CERN COURIER

11

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November 1962

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

The European Organization for Nuclear Research (CERN) came into being in 1954 as a co-operative enterprise among European governments in order to regain a first-rank position in nuclear science. At present it is supported by 13 Member States, with contributions according to their national revenues: Austria (1.90%), Belgium (4.07), Denmark (1.95), Federal Republic of Germany (19.15), France (20.81), Greece (0.60), Italy (9.90), Netherlands (3.77), Norway (1.58), Spain (4.21), Sweden (4.15), Switzerland (3.23), United Kingdom (24.68).
The budget for 1962 is 78 million Swiss francs.

The character and aims of the Organization are defined in its Convention as follows:

'The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.'

Last month at CERN

The **proton synchrotron** started operation again on 23 October, after the long shut-down period during which major changes had been carried out in the experimental areas and a considerable amount of work done on the accelerator itself. During the first week, apart from technical development and various beam studies, special measurements on shielding were carried out by a combined team from the DESY project at Hamburg, the National Institute for Research in Nuclear Science, at Harwell, and CERN. With the start-up for the second week, on 31 October, the **new operating schedule** was put into practice. In future the accelerator will run continuously from 2 p.m. every other Wednesday until 6 a.m. the next Sunday but one, that is, a total of 256 hours in each fortnight, of which some 30 hours will be for machine development and the rest for nuclear physics.

As mentioned last month, in the report of H.M. Queen Frederika's visit, the **main converter** set for the ring-magnet power supply was completely overhauled. Installation was nearly completed of the **electronic filter,** which will considerably reduce the effects of the ripple voltage of this supply on the ring magnetic field. Another important task was the installation of a completely new **security interlock system** for all doors in the ring (including the new ones at the East junction), the linac and the experimental areas. Each experimental area will now be controlled separately, with the aid of beam stoppers to shut off individual beams when necessary. Television cameras were also installed to watch the doors in the East junction.

The **31-cm hydrogen bubble chamber** is now installed in the North hall in one of the largest concrete blockhouses yet constructed here, with an interior volume of 440 m^3. This is in the path of the modified separated kaon beam, formerly k2, now referred as k3. Next to it, also in a concrete blockhouse, is the **Wilson Chamber,** set up to defect neutral particles arising from the interaction in a hydrogen target of pions in the beam *a$* (formerly *a2)*. In the South hall, the CERN **1-m heavy-liquid bubble chamber** has been placed at the end of the m2 beam, where it will carry out some test runs in connexion with the neutrino experiments.

The **synchro-cyclotron** was also shut down again at the beginning of the month, from 2 to 8 October. Among other things, some modifications were

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The cover photograph shows part of the crowd in the PS main control room, listening attentively to the explanations being given by E. Ratcliff, during CERN's 'open day' on 20 October.

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CERN COURIER

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OPEN DAY

On the afternoon of Saturday 20 October, some 600 members of staff and their guests took advantage of the opportunity given them to see as much as possible of the Laboratory's installations.

Between 2 p.m. and 6 p.m. they flowed through the SB gate, each one receiving a collection of site plans. Some started their visit then by inspecting the power house of the 600-MeV synchro-cyclotron, the latter shut down specially until 6.30 p.m. Many others first took a general look at the 41-ha site from the fop of the Administration building, and followed this by a spell in the auditorium, where films in three languages — 'Etoiles nucléaires', 'Matter in Question' and 'Das Europâische Kernforschungszentrum' — showed what CERN does.

Outside the auditorium an Information' stand distributed booklets by the dozen. A score of 'fixed guides', scattered among the Divisions, answered more specific questions. At the synchro-cyclotron, in the power house, in the building for nuclear-physics apparatus, beside the electron storage ring, near the instruments for examining and analysing bubble-chamber photographs, in the experimental halls, the control room and the funnel of the synchrotron (being got ready for the resumption of operation on 23 October) — everywhere they were bombarded with questions. Less exhausting, perhaps, but equally important, was the task of the 23 auxiliary guards, recruited from among the messengers and cleaners. Thanks to their concern for everyone's safety, and the care of the visitors themselves, the afternoon passed without a single accident •

Nuclear Physics in Africa and Asia

Some personal impressions

In Europe and North America, where the average income per head is about an order of magnitude higher than in most other parts of the world, the study of high-energy physics is taken for granted. Elsewhere, many countries exist at a stage of economic development that is far less advanced ; often ideas and methods unchanged for centuries still exist side by side with modern scientific ones. In such conditions, the study of fundamental particles offers little attraction, though in some cases the increasing need for electric power is encouraging work in the more practical fields of nuclear science and engineering.

At the end of last year, Helmut Reich, of the Proton Synchrotron Machine Division, undertook a lecture tour in South Africa, with short stops in Nigeria, Angola, Uganda, and the United Arab Republic, on the way out or back. Shortly afterwards, Owen Lock, of the Nuclear Physics Division, lectured in India and Pakistan. They have recorded here some of the impressions they gained on these visits, reinforced by other relevant facts, to give an idea of the status of nuclear physics, and particularly of high-energy research, in other parts of the ivorld.

South Africa by K. H. REICH

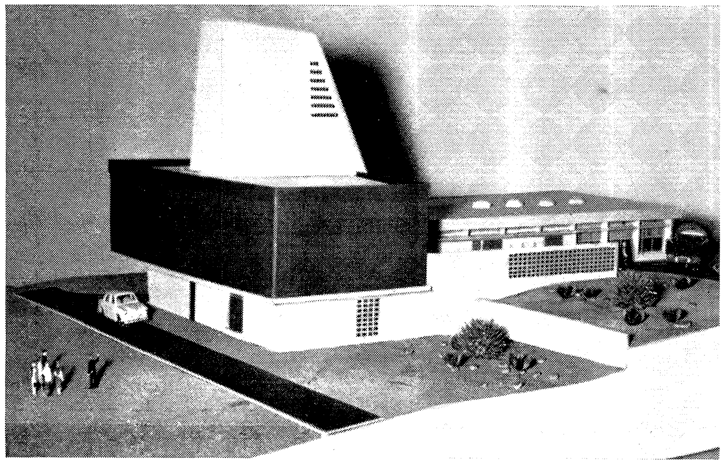
According to Walt W. Rostow* there are four stages in the economic development of a country : the 'transitional stage', the 'take-off, the 'drive to maturity', and the 'stage of high mass consumption'.

At the transitional stage, political and social changes are necessary to allow the application of modern science and technology to the basic problems, the nature of which can be inferred from the following figures :

	U.S.A. U.S.S.R.	Western Europe	Under-developed Area
Life expectancy	70 years		34 years
One farming family feeds	4 others		Vi other
Spending on education per head	$ 100	$ 30	$ 1 to 10
University students per million inhabitants	10 000	1500 - 4500	100 - 500
Engineers graduating each year per million inhabitants	400	100	a few

It is clear that such states will not and need not be in the forefront of developing new science. What they need is rather the application to their problems of what is already well known. Thus they are concerned with the improvement of agriculture, mostly their main source of income, and with a survey of their physical resources : a study of soils, rocks and minerals, rainfalls and river flows, and underground water. Next come the breeding of new plants and animals, the study of plant nutriments and animal foods, and the control of pests and diseases. The role of nuclear physics at this stage may be summarized by the words of the late Rev. Solomon B. Caulker of Sierra Leone : 'As important as nuclear fission and all these things are, it is far more important to let these people realize in these new states that there is a direct relationship between the kind of water you drink and the kind of health you have, between the kind of food you eat and the kind of health you have, and so on'. Or in the words of Brock Chisholm : 'The fact is that in most of the underdeveloped countries most of the boys growing up, and the young men, and the men, have never even seen or used a monkey-wrench, a screwdriver or a pair of pliers, and they do not think in terms of cause and effect with regard to mechanical relationship'.

So clearly, these people have an enormous job of education on hand, particularly at the secondary-school



Mode! of the building proposed for the 3-MV positive-ion accelerator at the Atomic Energy Board's National Nuclear Research Centre, near Pretoria.

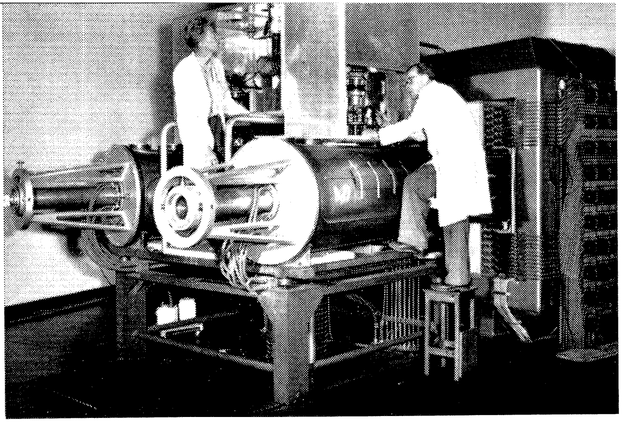
level. They need agricultural agents, laboratory technicians, maintenance engineers, and all those vast numbers of people (about five times the number of university graduates) who get a few years vocational schooling or apprenticeship after secondary school and who are also necessary to make the work of the graduates really effective.

As regards energy requirements, these are usually not very large or very concentrated. For example, the population density in Africa is often around 10 persons per square kilometre, and sometimes as low as 2. Thus, there is normally no question of using nuclear power, all the less as cheap power from hydroelectric power stations could be made available in many areas, and the limited scientific and technical effort available would probably yield a much larger return in other directions.

The stage of take-off usually lasts about two decades and is characterized by a strong increase in investments, so that the future growth becomes self generative. At this stage nuclear physics definitely becomes of interest.

To complete the picture, the drive-to-maturity stage leads to a greater diversification, and the stage of high mass consumption brings the 'affluent society' into being. This society can also afford the large particle accelerators which characterize modern high-energy physics. As the U.S.S.R. and Japan have shown, however, this possibility can also arise one stage earlier.

* Much of the information in this first section is taken from : Ruth Gruber (Ed.) ; Science and the New Nations. Basic Books, Inc., New York, 1961.



The 25-MeV cyclotron of the South African Council for Scientific and industrial Research, with two technicians v/orking on the oscillator.

Science in South Africa

Turning to South Africa, which can he said to he near the end of the 'take-off stage, most of its scientific activities come under the South African Council for Scientific and Industrial Research. This hody, which has an annual budget of about the same amount as CERN, runs central laboratories at Scientia, near Pretoria, and several others in the various provinces. Its research activities cover three main areas : opening up of the country and its resources, improvement of the standard of living of the population, and aid to young industries. For instance, besides its own research, the S.A. National Chemical Research Laboratory analyses minerals, clays and limestones, plants, and vegetable and animal fibres, submitted by farmers or industry. Such work has resulted in the local production of building materials, industrial ceramic products, packing sacks from new fibres, and improved qualities of wool.

For the geodetic survey of difficult terrains, the 'Tellurometer' has been developed. This portable radar-type range meter, working with 10-cm waves, allows the measurement of distances of 40 or 50 km with an accuracy of about 10 cm, in almost any weather. The Institute for Road Research has developed a portable instrument which measures in 5 minutes the moisture content and the density of the earth surface layer along the track of a newly planned road. Other research is concerned with the properties of local road-building materials. The systematic study of the quality of transmission of radio waves at various frequencies serves the optimization of operating conditions for wireless telecommunications, air and sea navigation, etc.

The improvement of the standard of living is the aim of research in medicine, psychology, food technology, and house building. Apart from the usual medical work, one question being studied is at what degree of civilization the population of the rural areas starts to be affected by modern diseases (or put another way, how much of present-day town life ought to be abandoned in order to prevent certain heart troubles, for instance). The systematic study of food has led among other things to an increase in the feeble protein content of bread by adding fish flour, to the conservation of fresh milk, and to the production of agar from algae.

On top of the list of the efforts to help industry is the creation of a modern Bureau of weights and measures. This bureau not only deals with the calibrations and checks prescribed by law but, on request, carries out all kinds of quality controls and measurements. The Institute for Hydrology has developed an economical procedure for reclaiming industrial water, and above all for the desalination of brackish and sea water. Other Institutes deal with specific problems of the mining, fishing, sugar, leather, wool, wood, and paint industries.

Nuclear physics

What has all this to do with nuclear physics and particularly with high-energy physics ? At first there may not seem to be any obvious relation, but the very real connexion is that all these basic, fundamental activities are in hard competition for funds, scientists and technicians with high-energy research, from which no direct and ready return is to be expected. It is understandable that at this stage, in a country whose population is similar to that of a smaller CERN member, high-energy physics has received little emphasis.

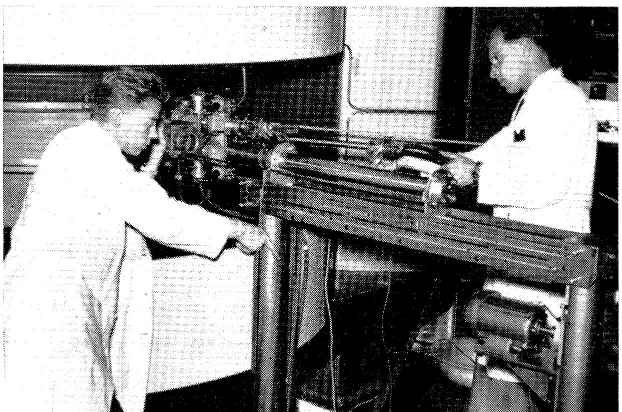
There is, however, active work in low-energy physics going on at Scientia as well as at the Universities of Pretoria, Witwatersrand (Johannesburg) Potchestrom, Stellenbosch and Cape Town. For this work, a 25-MeV deuteron cyclotron, built in South Africa, and several Van de Graaff and Cockcroft-Walton sets are available. More are on order, in particular a 5.5-MeV Van de Graaff for the Southern Joint Institute for Nuclear Research, located between Cape Town and Stellenbosch. In each of the physics departments of the universities quoted, some 5 to 10 students do graduate work on nuclear reactions and excitation levels, resonant scattering, and the like. The problems of carrying on such research 10 000 miles from the nearest large research centre, in a country lacking a developed scientific-instrument industry, are very real. It was in fact one of the most striking impressions of the tour to be confronted with such a situation.

Apart from the smaller cost of research in low-energy physics, some of the results are directly applicable elsewhere, and the techniques have a general usefulness. For example, the soil humidity measurements mentioned earlier depend on the use and measurement of nuclear radiation (beta rays), and radioactive 'tracer' techniques use similar detection methods.

In view of the coal available, there is no particular urgency for the introduction of nuclear energy, but like other countries in a similar position, South Africa needs some scientists qualified to watch evolution in this field and to advise the Government if and when to buy a particular type of nuclear power reactor (or perhaps to concentrate on solar batteries or fuel cells). More particularly, South Africa has a special interest in this field, as it is itself a producer of uranium. These nuclear-energy questions are being taken care of by the Atomic Energy Board, which is building up its own research facilities at the National Nuclear Research Centre, near Pretoria. This will have as part of its equipment a 3-MV positive-ion accelerator.

Notwithstanding the overall situation, there appears to be considerable interest in the work going on at CERN. At the C.S.I.R. they were in addition interested in questions of co-operation between CERN and the laboratories of Member states, a problem they have themselves on a smaller scale.

The target side of the C.S.I.R. cyclotron, showing the remotely controlled mechanism that enables highly radioactive targets, particularly those of short life, to be removed from the cyclotron, guillotined, and despatched rapidly to the laboratory for examination.



Pakistan and India by W. O. LOCK

The Indo-Pakistan sub-continent has a population of about 600 million people, many of them living in some of the most densely populated cities and areas in the world. There is a continuing tremendous increase of the population, and all reserves or achievements that are major in their own right appear insignificant when divided by this vast denominator. The problem facing these peoples is to raise their living standards, which in turn means extensive industrialization of their countries. The essential requirement for industrialization is electric power, and in both Pakistan and India it is felt that nuclear generating stations could be an economic source of such power. The Indian Atomic Energy Commission has been in active operation for over 15 years and has been one of the pioneers in discussing nuclear power and its economics in underdeveloped areas. In Pakistan the work of the Atomic Energy Commission only started with the advent to power of President Ayub Khan in 1958. Naturally both Commissions are placing most emphasis on applied nuclear physics, but pure nuclear physics is not neglected.

PAKISTAN

Pakistan is a country of some 88 million people — 40 million in West Pakistan and 48 million in East Pakistan — and an average population density of nearly 100 people per square kilometre. The two sections of the country are about 1800 km apart, with India in between.

The many problems facing the country were discussed at a symposium held in Lahore in early January 1962, the title of which was 'The role of science in the development of natural resources'. Some of the subjects discussed were : fuel and power, hydrology and water conservation, plant products, forestry, agriculture and soil, public health, and animal husbandry. As in South Africa and India it is on problems in these fields that the major scientific effort in Pakistan must be placed. Nevertheless one session was devoted to atomic energy.

Work of the Atomic Energy Commission

A large part of Pakistan consists of areas which are either desert (in the west) or flooded during the monsoon time (in the east). There are no resources of coal and few possibilities for hydroelectric schemes, although there are some natural gas resources. Interest in the generation of power from nuclear reactors is thus considerable. However, Pakistan is short of trained scientists, especially in the field of nuclear energy and its related subjects. The Atomic Energy Commission has therefore embarked on a large-scale training programme, which, over the next few years, involves sending a few hundred science graduates to different institutes all over the world, for advanced training lasting between 2 and 3 years. By 1965-6 most of these people will be back in Pakistan to form the nucleus of the National Institute for Nuclear Science and Technology which is being built at Islamabad, the new capital, near to Rawalpindi. This Institute should be ready in 1964-5.

At present, it is questionable whether the generation of electricity by nuclear reactors would be an economic proposition. For example, there is a new hydroelectric scheme at Kaptai (east of Chittagong), which will supply all the power requirements of East Pakistan for the next few years. However, the rate of increase of consumption of electricity is such that a new source of power will be required in the 1970s and it is then that nuclear power may be the best. To gain experience it is thus proposed to equip the new Islamabad Centre with a 5-MW swimming-pool reactor.

Atomic Energy Centres are also being set up in Lahore (opened in November 1961) and in Dacca (East Pakistan — construction started summer 1962). The Lahore Centre has about thirty scientists on the staff, covering such fields as radiobiology, radiochemistry, counting techniques, reactor physics, and nuclear physics. The main effort is devoted to giving short training courses, mainly to students who will subsequently go overseas for advanced training, but research is encouraged both in the applied sciences and in pure nuclear physics. For example, there is collaboration with the CERN Emulsion Group on the study of low-energy antiproton-proton scattering in nuclear emulsions. The Dacca Centre will be set up on similar lines with perhaps more emphasis on pure research, since it is proposed to install a 3-MeV Van de Graaff accelerator for the study of problems in low-energy nuclear physics. There will be close collaboration with the Physics Department at the University of Dacca, which is now starting a small emulsion group to work on emulsions exposed at CERN.

In the field of the application of radioisotopes there are small medical radioisotope centres at Karachi, Lahore and Dacca, while a fourth is now being established at Multan. Two agricultural research centres, which will use radioisotopes, are being established at the present time, one at Dacca and one at Tandojam near Karachi.

From this brief survey it can be seen that the Atomic Energy Commission in Pakistan is engaged in laying the foundations for the future large-scale expansion of science in that country. It is most encouraging to see that pure and applied science are being fostered together, although of course the main emphasis will be on the latter for many years to come.

University research

As in many countries of the world, the universities of Pakistan suffer from lack of money, equipment, facilities

Model of the Pakistan Institute of Nuclear Science and Technology, now under construction at Islamabad.

Part of the new building of the National Centre of the Government of India for Nuclear Science and Mathematics (Tata Institute of Fundamental Research).

and staff. Most of their effort is devoted to teaching, but small research groups exist. In addition to the one at Dacca University, there is a small nuclear emulsion group at Rajshahi University (East Pakistan). In West Pakistan, Lahore has a 1.2-MeV Cockcroft-Walton accelerator in the High-tension laboratory attached to Government College. However, it is clear that the major part of the research in nuclear physics in the next few years will be carried out in the Laboratories of the Atomic Energy Commission, which, at the same time, will endeavour to give all possible assistance to the research groups in the universities.

INDIA

India has a population of the order of 450 million, and an average population density of nearly 150 people per square kilometre. Its problems are very similar to those of Pakistan but on a much larger scale. Since achieving independence in 1947, great efforts have been made to build up industry in different parts of the country, and consequently the demand for electric power has been rising rapidly. Coal and oil deposits are extensive, but not when considered in terms of the total population. Available hydroelectric power is being rapidly utilized as, for example, at the very large Bhakra-Nangal project near to Chandigarh in the Punjab. This comprises two dams, a large number of canals, three power houses and a vast network of transmission lines spread out over the Punjab, Rajasthan and Delhi areas. The total installed capacity of the three power houses, now essentially complete, is 605 M¥, but the power demands of the Punjab are continually increasing and other sources of power are under active study.

Indian Atomic Energy Commission

Areas of India far from the mountains have no possibility of tapping hydroelectric power sources and are very much interested in nuclear power. The coal-producing areas of India are very non-uniformly distributed, mostly in the north east, and coal-fired stations on the west coast of India or in the Delhi area would have to be fed with coal hauled over a distance of 1500 km, with consequent increased costs and transportation problems.

The Indian Atomic Energy Commission has, therefore, been closely concerned for many years with the problems of the generation of nuclear power. Their establishment at Trombay (in north Bombay) is similar in scope to the British Atomic Energy Research Establishment at Harwell, though naturally not of the same size. At the present time there are three reactors operating. One, the 40-MW Canada-India reactor (CIR), commissioned in July 1960, is very similar to the NRX reactor at Chalk River and, as its name implies, was built as a joint project (under the Colombo Plan). The remaining two are a normal 1-MW swimming-pool reactor, commissioned in August 1956, and a zero-energy reactor, Zerlina, for lattice investigations and new assemblies, commissioned in January 1961. Considerable reserves of uranium have been detected and mining operations started ; in addition India has one of the world's most extensive deposits of monazite, which yields thorium. The fuel elements for the Zerlina reactor and half the first charge for the CIR were fabricated at Trombay from Indian nuclear-grade uranium. The facilities provided by these two reactors will pave the way to the design of power reactors to suit India's special requirements.

It has recently been announced that the first Indian nuclear power station, to be built by a U.S. company at Tarapur, 100 km north of Bombay, will consist of 2 reactors of the boiling-water type, each with a capacity of 190 M¥ (electrical). The cost will be equal to about 100 million dollars and it will be ready by 1966. Two further nuclear power stations are under consideration.

Nuclear physics

We now have to discuss where pure nuclear physics fits into this picture. Eirst of all, in Trombay, a 5.5 MeV Van de Graaff accelerator has just been installed, and is being used for experimental physics by a small research group, built up specially over the past few years. A considerable amount of solid-state and fission physics is also being carried on around the Trombay reactors. Nevertheless, it is at the Tata Institute of Fundamental Research, in Bombay itself, that the major part of Indian research in nuclear physics is carried out. This Institute was started seventeen years ago by a heavy endowment from the Tata trust and in collaboration with the Government of Bombay. Today most of its finances are provided by the Government of India and it is known as the National Centre of the Government of India for Nuclear Science and Mathematics.

The Institute is housed in a new building on the southernmost tip of Bombay Island. It has a very strong school of mathematics, the largest in the country, and some 180 scientists of the school of physics work in such fields as theoretical physics, nuclear physics, plasma physics, cosmic rays, geophysics, and computer technology. A 1-MeV Cockcroft-Walton accelerator has been used since 1954 to study various nuclear reactions, and also as a pulsed fast-neutron source to study neutron thermalization, the properties of uranium-beryllium-oxide lattice assemblies, and so on. Other areas of low-energy nuclear physics covered in the Institute are nuclear spectroscopy, nuclear magnetic resonance and electron paramagnetic resonance. The nuclear and electron magnetism laboratories are very well equipped, both with imported instruments, and those built in India. The main interests at present are on the structure of organic compounds, Knight shifts, and the properties of alloys and amalgams. Work in nuclear spectroscopy is on level schemes and nuclear models. Isotopes produced in Trombay are now available for many of these experiments.

A medium-sized electronic computer, TIFRAC, with a memory of 2000 words, has been designed and built at the Institute.

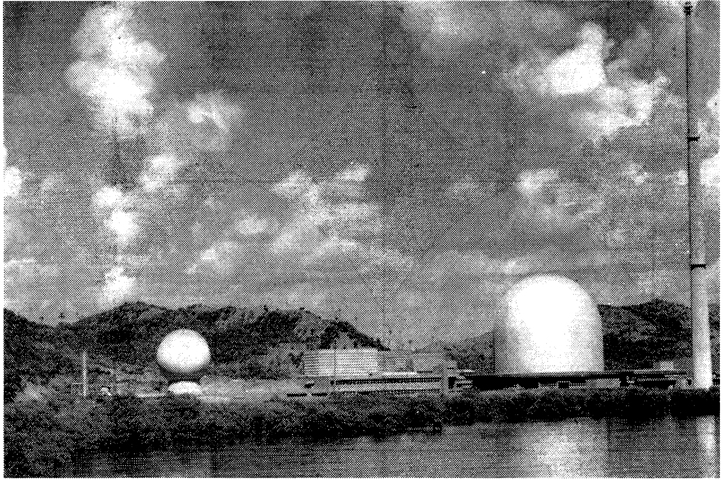
A variety of geophysical phenomena (such as atmospheric and oceanic circulation patterns, cosmic-ray prehistory) are being investigated using, as tracers, radioisotopes produced in the cosmic-ray bombardment of the earth's atmosphere. The rates of production of the various isotopes in the atmosphere have been estimated fairly accurately and their concentration in diverse terrestrial materials, for example, air, rain, sea-water, marine siliceous sponges, and ocean sediments, is being measured. A radiocarbon laboratory has been set up for studying human antiquity in India, and a tritium laboratory for studying ground-water movement and other such hydro]ogical problems. There is also a small but intensive programme of palaeomagnetic research ; the results obtained indicate that India has moved to its present position at about 40° latitude north from an earlier location south of the equator.

The largest single group at the Institute is the Cosmic Ray and High Energy Physics Group. In this the nuclear-emulsion section is probably the best-known internationally. It was responsible in 1953 for some good work on elementary particles using one of the earliest stacks of stripped emulsions. The observations made then included the first decisive examples of disintegrations caused by the capture of negative kaons in emulsions, examples of 'associated production' (which were then not recognized as such, but commented on), and so on. Recently the group has carried out a number of investigations on the primary cosmic radiation which have an important bearing on the origin and history of cosmic rays. Emulsions exposed to high-energy beams at CERN, Berkeley and Dubna are also being studied, and there is a big programme for the study of 'jets'. For this, in April 1961, a tungsten-emulsion sandwich stack, the largest such stack yet exposed, of area 1200 mm X 600 mm and weighing 675 kg, was floated for 30 hours around 26 000 metres in a flight from Hyderabad ; this work is in collaboration with the University of Bristol.

A large group exists for producing and flying plastic balloons, which carry loads of about 45 kg to 33 000 m. In addition to emulsion stacks, various counter telescopes, such as scintillator-Cherenkov detector assemblies, are flown for primary-cosmic-ray studies. The use of high-pressure gas Cherenkov counters to study the isotopic abundances of helium nuclei has been recently developed.

The cosmic-ray group has also a high-altitude field laboratory at Ootacamund (2200 m) — a hill station in South India. Here there is a big array for studying the properties of extensive air showers and an experiment in high-energy physics studying nuclear interactions between 20 and 200 GeV ; the latter uses a multiplate cloud chamber, a total absorption spectrometer and an air Cherenkov Counter (to separate pions from protons). A new multiplate chamber, measuring 2 m X 1.5 m X 1 m, is one of the largest of its type in the world. In the Kolar Gold Mines in South India, cosmic-ray intensities have been measured to a depth of 9400 m.w.e. (metres of water equivalent) — 2750 m below ground —, the greatest depth hitherto investigated. The cosmic-ray programme is thus a very extensive and varied one, and of great interest.

Two other Institutes in India are heavily financed by the Indian A.E.C. The Physical Research Laboratory at Ahmedabad has been engaged mainly on investigations of cosmic-ray time variations, aeronomy — particularly atmospheric ozone, and the properties of the ionosphere ; this laboratory is now entering into the areas of solar modulation phenomena in interplanetary space (plasma streams from the sun, geomagnetic changes -etc.), satellite tracking and telemetry, and geophysical observations based on rocket experiments. The Saha Institute of Nuclear Physics, Calcutta, is engaged in low-energy nuclear physics, mainly theoretical ; the principal experimental work there is in magnetic resonance and nuclear spectroscopy. There is also the Institute of Mathematical Sciences, Madras, which does theoretical work in elementary-particle and high-energy physics, applied mathematics, and astrophysics.



General view of the Atomic Energy Establishment at Trombay.

The amount of research carried out in the universities, is, by comparison, very small. The student numbers are large and the main emphasis is, of necessity, on teaching. However, some work in high-energy nuclear physics is carried out in the Universities of Delhi and Chandigarh, for example, which have both received nuclear emulsions exposed at CERN. Most of this sort of research work is supported by grants from the Atomic Energy Commission. The interest and enthusiasm of many of the people is very high, despite great obstacles.

CONCLUSIONS

The study of nuclear physics, and high-energy physics in particular, by its nature — because of the heavy financial outlay involved and the rapid developments in these fields — can only be considered at a later stage in the economic development of a country. Difficulties are not only the lack of funds and effort that can be spared in the earlier stages, but in most cases also the remoteness of the big centres. For instance, only the larger universities can afford journals such as the Physical Review, *and then they arrive usually some months after publication. Foreign-exchange regulations, necessary for the utmost use of low export earnings, make the purchase of even simple scientific equipment from outside either difficult or impossible. In such conditions it is a creditable achievement that so many groups are doing useful work in high-energy physics.*

One way in which CERN can foster the groiving interest in this field is by giving special attention to candidates from these more remote countries when awarding grants from the Ford Foundation for Visiting scientists, so long as there are possibilities for continuing the ivork after they return home. More generally, nuclear emulsions from research groups in these countries are exposed at CERN and returned for examination, and in some cases batches of bubble-chamber pictures could be sent to them for analysis. Noivadays, these tivo methods represent the easiest and cheapest approach to the subject. Another way in ivhich CERN helps is by sending its publications anyivhere, without restriction or charge. Clearly this kind of co-operation, not only by CERN but also by the many other established centres of high-energy research, will continue in an increasing ivay •

A. Lundby (second from left) **waits while E.G. Michaelis, who was Scientific Secretary of the Conference, signs for his volume of the Proceedings. Distributing the copies are H. Coblans, head of the Scientific Information Service, and Rhona Ball, his secretary.**

On 25 October the publication in record time of the **Proceedings of the 1962 International conference on high-energy physics** *ivas celebrated at a small party given by the Director-general.*

Copies of the book were available for those who had ordered them, only fifteen weeks after the end of the conference. Edited by J. Prentki, with an editorial committee of R. Armenteros, V. Glaser and A.E. Taylor, the Proceedings were **published by the Scientific Information Service of CERN** *(from ivhom copies may be obtained at the low price of* **60 Swiss francs).**

Conference Proceedings Published

We print beloiv a review of the volume by Prof. H. Feshbach, of the Massachusetts Institute of Technology, ivho has recently arrived at CERN to spend a year with the Theory Division.

This was undoubtedly a most exciting conference. To be sure a sizeable fraction of the world's most able physicists were here at CERN. But more important they had many things to report, much to discuss and clarify. And there was the realization, sometimes explicitly recognized, that a new branch of physics had come of age. For the first time there was confidence that the various landmarks and geographical features of this new world, which had been slowly making their appearance, would all come completely into view and that it would shortly be possible to ask the more subtle dynamical questions dealing with its topographical structure. And one must remember that fifteen years ago there were only some vague intimations of its existence ! The entire evolutionary process has been compressed into this short period, and because of this we have a remarkably clear-cut example of the operation and power of the 'scientific method'. It may sound trite to say so, but this writer has found it most thrilling to watch the experimental information develop from very vague first indications and the theories from speculative analogies.

The 'Proceedings' follow the general plan of the conference. There were several sessions running in parallel in which various invited as well as contributed papers were delivered. These were supposedly summarized in plenary sessions for the conference as a whole by the 'rapporteurs'. Not all of these gentlemen were faithful to their tasks. Several of the rapporteurs' articles are superb but for others it is necessary to refer back to the records of the original sessions in order to recover the available information fully. Be that as it may, reading the rapporteurs' papers and the summary delivered by V.F. Weisskopf will not only provide a framework for the more detailed sessions but will also reveal what were considered to be the most significant developments.

Each copy of the Proceedings

— **weighs 2.5 kg**
— **measures 28 cm X 23 cm X 5 cm**
— **contains 976 pages**
— **records 208 lectures and the discussion of 20 parallel, 1 special and 13 plenary sessions**
— **contains 810 illustrations, with 2 colour plates**
— **lists the names and addresses of 357 scientists from outside CERN who attended the conference**
— **indexes the names of 764 scientists who were part authors of papers or took part in the discussions.**

A special session was devoted to the neutrino experiment in which it was demonstrated that the neutrino emitted in pi-mu decay differs from that emitted in nuclear beta-decay. The cross-sections involved here are of the order of 10^{-38} cm^2, which points up the great advances in technique which must have been made in order to make it possible to observe these very rare events. Such selectivity, it might be added, is necessarily expensive. It is amusing to recall that one of the goals of the original meson theory of nuclear forces was to explain nuclear beta-decay ; it turned out that the experimental particle on which this notion was based was not the pi-meson, and to add insult to injury the neutrino emitted in pi-decay bears no simple relation to the beta-decay neutrino.

Although this experiment resolves one of the contradictions in the theory of weak interactions a very important 'difficulty' remains. The word difficulty is put in quotes only to indicate that is exists only within the framework of a certain set of hypotheses on weak interactions, namely the universal current-current coupling scheme. If this hypothesis is wrong the difficulty disappears. However, assuming its validity the experimental measurements showing that strangeness can change by two units in weak decays are in contradiction with the ratio of the decay probabilities to the mass difference of the K°_1 and K°_2 particles.

But these fascinating weak-interaction problems are really only tangential to the developments alluded to at the beginning of this review. For these we must turn to the strong-interaction sessions in which the meson (pi and K) interaction with baryons, the pion-pion and the pion-kaon interactions were discussed. There is much new data. There are the newly discovered multi-pion systems such as the omega, rho and eta particles. There are new baryon resonances induced by the meson-baryon interaction. There is much structure and we can expect more. But most remarkably there are theoretical

22nd session of

CERN COUNCIL

discusses growth of our organization

On 12 October, delegates from the 13 Member states, together with observers from Turkey and Yugoslavia, gathered at CERN for a special session of Council, under the presidency of Mr. J. Willems (Belgium).

Their main purpose was to discuss the report on the programme and budget, drawn up earlier this year by a working party headed by Mr. J.H. Bannier, Director of the Netherlands Organization for the Development of Pure Research (Z.W.O.). The report, which was briefly discussed at the Council meeting last June, was approved in its broad lines. Among its proposals are recognition of the need for CERN to continue growing, with expenditure increasing by between 10 and 14 per cent, per year for the next few years, and a procedure for long-term planning and budgeting. In future, planning will be on a continuing 4-year basis : each year a budget for the next year will be fixed, together with a firm estimate for the following one, and broad indications must also be given for the two years after that.

The members of the Council heard a statement by Prof. CF. Powell (U.K.) who, as chairman of the Scientific Policy Committee *, reported the assessment of CERN made by this body. 'The judgement and aspiration of those who founded CERN have been most brilliantly vindicated', he said: 'Every month brings important discoveries ... and there can be hardly any doubt that in the next decade this process will continue and ... bring radical changes in our understanding of matter and in our basic conception of it. Through the development of CERN, Europe has to make very valuable contributions to these great developments. In all the member States, physicists see CERN as their chief place of experiment ... and sometimes forego equipment and resources in order that CERN can be better supported. The Scientific Policy Committee concludes that CERN plays an indispensable part in the development of European physics and this institution can have a brilliant future.'

Thanking the representatives of the member States for the support and recognition they have given to the work of CERN, the Director-general, Prof. V.F. Weisskopf, said : 'The recent Conference on high-energy physics has shown that CERN now plays a leading rôle in this field. Our policy has been to do the best experiments here and to make ourselves available to a growing number of visiting scientists. A result of this is the ebbing and even reversing of the flow of European physicists going to work in the United States. However, probing the secrets of the fundamental aspects of the universe will become harder and harder and this will require an appropriate rate of increase' •

* The Scientific Policy Committee is a committee of Council which keeps under review and makes recommendations to the Council on the scientific work of CERN. Its members, who are not necessarily Council delegates, are distinguished scientists, selected primarily on personal scientific grounds with no considerations of nationality. Present members are Prof. C.F. Powell (Chairman), Prof. L. Leprince-Ringuet (Vice-chairman), Dr. J.B. Adams, Prof. E. Amaldi, Prof. N. Bohr, (until his death on 18 November), Prof. W. Gentner, Prof. C. Môller, Prof. F. Perrin, and Prof. P. Scherrer.

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The chairman of the Scientific Policy Committee and the Director-general, Directorate Members and Division Leaders of CERN were present ex officio.

* Adviser ** Alternate

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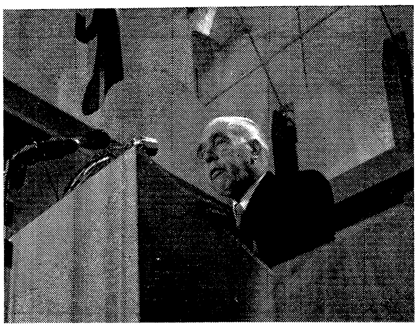
speculations; the Regge pole-trajectory hypothesis, which seems to be able, to some extent, to order these resonances and particles and thus permit one to expect that in the near future we will be dealing with fundamental dynamical questions. The reason for this optimism lies in the experimental verification of one of the predictions of Regge pole theory, namely the shrinking of the forward diffraction peak in nucleon-nucleon scattering. It is not clear that these predictions about the high-energy behaviour of cross-sections are indissolubly connected with all the assumptions made about the Regge trajectories, and of course much work, both experimental and theoretical, remains to be done in this area.

All of these matters and many others are discussed in the record of the conference. It hardly needs to be said that all persons interested in high-energy physics, and I include both those who did and those who did not attend the conference, will profit from reading this volume. It is of course not a book for a beginner, for it presumes a certain background and the possession of a certain vocabulary.

This review would be incomplete without some words of commendation for the editors and publishers. The report was published only three months after the conclusion of the conference. A glance at the vital statistics shows what a remarkable performance this was. And even under these highly rushed circumstances a fine-looking, well bound, legible book was produced. It is inevitable that there are some typographical errors but they are not likely to confuse •

H. Feshbach

NIELS BOHR



While this issue was in preparation news came of the death in Copenhagen on 18 November of Prof. Niels Bohr. World-renowned as a physicist and as a man, he is remembered here at CERN especially for the leading role he played in our foundation, and as the leader of the Theoretical Study Group, in his own Institute of Theoretical Physics, in the early days before the laboratory at Meyrin was ready, as well as for his guidance as a member of the Scientific Policy Committee.

On the day the news was received, Prof. Weisskopf, himself a former student and collaborator of Bohr's, wrote the following appreciation :

The flags at CERN are flying at half mast. CERN has lost the greatest of its founders. The world has lost a great man.

Niels Bohr died yesterday after a life full of achievements. He discovered in 1913 the fundamental role of the quantum in the structure of the atom and since then he was the intellectual leader of the greatest scientific break-through in the history of human search info the nature of things.

Before Bohr, nobody knew about the structure of matter ; after Bohr the material phenomena with which we are surrounded are well understood. Because of Bohr, we know how light is radiated and absorbed, how atoms join info molecules and how electricity produces its effects, and our knowledge even penetrates info the secrets of the atomic nucleus. Never before was so much explained by so few in such a short period of time as it was under Niels Bohr's leadership.

It was his way of looking at the atom which gave science a fool of comprehension, so all embracing that if was possible for the first time to consider all natural phenomena from the hottest star to the living cell, as the effect of one fundamental principle.

His influence is felt wherever science is pursued all over the world. CERN would not exist if if had not been for the untiring efforts of Niels Bohr to bring about in the heart of Europe an international laboratory devoted to the innermost structure of matter. He always looked at science as an endeavour which goes beyond national boundaries, not only as a means for research but also as a bond between men.

The significance of Niels Bohr for humanity cannot yet be estimated. We are too near to his work and to the developments which his work has created. Future generations will recognize how his work stands ouf as a tower of achievement in the culture of our days #

It was Prof. Bohr who released the traditional bottle of champagne to mark the inauguration of our proton synchrotron on 5 February 1960. The photograph above was taken during the address he gave on that occasion.

IMI GBrZN (cont.)

made to one of the two main vacuum pumps, but the most important change was the installation of a system for modulating the voltage of the **radio-frequency system** during the accelerating cycle. This was the second stage of the r.f. modifications designed to increase both the internal circulating beam and, more important, the yield of secondary particles from internal targets. Modification of the focusing system and better adjustment of the extractor for the **external proton beam** resulted in an intensity of 3×10^{11} protons per second in the proton room, focused into an area of about 2 cm^2. This was with a circulating-beam current of 1.2 microamp.

On 3 October the **magnet** for the CERN **2-m hydrogen bubble chamber** was subjected to a 24-hour run at full current, thus sucessfully completing its acceptance tests. This magnet, which is the largest single magnet at CERN after that of the synchro-cyclotron, contains 350 tons of iron and 60 tons of copper. To excite it fully, a current of 10 000 A is required at 600 V, giving a power consumption of 6 MW. Cooling water is circulated at the rate of 50 litres per second. Following its acceptance, systematic measurements of the magnetic field were carried out, showing that over the volume of the bubble chamber looked at by the cameras (approximately 2 m X 50 cm X 60 cm) the field is uniform to ± 2 %. The maximum field is 17 200 gauss. These measurements confirmed the design figures and those calculated earlier from model tests.

On the last Saturday in September, dismantling was begun of **Barrack 11,** situated beside the entrance road leading to the administration building. Its departure is to make way for the new electricity sub-station that will be erected on that part of the site. Re-erection of the Barrack was later begun near the synchro-cyclotron building.

Also during October, a start was made on the **new road** leading from this entrance around the eastern side of the administration building to the new accelerator research building.

At the end of the month, the Director-general, Prof. **Y.F. Weisskopf,** travelled to Israel, where on 31 October he was invested as an Honorary Fellow of the Weizmann Institute, Rehovoth, in recognition of his work as an 'international scientific ambassador', striving always to overcome national barriers and to develop scientific collaboration •

BOOKS

L'oxydation des métaux ; Tome I, Processus fondamentaux, (The oxidation of metals ; Vol. I, Fundamental processes.) Edited by J. Benard (Paris, Gauthier-Villars, 55 NF).

In addition to the chapters provided by the editor, this book includes contributions from Jean Bandolle, Florent Bouillon, Michel Cagnet, Jean Moreau and Gabriel Valensi.

Oxidation phenomena are studied in such a way that the reader can follow the whole development of research relating to each aspect of the problem, namely, adsorption, germination, growth of thin films, growth of thick layers, and oxidation of alloys.

The authors have relied on experimental results in their identification of the various factors involved and the establishment of correlations between them. In theoretical studies based on the results of this work an adequate number of observations is taken into account.

Two aspects of oxidation are covered to the same extent. One concerns the chemisorption of oxygen in a weakly oxidizing atmosphere, a phenomenon which is of great importance for ultra-high vacuum and the optical properties of reflecting surfaces. The other concerns the properties of true oxides forming on the surface of metals, and especially the mechanical properties of such oxides.

The book is well written and contains a good number of illustrations of the phenomena discussed.

R. Godef

Low-temperature physics. Lectures delivered at Les Houches during the 1961 session of the Summer School of Theoretical Physics, University of Grenoble. Edited by C. Dewitt, B. Dreyfus, and P.G. de Gennes (New York, Gordon and Breach, $ 20.00, students' edition $ 9.50).

The lecturers, some using English, some French, are A.B. Pippard, M. Tinkham, H. Suhl, J. Beenakker, A. Herpin, L. Néel, C. Kittel, A. Abragam, and J. Friedel. They cover in a fairly general way the theory of electrons in metals, superconductivity, superfluidity, magnetism, defects and irradiation, and the Môssbauer effect, with a more specialized account by Néel of the properties of 'grains fins antiferromagnetiques'. The arguments of the general articles are on conventional lines, except for that of Pippard on electrons in metals. There, a sustained attempt is made to work as far as possible in classical and geometrical terms ; this will appeal to some people, and others will find it perverse.

Except for Néel's article, and that of Friedel on irradiation effects, the work is strongly theoretical in character; however, the theory is not developed in the abstract, but with constant, if schematic, reference to experimental data. The book is valuable to theorists as a fairly up-to-date review of this field. It could also be useful to low-temperature experimenters prepared to work rather hard to understand the theory.

J.S. Bell

There can be found, in what would be called 'good libraries', a half-dozen or so very good English-language periodicals, whose aim is not so much the popularization of science as — to use an expression of M. Louis Armand's — its 'cultivation' ('culturisation').

Such journals are scarcer in French ; there are perhaps three or four. **'Sciences'** (115, bd St. Germain, Paris 6, 27 NF for 6 issues per year) is one of these. Each issue offers a variety of interesting articles of high scientific value, written by scientists or engineers on a level suitable for a large educated readership.

As a typical example, Prof. Louis Leprince-Ringuet has recently contributed an article on 'The era of giant accelerators', in which he reveals a certain amount of sadness at the disappearance of the older methods of physics in favour of the more specialized work of the present-day large laboratories.

Easy reading of the articles is helped by the layout and printing.

'Sciences' has now reached its 18th issue. If its publication only every two months, and somewhat irregularly, is to be regretted, its publishers must be given credit for knowing how to present to the exclusively French-speaking man with an enquiring mind a publication which will keep him informed about the major currents of contemporary science.

R. A.

Also received :

Polish Academy of Sciences, Institute of Nuclear Research, Chemical Publications 1955-1960. (Warsaw, Office of the Government Commissioner for Use of Nuclear Energy, Division of Scientific and Technical Information, 1962). — Photoprints in full or summaries of published and unpublished papers, reports, reviews, and books. Abstracts in Polish, Russian, and English •

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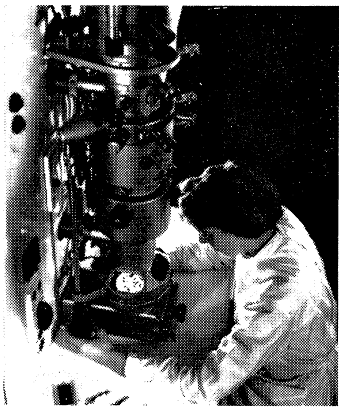

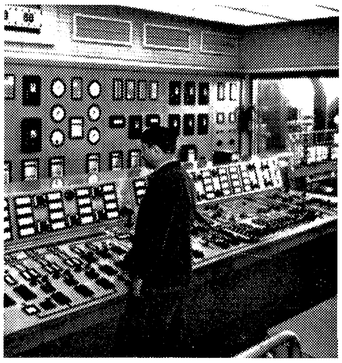

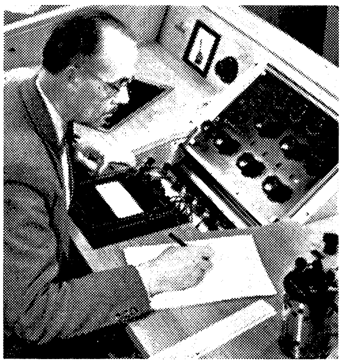

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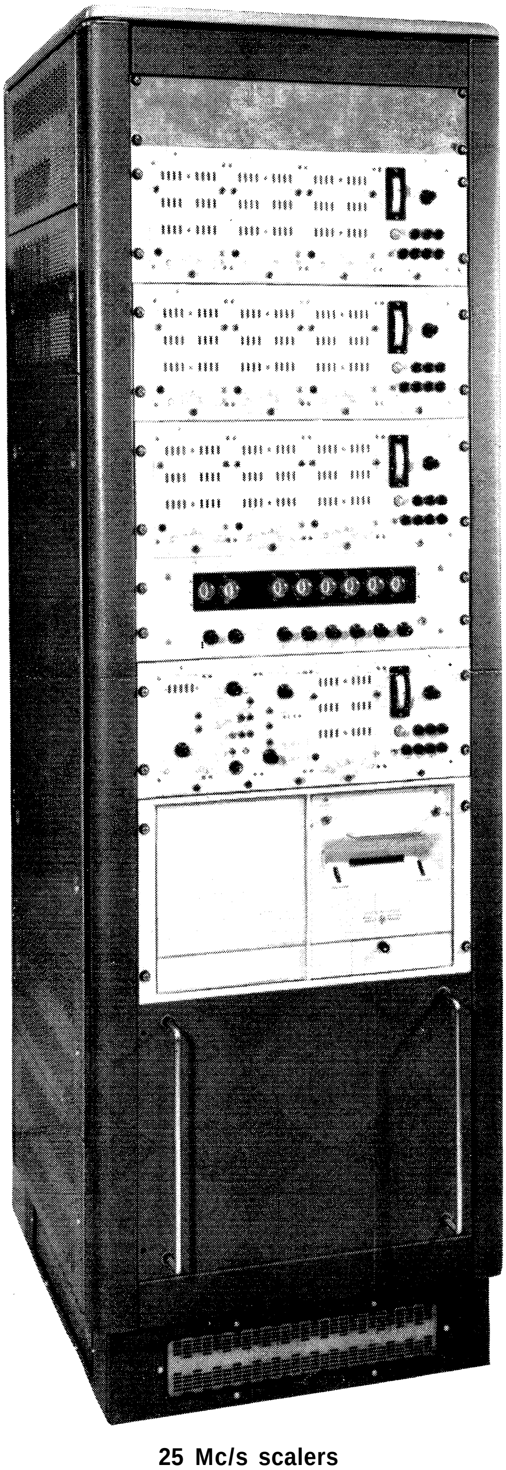

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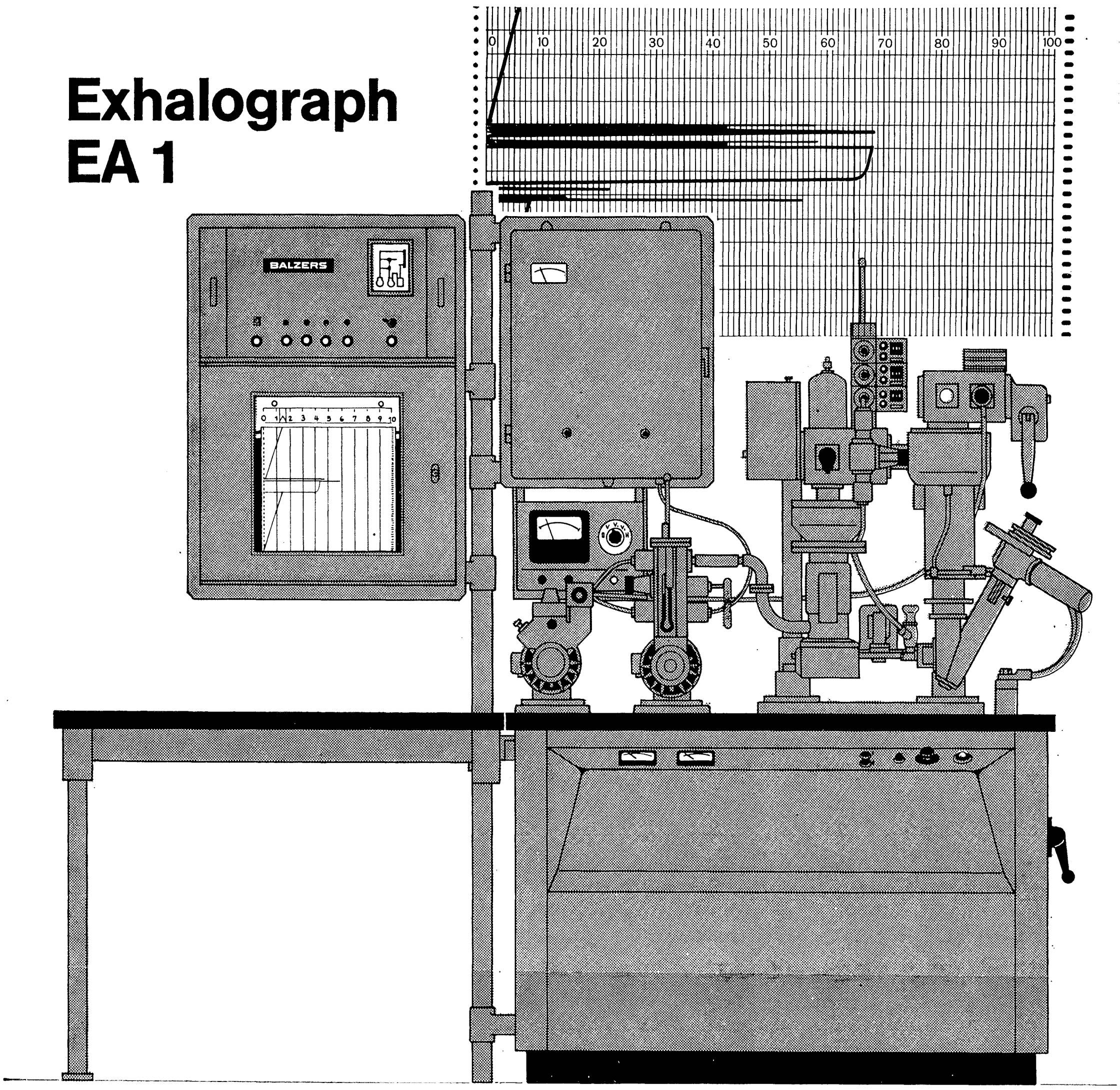

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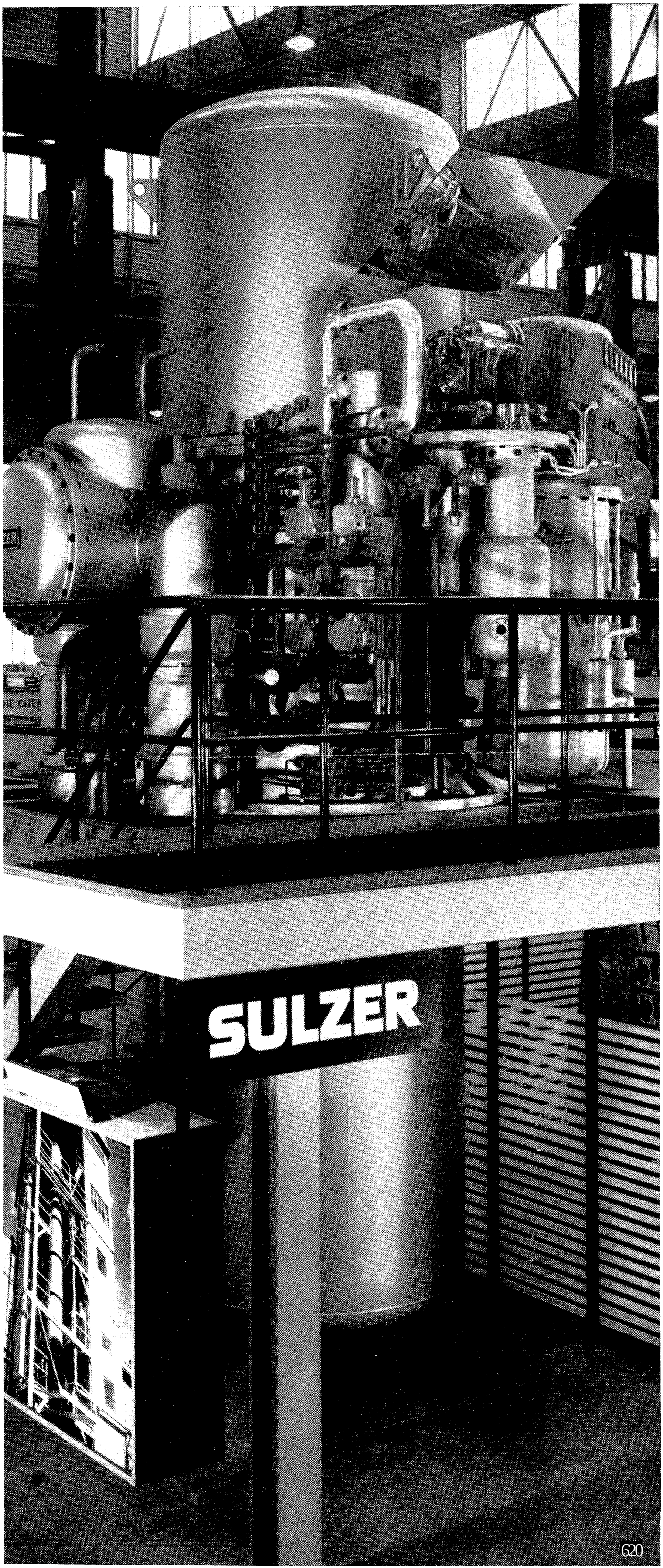

SULZER

Low-Temperature Installation for the Two-Metre Hydrogen Bubble Chamber of the European Organization for Nuclear Research (CERN)

-250°C

At the present time CERN in Geneva is constructing a large hydrogen bubble chamber with a useful length of 2 metres and a liquid capacity of about 1 000 litres for experiments with the 28 giga-electron-volt proton-synchroton.
To cool this chamber from room temperature down to the operating temperature of about —245° C, to fill it with liquid hydrogen and to maintain stationary conditions during experiments, Sulzer Brothers are supplying a low-temperature installation with a nominal refrigeration capacity of 4 000 watts (3 440 kcal/h) at -250° C (23° K), obtained exclusively by gas expansion in turbines.

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