

BOOKS

Science in the new nations. The Proceedings of the International Conference on science in the advancement of new states, at Rehovoth, Israel, August 1960. Edited by Ruth Gruber (New York, Basic Books, 1961 ; \$ 6.50).

'In the non-Soviet world there are two broad classes of countries : in one, comprising some 400 million people, the average income per head (per year) is about 1000 dollars ; in the other, with some 1000 million people, the average is 100 dollars per head.' In these few words Prof. Blackett starkly put the problem of the second half of the 20th century and provided the keynote of the Conference held at the Weizmann Institute of Science in August 1960. It led to a proposal, by the Governor of the Bank of Israel, that each 1000-dollar country should tax itself by 2% of its national income to help the 100-dollar countries.

The volume under review is a skilfully edited version of the majority of the papers and discussions of this Conference, which brought together some 120 participants from 40 countries, mainly scientists from the 'rich' countries and statesmen from the new and developing ones. The chief aims of the Conference were to show how science and technology could and should be used to help the new Afro-Asian states and how the host nation, acting as a sort of large-scale pilot project, was trying to solve these problems. Inevitably the field covered was very wide — energy sources ; radiation (uses and hazards) ; food, textiles and oil ; water ; medicine, health and the population explosion ; economics ; education.

From such a welter of information, reported experience and conflicting opinion, one can only select a few highlights in a brief review. In some ways the most disputed question of all was whether the 'poor' states should devote their limited resources in trained and educated personnel and capital to a great leap into the nuclear sciences. Thus Prof. Zacharias of M.I.T. said quite bluntly that 'it is irrelevant to discuss fission power or fusion power. We should not discuss the big accelerators, nor radio astronomy, nor space research, nor that foolishness called space travel, nor monster team researches. They just have no relevance to the problem of the new states'.

One of the most significant figures at the Conference was Dr. Solomon B. Caulker, the Vice-Principal of the Fura Bay University College in Freetown, who put an African view even more powerfully. 'Show me how science can answer the witch doctor. In Sierra Leone eight out of every ten infants die before one year... This is a primary problem : whether typhoid is caused by drinking dirty water or... by someone who has bewitched you... We cannot believe that Nature, God, call it what you like, loves English children or American children or Israeli children any more than African children'.

Repeatedly it was stressed that the utilization of what applied science can offer is basically tied with educational resources. There is no short cut. United Nations Technical Assistance can send scientists as short-term experts but progress can only be maintained by local achievement. And here the statistics are clear and revealing. 'While the U.S. and the U.S.S.R. claim an annual expenditure of 100 dollars per capita of the population for education, Israel and most European countries spend annually about 30 dollars, while the under-developed countries can afford only from 1 dollar to 10 dollars.'

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Thus in summarizing the discussions Abba Eban, the President of the Weizmann Institute stated, among others, two important conclusions for the New States. The maximum possible resources must be made available to the educational system, in which science must be given an immediate and important place. Regional centres of research and education must be set up to serve groups of countries which cannot afford such luxuries at this stage. (In this connexion CERN was often quoted as a successful example of such regional co-operation.)

The results of a Conference of this type, however successful it was, can only mature over the years. It has pioneered a new approach and is already being followed up by the holding of a more comprehensive meeting at intergovernmental level. In February 1963 a United Nations Conference on the 'Application of science and technology for the benefit of the less developed areas' will be held in Geneva.

H.C.

ERRATUM : The 'Glossary' on p. 4 of the September issue contained an important error of fact. In the description of **bubble chambers** it was stated that the pressure on the liquid is released *after* ionizing particles have passed through, whereas in fact the pressure must be released *just before*. This is why one cannot 'choose' particular particles to be photographed, after they have traversed the instrument, in the way one can with a cloud chamber or spark chamber.

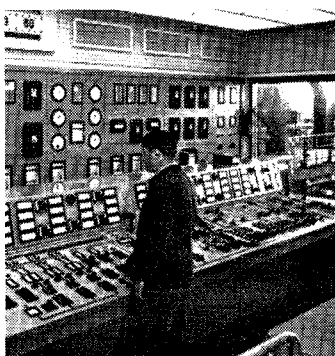
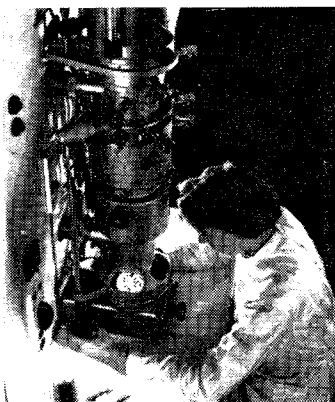
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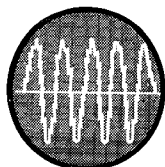
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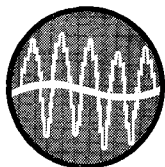
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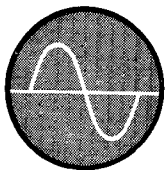
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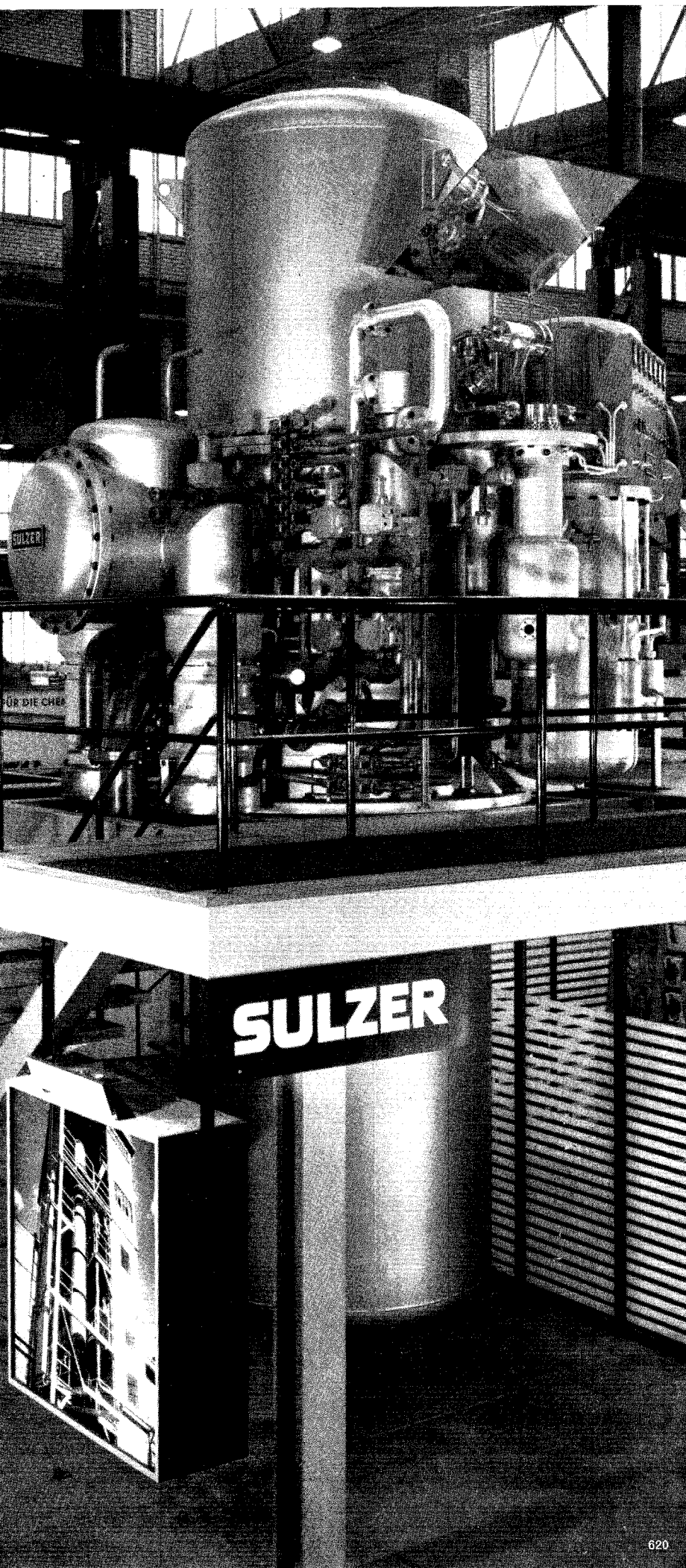
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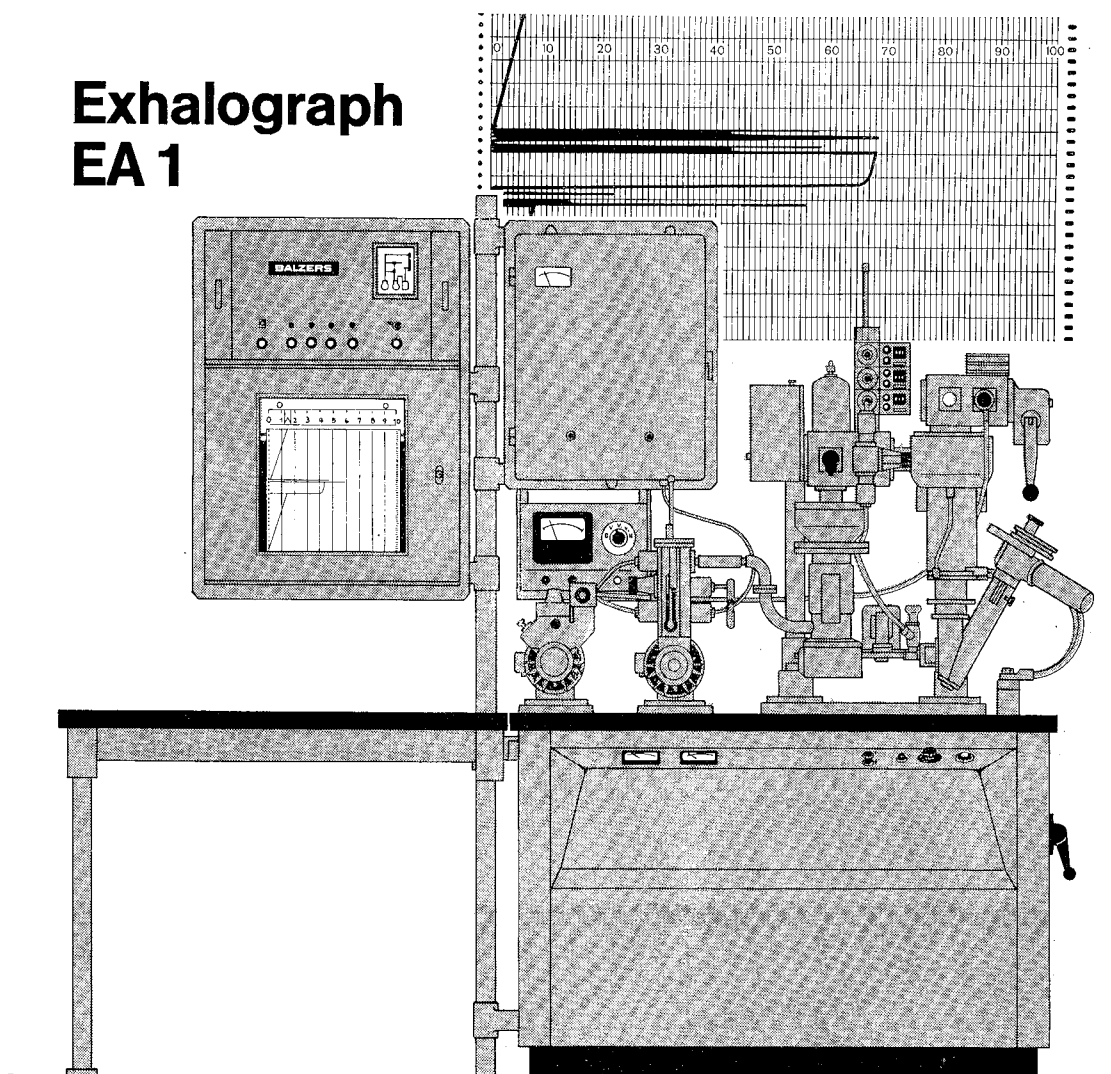
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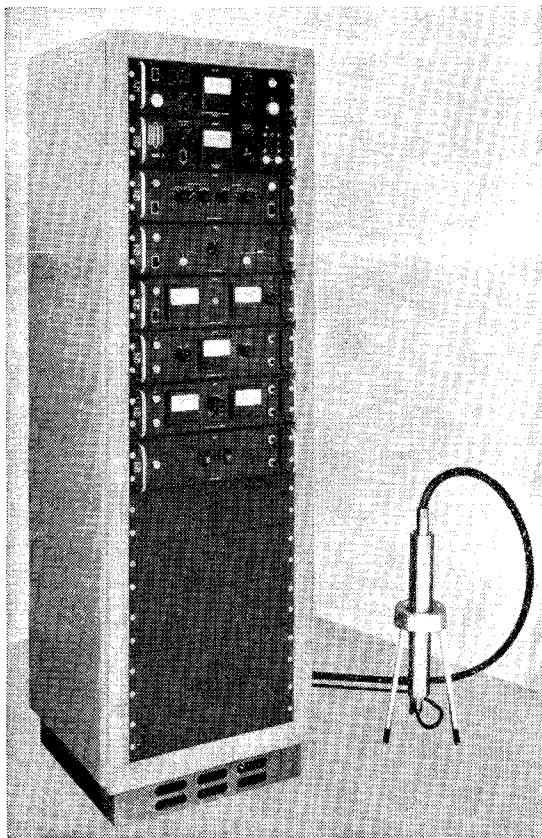
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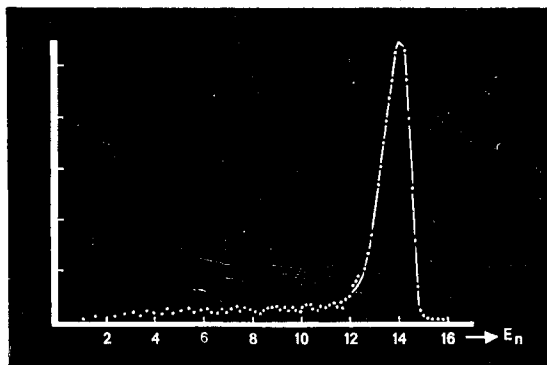
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NIELS BOHR

**A tribute by Prof. V.F. Weisskopf,
Director-general, given before the
staff of the European Organization
for Nuclear Research (CERN) on
23 November, 1962.**

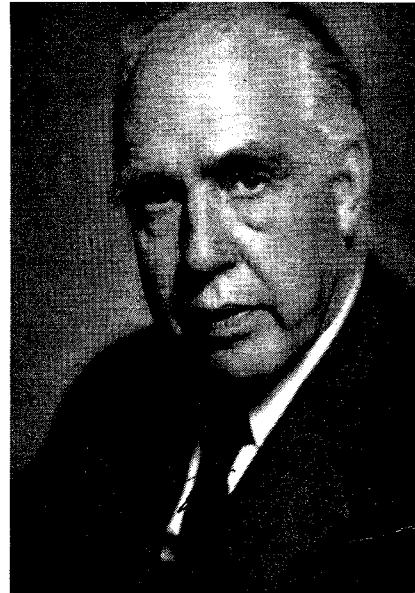


Photo : H. & H. Jacobsen, Copenhagen

Friends and Collaborators,

We are assembled this afternoon to pay tribute to Niels Bohr. Niels Bohr is the symbol, he is the origin, he is the main architect of our work. It was through him, by him and with him that all this on which our work and our existence stands was created. He was a great man. What is greatness? A great man is one who creates a new period, a new way of thinking, and truly he and his life correspond to this definition. The influence of what he started is seen all over in every aspect of our life. Modern science has reshaped our world. It became the determining factor in our thinking, in our culture, even in politics, and it establishes the direction in which mankind will move in the next decades. The real significance of the development which was initiated by Bohr cannot yet be judged by us. We are too close to his life. Only from a distance can one see how much Mont Blanc towers over the other mountains of the Alps

Niels Bohr was born in 1885. His life as a scientist began about 1905 and lasted until today. What a time to be a physicist! He began when the structure of the atom was still unknown, he ended when atomic physics, which he created, had reached maturity. Science, and in particular physics, was not in 1905 what it is now. Let us have a look at physics at that time.

It was an interesting time. It was the year when Einstein published his concept of special relativity, it was a period in which many new phenomena were discovered, but not understood. It was the time — a few years later only — of Planck's great discovery of the quantum of action. Only very few people at that time had noticed Planck's new paper, let alone understood what it meant. It was a time when chemistry and physics were wide apart. Chemistry, on the one hand, was the science of matter and its specific properties. The atom was a concept of chemistry — the atoms of gold, of oxygen, of silver: different specific entities whose existence was noted, but not understood. Physics, on the other hand, was a science of general properties, of motion, of strain and stress, of electric and magnetic fields, and the two sciences were

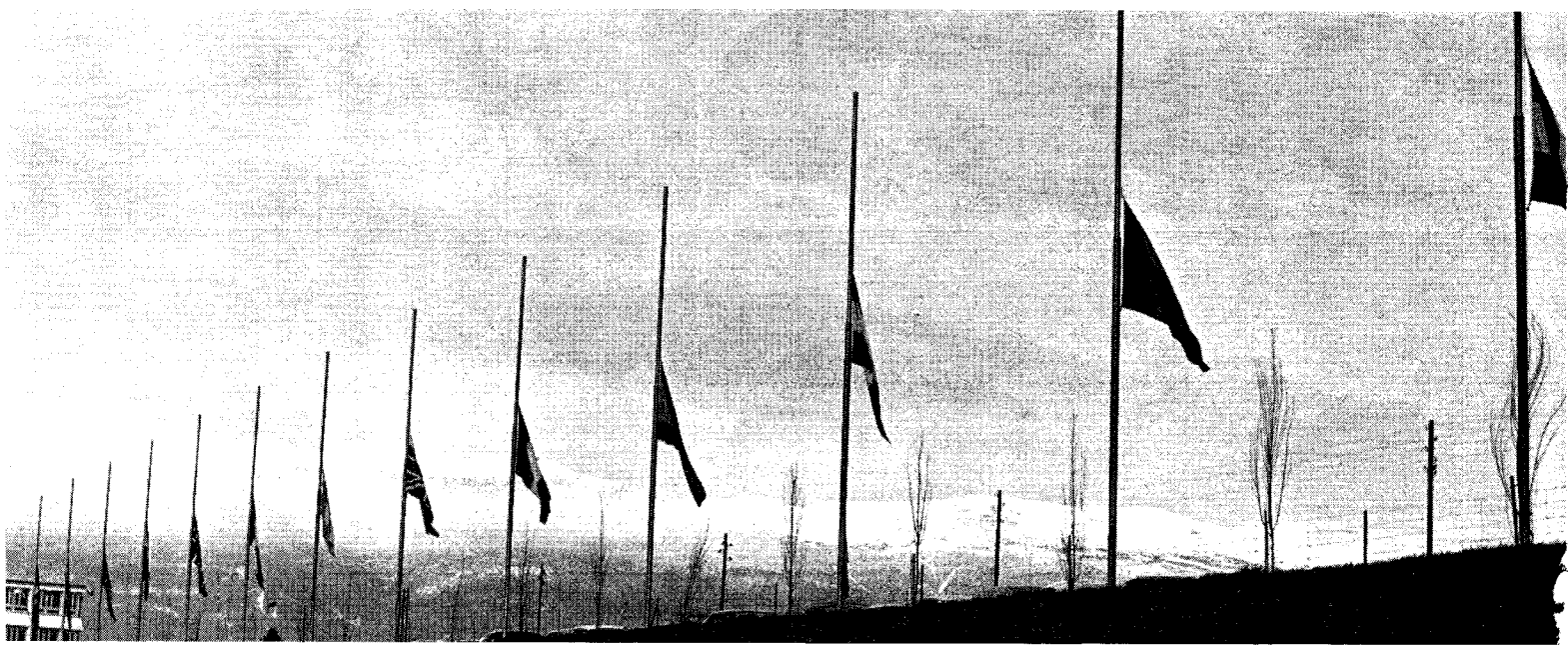
far apart. One was not yet able to answer the question: 'Where do the properties of matter come from?'. Bohr had the great luck to be there at the beginning, or perhaps we should say, mankind had the great luck that he was here at that turning point.

The work of Niels Bohr can be divided into three periods. In each one he exerted a tremendous impact on the development of modern science, in three different ways, at three different times. The first one is the decade from his meeting with Rutherford in 1912 to the year 1923. It began with the publication, in the year 1913, of his work on the quantum orbits of the hydrogen atom. He proposed to explain the unexplained properties of the atom by introducing the concept of quantum states — a concept which was already prepared by Planck and Einstein, and which he applied to the structure of the atom. There is hardly any other paper in the literature of physics from which so many new ideas and discoveries grew. There is hardly anyone so revolutionary. His concept of atomic quantum states was apparently in complete contradiction to the picture of the planetary system which followed from the experiments of Rutherford. But this was a contradiction containing in it the answers to the most fundamental questions

This famous paper marked the beginning of a series of new insights. In the ten years following the publication, many previously ununderstandable things fell into place; the structure of the spectra of elements, the process of absorption and emission of light, the reasons for the periodic system of elements, the puzzling sequence of properties of the 92 different atomic species. It was the period in which quality, the specificity of chemical substances, was reduced to quantity, to the number of electrons per atom. All this rested on Bohr's quantum assumption, at that time still a provisional hypothesis. Bohr's contemporaries, however, took the allowed and forbidden quantum orbits of the electron quite literally, although Bohr warned them in his papers and at meetings that this could not be the final explanation, that there was something fundamental to be discovered first, in order to understand really what was going on in the quantization of the atom.

We now come to the second period of his work: the years 1923 to 1932. This was the great period in which the quantum was fully understood. It was a heroic period without any parallel in the history of science, the most fruitful and most interesting period of modern physics. There is no single paper by Niels Bohr himself which characterizes this period as did the 1913 paper in the first period. Bohr found a new characteristic way of working. He did not work as an individual alone, he worked in collaboration with others. It was his greatest strength to assemble around him the most active, the most gifted, the most perceiving physicists of the world. At that period, we find with Bohr at his famous Institute for Theoretical Physics, in Copenhagen, people such as Klein, Kramers, Pauli, Heisenberg, Ehrenfest, Gamow, Bloch, Casimir, Landau and many others. It was at that time, and with those people, that the foundations of the quantum concept were created, that the uncertainty relation was first conceived and discussed, that the particle-wave antinomy was for the first time understood. In lively discussions, in groups of two or more, the deepest problems of the structure of matter were brought to light. You can imagine what atmosphere, what life, what intellectual activity reigned in Copenhagen at that time. Here was Bohr's influence at its best. Here it was that he created his style, the 'Kopenhagener Geist', the style which he has imposed on physics — a style of a very special character. We see him, the greatest among his peers, acting, talking, living as an equal in a group of young, optimistic, jocular, enthusiastic people, approaching the deepest riddles of nature with a spirit of attack, a spirit of freedom from conventional bonds, and a spirit of joy, which can hardly be described. As a very young boy, when I had the privilege of arriving there, I remember that I was taken a little aback by some of the jokes that crept into the discussions, and this seemed to me a lack of respect. I communicated my feelings to Niels Bohr and he gave me the following answer: 'There are things that are so serious that you can only joke about them'.

In that great period of physics, Bohr and his disciples touched the nerve of the universe. The intellectual eye of man was opened on the inner workings of Nature that were a secret up to this point. The concept of quantum state was cleared up, its fundamental wholeness, its indivisibility which, however, has that peculiar



way of escaping ordinary observation because the very act of such observation would obliterate the conditions of its existence. Bohr, whose penetrating analysis contributed so much to the clarification of these problems, called that remarkable situation 'complementarity'. It defies a pictorial description in our accustomed classical terms of physics, but it reveals a much richer world than our classical experience has led us to expect.

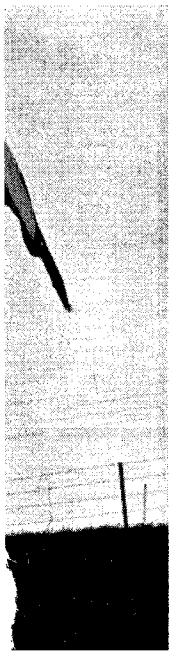
Once the fundamental tenets of atomic mechanics were settled, it was possible to understand and to calculate almost every phenomenon in the world of atoms, such as atomic radiation, the chemical bond, the structure of crystals, the metallic state, and many others. Before that time, this world was full of forces, electric, adhesive, chemical and elastic; then, all these forces were reduced to one: to the electromagnetic force. In the course of a few years only, the basis was laid for a science of atomic phenomena which grew into that vast body of knowledge known to us today. Never before have so few done so much in so short a time.

Then follows the third period of Bohr's work: the time between 1932 and 1940. The year 1932 was an important year in the development of physics. In that year, the neutron was discovered, the positron and artificial radioactivity found, and also the first particle accelerator was put into use. Bohr's Institute, now well known all over the world, became the centre of theoretical physics. After the solution of the fundamental problem of the quantum, theoretical physics went on in two new directions. One was the application of the quantum concepts to fields, to electromagnetic fields, and, later, to nuclear fields. This attempt is not yet quite completed today, and many deep problems concerning the structure of the sources of fields, the elementary particles, are still unsolved. It was vigorously pursued during that period in Copenhagen in close collaboration with Pauli, Dirac and Heisenberg. Bohr himself, in a famous paper published with Rosenfeld, established the physical basis of the new concepts in field quantization. This work is a typical example of Bohr's concern with the physical content of mathematical theories.

The other direction of research in this period was towards the exploration of the innermost part of the atom, the atomic nucleus. In the previous periods, the nucleus was considered only as the massive centre of the atom. In the third period, the structure of the nucleus was a subject of interest, since more and more facts were known about phenomena connected with the innermost part of the atom. These facts were quite puzzling at the start, but, under Bohr's active leadership, it was soon discovered that the same laws of quantum mechanics also govern the world within the nucleus. One was facing, however, a more complicated problem because of the appearance of new and much stronger forces which hold the nucleus together, the nuclear forces. When the world of physicists was puzzled by the enormously large number of quantum states found in nuclear reactions, it was again Bohr's concept of the so-called 'compound nucleus' which made it possible to understand how the large number of states is connected with the strong interaction between the constituents of the nucleus. Bohr's work, and the stimulation from the discussions at Bohr's Institute, created a new science of nuclear structure which led to the understanding of nuclear phenomena, and also of a problem of old standing: the source of energy in the sun and in the stars.

We now reach 1940, the beginning of the Second World War. What follows now in the life of Bohr is, in some ways, even a greater testimony to the greatness of this man. What follows now can no longer be told in purely scientific terms. Bohr was not only a great scientist, he also was a man of unusual sensitiveness and feeling for the world in which he lived. The relation of science with the world of men was for him an important question. He was aware, earlier than many others, that atomic physics is, and would be, a decisive part in civilization and in the fate of mankind — that science cannot be separated from the rest of the world. The events of world history brought home this point earlier than expected. Already in the 1930s, the ivory tower of pure science was broken. It was the time of the Nazi régime in Germany, a stream of refugee scientists came to Copenhagen and found help and support from Bohr. He asked some to stay with him at that time; James Frank, Hevesy, Placzek, Frisch and many others found a haven in Copenhagen where they could pursue their scientific work. But not only this, Bohr's Institute was the centre for everybody in science who needed help, and many a scientist got a place somewhere else — in England, in the United States — through the help of Bohr's personal actions. Then came the years of war; Denmark was occupied by the Nazis in April 1940; pure science was at an end. Bohr was in close connection with the Danish Resistance. He refused to collaborate with Nazi authorities. Soon he was forced to leave Denmark, he had to escape to Sweden, and then came via England to the United States.

There he joined a large group of scientists in Los Alamos who, at that time, were working on the exploitation of nuclear energy for war purposes. He did not shy away from this most problematic aspect of scientific activity. He faced it squarely as a necessity, but at the same time it was his idealism, his foresight and his hope for peace that inspired so many people at that place of war to think about the future and to



prepare their minds for the tasks ahead. He helped us to see that, in spite of death and destruction, there is a positive future for this world of men transformed by scientific knowledge. But he did more than that. He came into contact with people in power; he saw Roosevelt, he saw Churchill. He did many things that today would look naïve. We all were naïve at that time when we hoped that the bomb would be abolished after the war, and that a durable peace would be established immediately, but it is this naïveté that carries the hope and the strength for a peaceful future. Today, we should be aware that it was that attitude, and the discussions and activities which took place because of this hope, that contributed to the realities of today, and perhaps to the fact that we are still alive and we can still look with some confidence to the future.



Photo : M. Benarie, Tel-Aviv

Then came the post-war years: from 1945 to the end. Physics had a different aspect. The war had made it obvious, by the most cruel of all arguments, that science is of the most immediate and direct importance to everybody. This had changed the character of physics. Physics became a large enterprise: large numbers of people, large machines were necessary to carry out physical research. Bohr recognized this as a logical continuation of what he and his friends had started. The new insights which he found were greater than the ivory tower of the universities in which some people wanted to contain this knowledge. He saw that out of these ideas would develop a great thing which could encompass all fields of human activities, and so he saw the necessity of physics on a large scale, on an international scale. In no other human endeavour are the narrow limits of nationality or politics more obsolete and out of place than in science. Therefore Bohr was always aware of the leading rôle science must play in creating a lasting bond across national and political boundaries, in creating the beginning of a supernational society of human beings on earth. This is why he was actively engaged in the creation of international scientific centres: the Scandinavian centre, NORDITA in Copenhagen, and, last but not least, the centre in which we are working here. CERN exists because of Niels Bohr. It was Niels Bohr's personality, Niels Bohr's weight and Niels Bohr's work that made this place possible. There were other personalities who started and conceived the idea of CERN. The enthusiasm and the ideas of the other people would not have been enough, however, if a man of 'his stature had not supported it, and not only supported it, if he had not participated actively in every important act of founding and developing, if he had not sat together with the others and worried about every detail. That was Niels Bohr.

The greatness of this man comes out in this period more than in any other. Bohr in his sixties was fully aware of the new developments in physics, of the new phase which began a decade ago, when the availability of high-energy beams made it possible to go beyond the structure of the nucleus and to explore the structure of the constituents of the nucleus, the world within the proton and the neutron. This new stage of

our science is nothing else but the continuation of the great wave that he had started. Bohr was aware of this, and that was why he had put all his enthusiasm, his zest for life, his positive attitude in support of this new development and, in particular, in support of the new upsurge of fundamental physics in Europe. I remember only a year ago an example of how much he cared for the details of what was going on at CERN. He was asked for help because of some budgetary difficulties. He came and did a great deal to alleviate the situation; after the meeting, which took the whole day, when everyone was tired, he asked one of the members to go for a walk with him, and he spent two hours in the rain of Geneva explaining his views of the present situation. It is hard to understand how a man of this age could have had this energy, this enthusiastic interest in life; but it was a necessary condition to be able to do what he did. It was he who gave us this tremendous expansion of our vision of reality, which shook the world to its foundations, but it was also his spirit of optimism and enthusiasm which will enable us to overcome the dangers we face.

With Niels Bohr's death an era disappears — the era of the great men who created our science. But it was Niels Bohr himself who helped to create the basis for the continuation of his spirit into the future; our institution, CERN, is a testimony to this. It puts us under the obligation to continue what he wanted to do.

His death symbolizes his life. It was only two weeks before his death that he came back from a vacation, fully recovered from a slight stroke he had a year ago, and his doctors told him that he could go ahead and work as usual. So he did and he was very well, and even on Friday, two days before his death, he chaired a meeting of the Danish Royal Academy of Science; on Sunday he planned to have a party of friends at his house. He was happy and healthy, but when he lay down in the afternoon for a little rest, he did not wake up. That such a life was, and could be lived today, should be a great encouragement to all of us ●