in a few months.

The Chairman of the Australian Atomic Energy Commission and Governor from Australia on the IAEA Board, Sir Philip Baxter (left), with the IAEA Scientific Secretary for the Symposium, Dr. Horst Eisenlohr.
Photo: AAEC

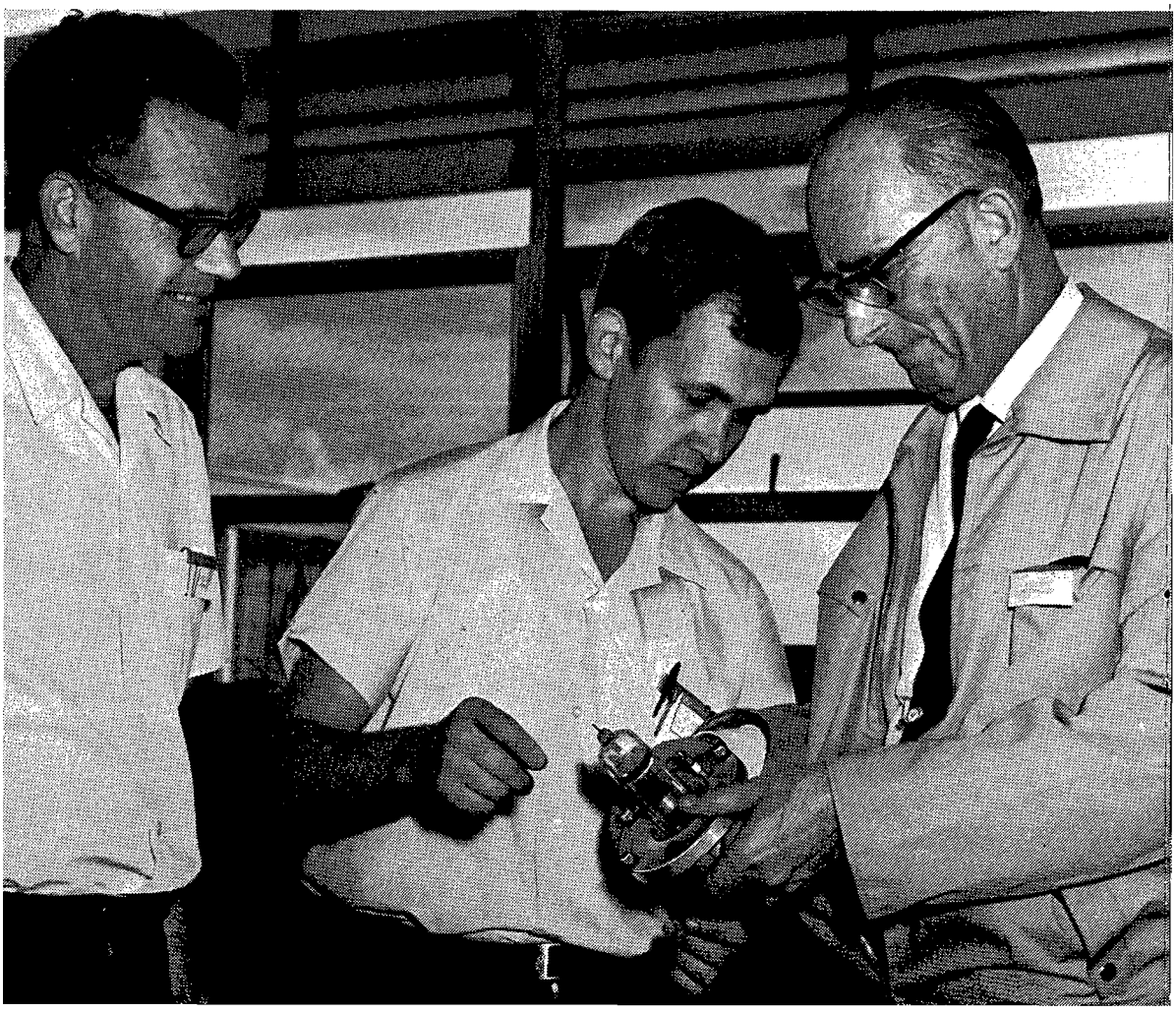
Radiation quality

One of the three survey papers was delivered by J.E. Turner, of the Health Physics Division, Oak Ridge National Laboratory, US. He considered at length the meaning and assessment of radiation quality, beginning from first principles.

Turner pointed out that when ionizing radiation strikes a target it interacts with it and produces directly certain changes; these, which could be termed primary events, take place at the nuclear, atomic, and molecular levels. Their type and distribution in space and in time depend on the kind of incident radiation, its energy spectrum and the dose rate, as well as on the physical constitution of the target. As a result of the initial primary events atomic recoil particles of various types are generated, and these can in turn produce secondary and tertiary energy transfer processes.

One of the goals of radiation physics and radiation biology, as has been noted, was to obtain what could be called a quantitative description

Participants in the symposium on biophysical aspects of ionizing radiation examine an RF ion source for an accelerator at the Lucas Heights research establishment of the Australian Atomic Energy Commission. From left to right: Y. Feige (Israel); M. C. E. Petersen, AAEC Research Establishment, Lucas Heights; R. Wideroe, Eidgenössische Technische Hochschule, Zürich, Switzerland. Photo: AAEC



of everything that happened as a result of radiation striking a living system, said Turner. Given complete knowledge of the radiation field and the target, the investigator would like to know the microscopic distribution of all primary and secondary events. This information would be useful in understanding and interpreting the effects of radiation in producing the observed biological changes.

Turner argued that there were limitations to the concept of relating biological effects to the properties of radiation alone. The dependence of some effects on the properties of the target itself was recognised: oxygen tension, radiosensitivity, the biological endpoint under study, and so on.

In addition, the processes that followed the irradiation of a biological system must be so complex and so tied in with the processes of life itself — which were incompletely understood — that "it is surprising in a way that there is some hope of correlating biological effects in terms of properties of the incident radiation. But this is the aim of radiation dosimetry".

A fundamental calculation in this work is that of relative biological effectiveness (RBE), a quantitative description of the absorbed dose of a given type of radiation required to produce a certain biological endpoint, calculated relative to the required dose usually of X-rays or gamma rays from a cobalt-60 source to produce the same endpoint. Here, one paper reported observations on the biological effects of neutrons with energies from 1 MeV down to 14 keV using cell survival and chromosome aberrations induced in cells as their endpoints. An increase in the RBE of neutrons as their energy decreased was evident; and at most energies neutron RBE was dependent also on the stage reached in the growth cycle of the cell which was struck.

Iodine-131, Iodine-125 and heavy charged particles

Iodine-131 has been used for years in the diagnosis and treatment of diseases of the thyroid gland; recently, Iodine-125 has also come into use for these purposes. Three papers presented at the symposium were concerned with the biological effects of electron cascades (the so-called Auger effect) induced in tissue when Iodine-125 is used. One paper concluded that the effects might well be in excess of those to be expected on the basis of the dose absorbed in the target tissue; a second that the discrepancy in measurement of dose was not to be met simply by applying a quality factor; the third, that the biological effects induced by Iodine-125 for a given dose measured in rads were much greater than those associated with use of Iodine-131.

There were indications also at the symposium that much work may be required in future in the assessment of the radiation quality of heavy charged particles such as those encountered by astronauts in space or physicists working with high-energy accelerators. At present the number of people exposed to such particles is very small; but this number may increase considerably if or when high-flying supersonic aircraft are used for commercial transportation. The actual dose received by any individual is likely to be very small; but the study referred to is nonetheless necessary.

A very great deal is known about the actual, gross effects of absorbed doses of the various types of ionizing radiation; and the symposium can not be reckoned to have challenged the bases for accepted radiation protection guidelines. Rather, it served to highlight the fact that much more work remains to be done before quality factors can be specified precisely. Work reported at the meeting indicated useful progress in several distinct fields but, as one participant put it, there is a large gap between the primary physical events and their ultimate consequences which still remains to be filled in.

Palais des Nations,
Geneva,
6-16 September 1971

FOURTH INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY

Fifty-six Governments have accepted the invitation to participate in the Fourth International Conference on the Peaceful Uses of Atomic Energy, to be held in Geneva from 6 to 16 September this year.

When it authorized the holding of this Conference, the General Assembly of the United Nations expressed the hope that it would serve as a means of acquainting Governments of all Member States with the many and varied benefits that their countries could derive from the prudent use of atomic energy for peaceful purposes. It was also believed that it would be useful for the developing countries to realize that there are not only many things that atomic energy can do for their countries, but also some things that it cannot do. The Conference is expected to indicate to the developing countries in particular how far and in what direction they should go in developing their peaceful atomic energy programmes.

The main topics to be discussed at the Conference are grouped under six major headings: nuclear power; nuclear fuels; health, safety and legal aspects of the use of atomic energy; isotopes and radiation; international and administrative aspects; and selected subjects of particular interest to developing countries — the potential contribution of nuclear technology to their economic growth, criteria for decision making, the conditions which should be met to obtain financial assistance, and possible sources of finance for nuclear projects. The Conference will also review the contribution of nuclear science to education.