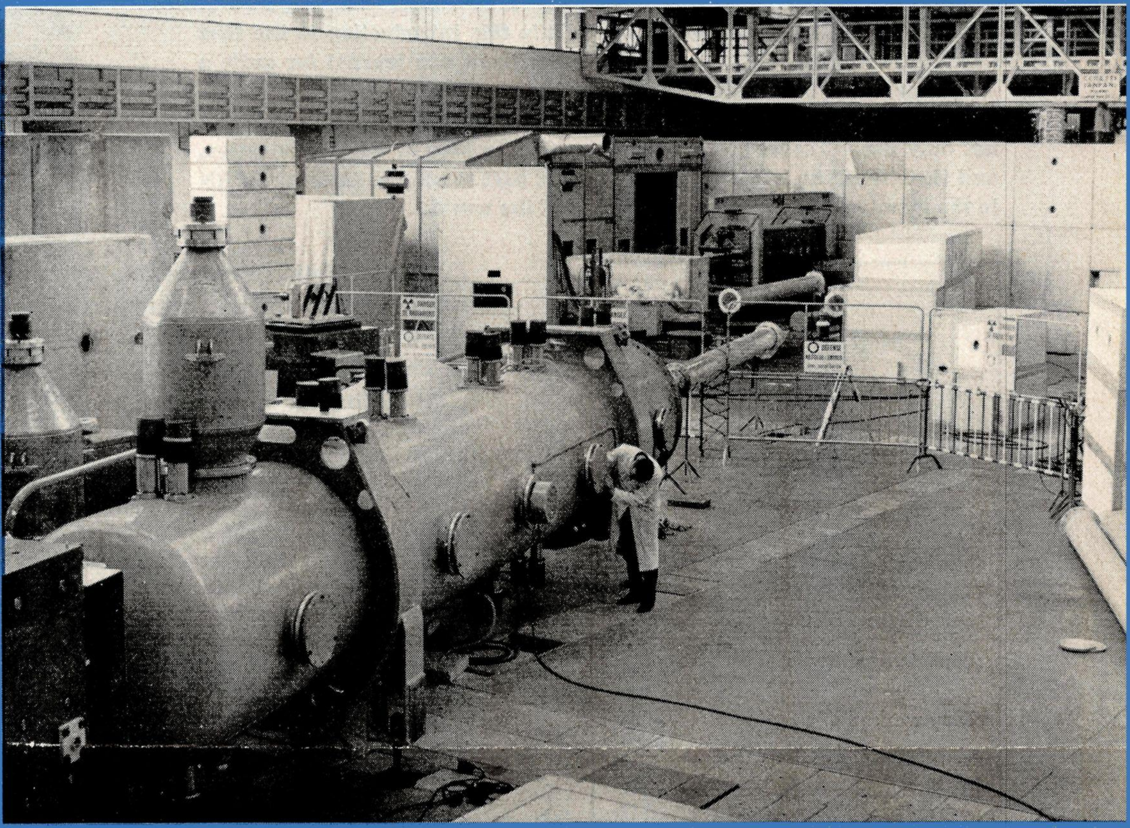
CERN COURIER



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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

A message from the Director-General

I am very glad to be able to contribute this introduction to the first *CERN COURIER* of 1962. We have been without our journal for quite a long time, but we can now look forward to seeing it regularly again once a month. *CERN COURIER* is an important publication of ours, because not only does it serve to link together all members of the Organization, and their families, but it also has a strong part to play in showing CERN to the member States and to other parts of the world.

This institution is remarkable in two ways:

It is a place where the most fantastic experiments are carried out.
It is a place where international co-operation actually exists.

These two statements call for some explanation:

It is difficult to appreciate the full significance of an activity if all one's energy is devoted to it. The everyday work accomplished at CERN hides its real importance, the tremendous impact of what is going on here. What I am tempted to call the 'romantic glory' of our work is overlooked. But you must never forget that in the PS, at the moment when the beam hits a target, at the moment when matter undergoes a transfer of energy, you have created conditions which probably do not exist anywhere else in the universe, not even in the explosions of super-nova stars. What an opportunity to penetrate the innermost structure of matter in conditions never created even by Nature !

But CERN is also a centre of international co-operation, unique of its kind. There are other examples of such co-operation in economic, political, and military fields. But all our work is for an idealistic aim, for pure science without commercial or any other interests. Our effort is a symbol of what science really means, namely the exploration of Nature by Man. Here, differences based on nationalities are non-existent. And, in this respect, CERN is the only really scientific laboratory, because it is international.

CERN is now passing from the first period, of machine construction, to the second, the period of scientific research with the machines. The first period has been a heroic one. CERN has accomplished an incredible task which is outstanding in the history of accelerators. Many people thought Europe would never be capable of such an effort. In fact Europe managed it even better than others.

We now possess two of the best accelerators in the world. One, the PS machine, which, together with the Brookhaven accelerator in the U.S.A., is the largest machine in the world ; the other, the SC machine which is smaller but still an extremely useful tool of research.

We must do our best to exploit these machines for scientific discoveries. For this purpose many large instruments have to be built. We need bubble chambers, separators, beam transport equipment, and many other things which have still to be built.

At the same time, we are beginning to perform experiments, and to discover new phenomena and new facts of nature. The work at CERN has already contributed much to the knowledge of the structure of the elementary particles which make up atoms. If we are successful, the next few years at CERN will be most interesting and exciting. The beams of the accelerators at CERN penetrate the innermost parts of the atom. CERN therefore presents a unique opportunity to the physicists of Europe for solving some of the most important questions: What is the structure of the proton and the neutron ; what are the constituents of atomic nuclei ; what is the nature of the nuclear force which keeps them together and which is the cause of nuclear energy ; what is the secret of radioactivity ; and what are the properties of anti-matter ?

All these questions and many others are under study here, in international collaboration: fourteen nations are exploring the unknown.

Victor F Weisskopf

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The cover photograph shows the large electrostatic separator, the second of a series of three built by the NPA Division, installed in the South experimental hall of the synchrotron. In the background are a portable radiation barrier and concrete shielding (an article on radiation safety begins on p. 4).

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BRINGING THE RECORD UP TO DATE

Last year at CERN

Owing to the long time since the last appearance of *CERN COURIER*, our usual feature 'Last month at CERN' requires a temporary change of title. Unfortunately it is not possible to cover in detail all the events of the past year, but it is hoped that the following account includes the chief items of interest and gives an idea of what has been happening recently at CERN.

From the beginning of the year, the laboratory was reorganized internally into **twelve divisions**, indicative of its broadened scope and increased emphasis on experimental work, following the full operation of the second particle accelerator. The divisions are : PS Machine, SC Machine, Nuclear Physics, Engineering, Data Handling, Theory, Track Chambers, Nuclear Physics Apparatus, Accelerator Research, Site and Buildings, Finance, and General Administration. Then on 1 August, J. B. Adams left for England, to be replaced as Director-General by Prof. V. F. Weisskopf. The 19th Session of the **Council**, reported briefly elsewhere in this issue, took place at CERN on 2 June, and the 20th on 19 December.

A noticeable change has been brought about in the appearance of the site by the progress on new **building projects**. In April, 1120 m^2 of floor was laid in the courtyard at the eastern end of the South experimental hall of the proton synchrotron, followed two months later by roofing, thus providing another large area for engineering and auxiliary experimental work. A further wing was added to the adjacent laboratory block. One result of these changes was to enable the **Engineering Division** to release the space it formerly occupied in the South hall. For the new **East experimental area** the large triangular apron has been laid and the new building at the end of it has already started to receive sections of the 1,5 m **British Hydrogen Bubble Chamber**. The neighbouring compressor and generator buildings to serve this and the CERN 2-m hydrogen bubble chamber that will also be installed, are more or less finished, and at the end of the year a 10-m-diameter steel sphere was being completed at one corner of the apron. This is to accept in the form of gas the whole volume of hydrogen from either chamber in case of emergency.

The **NPA building**, for development of nuclear physics apparatus was brought into operation in June, and parts of the new building for the **Accelerator Research Division** in December. On 6 November, new electrical and mechanical stores for the **Site & Buildings Division** were inaugurated.

An important step forward in the use of the proton synchrotron was the bringing into service of the **North experimental hall** in September. Towards the end of the year, the first of the **CERN electrostatic separators** was installed there as part of the system for providing a 1,5 GeV/c negative K-meson beam. The electrostatic field of this separator can be as high as 53 kV/cm over a gap of 8,5 cm. The **32-cm hydrogen bubble chamber** operated by the **Track Chambers Division** was transferred to the North hall initially to help in setting up the beam and then for experiments. The d.c. power supplies in this hall total 3500 kW for beam-transport magnets and 3000 kW for track-chamber magnets.

Full exploitation of the **synchrotron** was hampered to some extent by the civil engineering work on the East junction, and for some time it was possible to run the machine only at week ends. Complete shut-downs totalling 11 weeks were also necessitated by this work, by the installation of new equipment, and for changing beams. More time was lost by the breakdown of parts of the injector system. In spite of these pauses, however, some **1540 hours** were devoted to nuclear physics in the six months from June to November, out of a total running time of 1907 hours, and at the end of the year **93 hours a week** were being given to nuclear experiments. Beam intensity then was **$2{,}5 \times 10^{11}$ protons per pulse.** The **permanent PS control desk** was installed in August, and a platform erected in the North hall to act as a centre for counting and control equipment belonging to the experiments. The accelerator can now produce secondary beams of 120-milliseconds duration, and a 6-headed **target** assembly is also being used with success.

In June, there were altogether 44 standard magnets and lenses available for the guidance of secondary beams from the PS. To supply them with power the new **generator building** houses 30 generators with outputs ranging from 40 to 320 kW together with 4 of 1500 kW each.

In the first ten months of 1961 the **synchro-cyclotron** provided **5361 hours** operating time for nuclear physics, apart from over 1000 hours when 'parasite' experiments were possible. In this time only 195 hours were lost because of machine faults. In addition to the Easter holiday, there was one shut-down of 10 days in mid June and another in October.

The internal beam intensity was raised during the year from **0,3 μA to 0,8 μA**, by mixing small amounts of argon in the hydrogen supply to the ion source, and improving the electrostatic focusing near the source. Another way of increasing the usefulness of this accelerator has been the installation of devices designed to increase the duty ratio of internally produced secondary beams. An increase from below 1% to about 25% is achieved. Further studies and experiments are continuing to augment the intensity and improve the duty ratio of the extracted proton beam. Twelve new generators of a total capacity of 680 kW have been installed to supply beam transport equipment.

Among activities in the **Engineering Division**, two prototypes of controlled semi-conductor rectifiers were built, one rated at 500 A, 125 V, the other at 100 A, 25 V. Such rectifiers, used instead of motor-generator sets, will simplify the provision of power for beam-transport magnets. Other applications of semi-conductors, developed by the **Nuclear Physics Division**, are transistorized scalers, fast pulse amplifiers, etc.

Still on the subject of new equipment, the magnet armature for the **CERN 2-m hydrogen bubble chamber** was completed at the manufacturers' works towards the end of the year. Also nearing completion was the transport system : on site, the 4000-W refrigeration system was being erected.

Development of the **microwave particle separator** has continued, the aim being to produce separated beams of antiprotons and positive and negative kaons between 10 and 20 GeV/c. Experimental equipment to permit the accurate study of **spark-chamber** operation was completed.

A major success of the year was the setting up of the separated **antiproton beam** (up to 1 GeV/c momentum) from the PS. This was carried out by the **Nuclear Physics Division** with the assistance of visitors, and was made possible by the use of two electrostatic separators from the **University of Padua**. In addition, a score of lenses and magnets were used to guide the beam, fed by 18 independent generators. The first experiment using the **81-cm hydrogen bubble chamber from Saclay** was carried out with this beam, resulting in 170 000 photographs showing 300 000 antiprotons stopping in the chamber, and another 90 000 photographs showing low-energy antiprotons passing through. A study is being made of the production of pairs of K-mesons by antiprotons at rest. Measurements of total cross-section in hydrogen have also been made. In September, this beam was replaced by its successor, designed for separated antiprotons up to a maximum of 6 GeV/c. With the second of the **CERN electrostatic separators** installed in the South PS hall, 3,6 GeV/c was reached in December.

It is not possible to note all the dozens of experiments that were carried out during the year. We should mention

(continued on p. 12)

Radiation Safety at CERN

by Johan Baarli, Head of Health Physics

*In this article, adapted from a paper which he read at the IVe Conférence Internationale de Protection Civile, at Montreux, last October, Dr. Baarli describes the means adopted at CERN to ensure safety from radiation hazards, and how effective they are. A previous article by Bernard M. Wheatley (*CERN COURIER *No. 13-14, Aug.-Sept. 1960) dealt more fully with the Health Physics Group itself.*

During the design of the CERN accelerators theoretical studies were carried out in order to determine the specifications of the necessary shielding arrangements. Shielding is of importance for two major reasons: to reduce the radiation level around the machines in order to carry out experiments under conditions which are as 'clean' as possible, and to give general protection against radiation. The results of these calculations have to a large extent determined the shielding dimensions and arrangements now forming part of the machines.

Radiation safety at the CERN site falls into two major categories according to whether the machines are operating or not. During usual operation of either machine the acceleration of protons takes place in the vacuum chamber, which is completely surrounded by the radiation-shielding arrangements. The beam of accelerated protons then hits a target located in the vacuum chamber. Scattered protons, or particles produced by nuclear reactions in the target material, pass out of the vacuum chamber, are collimated through holes in the shielding, and are used for experiments in the halls located outside. Under these circumstances the radiation outside the shielding is kept low, although there is still a certain radiation level outside due to some penetration. This radiation is mainly composed of fast charged and uncharged particles and offers special problems for measurements of radiation dose and judgement of radiation hazards.

During shut-down of the machines, radiation-safety problems are mainly caused by induced radioactivity in the targets and in the materials of the vacuum chamber and surrounding machine components. Particles accelerated to high energy cause nuclear reactions which result in radioactive nuclei of great variety. Problems of radiation safety in this connexion are quite similar to those met when working with radioactive isotopes, the difference being that the radioactivity is here concentrated in the machine components and materials that the beams have been hitting. This necessitates special precautions for work near the machines, and for maintenance and repair of the machines themselves.

Most danger arises when machines are operating, but heavy shielding and restricted access ensure safety. Main hazard is given by fast and slow neutrons — apart from external beams, which are made inaccessible. Prediction of actual beam hazards is difficult because of scarce data on biological effects of particles with GeV energy. Neutron intensity outside PS shielding but within safety fence is 5% of maximum permissible level (2.5 mrem/h) for continuous exposure, in plane of beam ; rather more than m.p.l. near ventilators. Measurements in general site area show neutron level only few times background with both machines operating.

Hazard with machines shut down is local, mainly beta and gamma radiation from iron in vacuum tank. Levels of 6 rem/h in vacuum tank to 10 mrem/h in machine hall have been measured for SC ; 2 rem/h near targets for PS.

- **800 people out of 1400 wear gamma film badges;**
- **150 also wear neutron film badges.**
- **All 800 have medical inspection at least once a year.**

In 1960, 703 received less than 1/5 maximum permissible exposure of 5 rem; only 1 slightly above.

General radiation-safety problems, apart from those closely concerned with the machines, are also met at CERN in connexion with the use of radioactive sources for calibration and testing purposes, and also in connexion with irradiated targets taken out and used for nuclear chemistry studies. In addition, there is the control of radiation-exposed personnel, which forms an important part of the CERN radiation-safety activities.

Safety during operation

Fig. 1 shows a plan of the 600 MeV synchro-cyclotron (SC) with the vacuum chamber, the target, magnet, shielding walls, and experimental halls. Beams of fast particles produced in the target are taken out into the experimental halls through channels in the shielding. The radiation level inside the machine hall is quite high when the machine is operating, and a very reliable security system ensures that nobody is left inside or can enter this region at such times.

It is also a general rule that nobody is allowed to enter the experimental halls unless the beam holes are plugged. If, however, radiation survey measurements result in tolerable dose-rates, even with the holes open, access is given according to the results obtained. On this point it is of interest to mention that CERN follows the rules and regulations set forth by the International Commission on Radiological Protection (ICRP).

The radiation safety during operation of the synchro-cyclotron can be judged from dose measurements made just outside the main shielding. Such measurements have shown that the major part of the radiation level is caused by fast and slow neutrons. However, the level is low during normal operating conditions, and can only be detected with some accuracy using neutron counters and nuclear-track emulsions. Values obtained using these kinds of instrument show dose rates on an average well below 10% of the maximum permissible level of 2.5 mrem per hour* for 40 hours a week. Although this information is based on calibration with polonium-beryllium neutron sources, and as such would require a similar spectral distribution of neutrons for accurate measurement, it is believed that the values cannot be far out. This view is supported by the good agreement between values obtained with different kinds of instruments used for the same measurements.

In the regions outside the walls of the experimental halls the radiation level varies greatly according to the kind and number of experiments which are carried out at any particular time. This makes the prediction of radiation safety for these regions quite difficult. However, shielding barriers of movable concrete blocks along the outside of the walls reduce the radiation level in these regions also to values of the order of a few percent of the permissible level.

It remains to be mentioned that the whole accelerator, together with the

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* **mrem** is the abbreviation for **millirem**, or one-thousandth of a **rem**, and is a measure of the effect of any form of ionizing radiation on human beings. The rem is obtained by measuring the amount of radiation in **rads** and multiplying by an appropriate factor of **relative biological efficiency.** For x-rays, the rem, the rad, and the **rœntgen** are approximately the same.

What is Radiation Safety?

Most readers will know that nuclear radiations are 'dangerous', which really means that appropriate care is necessary whenever or wherever they may be present. Even this perhaps needs qualifying, since long before men learned to use nuclear energy they lived in a 'background' of nuclear radiations, coming from outer space above and the soil beneath.

Nobody knows exactly what damage radiation will do to the human body. A large amount of radiation will cause death, it is true, but as the intensity is reduced it becomes more and more impossible to predict precisely what will happen. A given amount of radiation may or may not have noticeable effects. One is in a position to say that if 100 people were accidentally exposed to a large amount of radiation then in a certain case 10 of them would become ill, but one could still not say just which 10 that would be, or even whether the number would be 9 or 11. Certainly all 100 would not be affected in the same way. The genetic effects, that is the possible damage to their future children, would be even more difficult to predict in a precise manner. One can only estimate the chance of any particular result. The smaller the amount of radiation received the smaller is the chance that any damage will be caused, and this gives the clue to the way in which radiation can be used safely.

It has already been mentioned that we have always lived with a certain amount of radiation, but this amount is not constant. There are more neutrons in the air on top of a mountain than there are in the valley, for example ; rocks and soil, and indeed bricks for houses, in some parts of the world are more radioactive than in others ; disturbances on the sun can change the intensity of the cosmic rays hitting the earth. As people live and move around, the amount of radiation they meet changes; sometimes more, sometimes less. Thus, providing the amount of man-made radiation and the number of people subjected to it are together kept below a certain level, it is impossible to detect any difference in the overall health of the population.

These permissible levels of radiation of different sorts, and various other rules for the safe use of radiations, have now been generally established by law, based on the recommendations of such bodies as the International Commission on Radiological Protection, which has brought together specialists in relevant fields from many countries since 1928.

Any source of nuclear radiations has to be constructed or used in such a way that no significant amount of radiation is produced by it in areas open to the general public. The people working with it are allowed a higher dose, because they form a relatively small group of the population and the amount of radiation they actually receive can be measured. Various instruments are used to detect the different types of radiation and to measure their intensities, to show how safe any particular area is. In addition, a small piece of special photographic film is worn by every person likely to be exposed to the radiation, the blackening of this film when developed after a certain time indicating the amount of radiation absorbed in that period. More directly, special dosimeters can be worn, if necessary, to show at once the accumulation of the dose.

Generally, the intensity of the radiation is reduced by absorbing it in suitable material, such as lead, concrete or earth, or just in air over a greater distance. The difficulty of the shielding problem depends, of course, on the original intensity ; with accelerators like those at CERN it is easier than with a large nuclear reactor for electric power production, for instance. The biological effect of the radiations also depends more or less on the total amount absorbed, so that in cases where it is not possible to reduce the intensity further, safety can be retained by limiting the time of exposure.

experimental halls, is surrounded at some distance by a fence, inside which there is no general access while experiments are in progress.

A completely different picture of the radiation level around the machine is seen if the high-energy beam of protons is extracted through the shielding wall. In this particular case the dose rates become significant over a rather large area, especially in the beam direction and to both sides of it. After passing through the experimental hall the proton beam hits a beam trap, essentially a hole made up of massive concrete shielding blocks located in front of a large hill of earth ; but even with the beam passing through air only, dose rates up to 10 mrem/hour have been measured lately outside the fence in the worst position. This value is approximately four times the maximum allowable for continuous exposure. Fortunately this mode of machine operation has been extremely rare, amounting to not more than a few hours a month. Also it is still possible to reduce the dose rates in such cases, and studies are being undertaken in order to be able to shield off the stray radiation and allow the extracted protons to be used more extensively for experiments under better radiation safety conditions.

Fig. 2 shows the general layout of the 28-GeV proton synchrotron (PS), with the injector and the North and South experimental halls. The injector, which is essentially a 50-MeV linear accelerator, provides protons for acceleration by the large machine up to 28 GeV. The ring, which has a diameter of approximately 200 m, houses the vacuum chamber and 100 magnet units aligned along it. The target is located inside the vacuum tube and produces scattered protons or other particles when hit by the beam. These particles are collimated through holes in the shielding and led into the experimental halls to be used for nuclear studies.

The whole ring-shaped accelerator is completely surrounded by a considerable amount of shielding made up of concrete covered with earth. During operation, the machine is inaccessible. The same is true of the experimental halls, which are likewise surrounded by shielding built up of concrete blocks. Outside, fences are placed on either side of the earth ring, making this area inaccessible also.

During normal machine operation, the radiation level outside the shield-

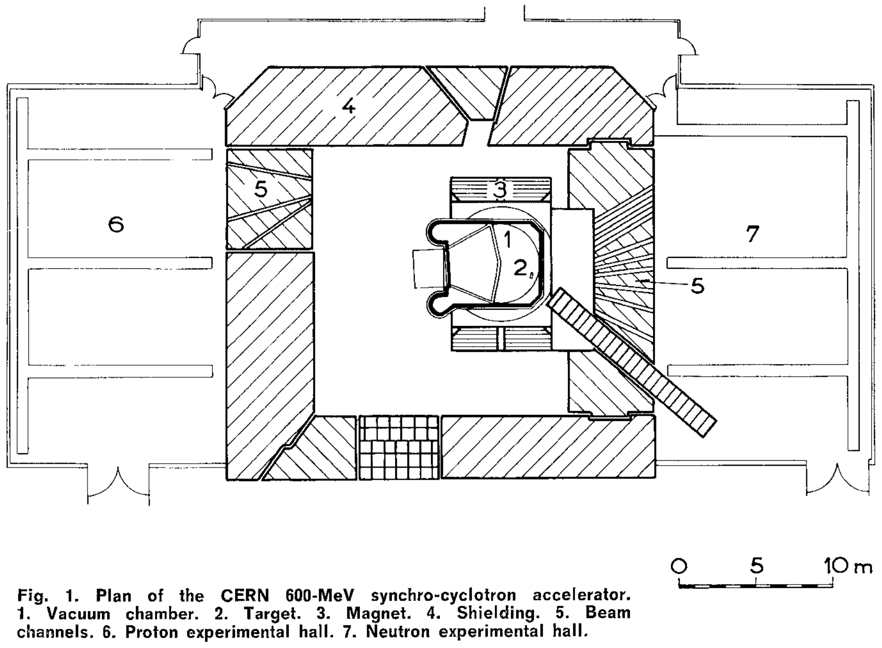


Fig. 1. Plan of the CERN 600-MeV synchro-cyclotron accelerator. 1. Vacuum chamber. 2. Target. 3. Magnet. 4. Shielding. 5. Beam channels. 6. Proton experimental hall. 7. Neutron experimental hall.

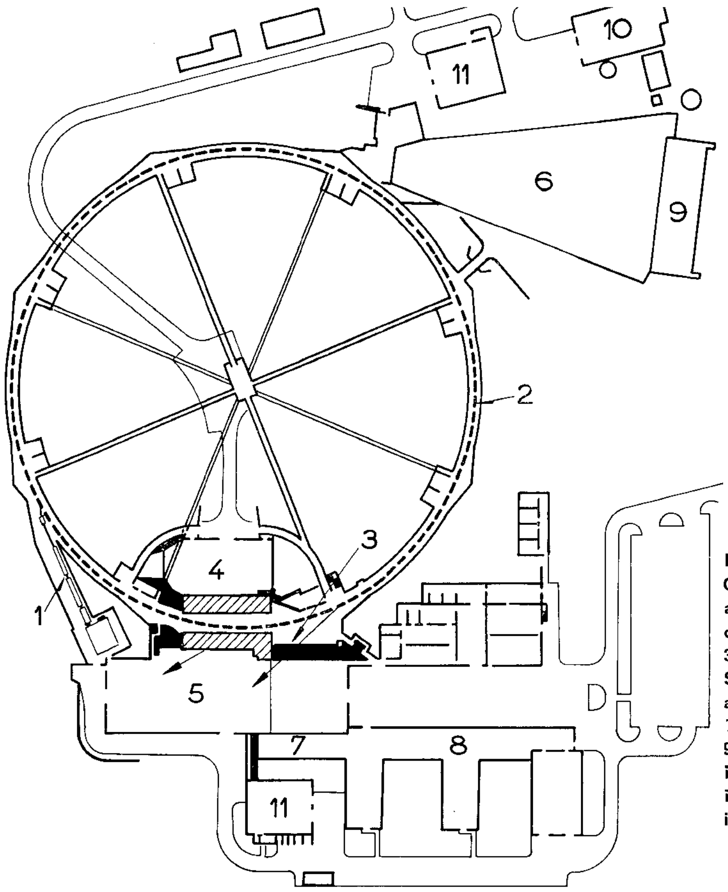


Fig. 2. General layout of the CERN 28-GeV proton-synchrotron accelerator. 1. Injector. 2. Accelerating ring, diameter 200 m. 3. Target area. 4. North hall. 5. South hall. 6. East experimental area (in course of construction). 7. Control rooms. 8. Laboratories. 9. Large-bubble-chamber building. 10. Hydrogen service building. 11. 10-MeV-generator building.

ing is barely detectable when measured in the plane of the beam. Values of less than 5% of the maximum permissible dose rate are generally observed, largely due to neutron radiation. On top of the shielding inside the fence, a larger dose rate exists, going well above the limit of 2.5 mrem/hour at spots where there are ventilation pipes.

As in the case of the synchrocyclotron there is usually no access to the experimental halls when the beam holes are open and experiments are going on. Several beams are usually in operation at the same time in the South experimental hall, making this area uncertain from a radiation-safety point of view. The prediction of radiation hazards due to beams of particles in the GeV energy region is difficult, both because the present knowledge of accurate dose measurements is scarce and because almost nothing is known about the biological effects which these very high-energy particles can produce.

When the beam holes are blocked with the accelerator still operating, access is given to the experimental halls. The dose rate measured then varies from place to place, and changes also with the beam intensity and according to the target which is being exposed. The dose rate measured, however, has been found not to exceed the maximum permissible level, except in a small region close to the shielding immediately beyond one of the targets in use. Similar results have been obtained for the North experimental hall when operating targets further away from this region. As a general rule, in areas where any appreciable amount of radiation is suspected, radiation survey measurements are always carried out before access is permitted. Regulations and rules for access are then based on the information obtained.

Outside the fence and elsewhere on the site the radiation level is very low and not measurable with normal sensitive radiation dosimeters during machine operation.

This degree of safety has been confirmed by special low-level neutron measurements carried out in a laboratory located 400 m from the centre of the PS machine and 110 m from the SC machine. At this position an increase in the neutron background by a factor of 3 was found to be caused by the operation of both machines together. A similar measurement was done at another position, 40 m from the SC and approximately 350 m from the PS. This showed an increase by a factor of 5, which compares favourably with the factor of 10 obtained just by going to an altitude of 3000 m. Assuming a cosmic-ray neutron level at the CERN site of 50 n/cm^2 per hour, all these values are less than 1% of the maximum permissible radiation level.

The brief indications given here justify the view that the CERN machines are well shielded and that the site and surroundings can be considered as very safe from a radiation point of view, when the machines work under normal conditions.

Safety during shut-down

Radiation safety during shut-down of the particle accelerators is related to the induced radioactivity formed by the beams of high-energy particles produced during operation. This induced radioactivity is largely confined to targets, vacuum-chamber wall, magnets or other parts, and places which have been hit by the beam. The concentration depends upon several factors such as beam intensity, exposure time, and half-life of the isotopes formed, and the radiation level will therefore vary from place to place in the accelerator, depending also upon the preceding method and time of machine operation.

The safety problems arising from the induced radioactivity in the accelerator parts are of particular concern for all kinds of maintenance and repair work on the machine itself, and also for other work which has to be carried out in nearby regions.

On the synchro-cyclotron, the vacuum chamber between the magnet poles represents the region with the highest radiation level. This is mainly due to induced radioactivity in iron. The level changes from time to time, but dose rates up to 6 rem/hour have been measured, due to gamma and beta radiation.

Strict rules are observed for entering the tank, and written authorization is required. This states the length of time a person can spend in the tank, judged from dose-rate measurements and his previous exposure. Special clothes, together with caps and shoe-covers, are used in order to avoid contamination, and the dose is monitored by integrating dosimeters. Recently the time allowed for work in the tank has been of the order of 10 minutes for each person, and for work requiring a longer time several people share the job.

Immediately outside the vacuum chamber a great variation exists in the radiation dose rate, ranging from 100 mrem/hour to nearly 1 rem/hour. All work in this region is also limited in time, usually determined from the readings of an integrating pocket dosimeter.

In the machine hall the dose rate is much less, of the order of 10-15 mrem/hour.

Since the decay of the isotopes formed has a great influence on the radiation level in the vicinity of the machine, it is of interest to know the decay curve. This has been measured for iron, which is the main material in the machine. The curve, shown in fig. 3, indicates a rather fast decay to start with, slowing down with time. As a consequence of this, one day's cooling time is usually allowed before major work is done in the tank of the machine.

It should be kept in mind that this machine usually operates from Tuesday to Sunday and that repair work and maintenance are carried out on Mondays. This means that the permissible weekly dose is concentrated into one day.

On the proton synchrotron the distribution of induced radioactivity extends over a much larger region.

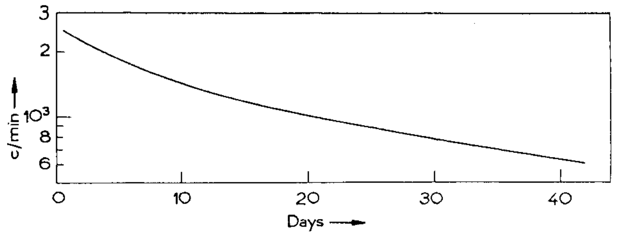


Fig. 3.
Decay curve for induced radioactivity in iron from the synchro-cyclotron.

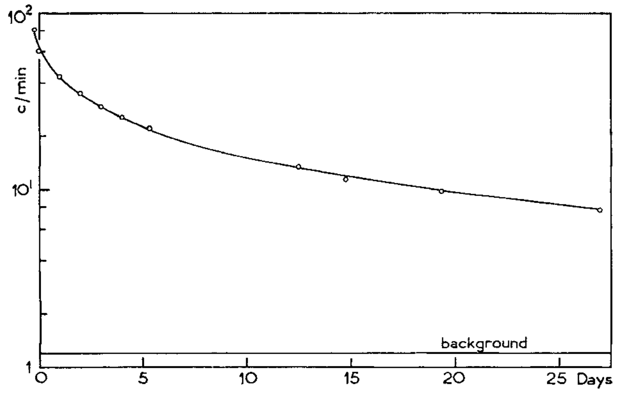


Fig. 5. Decay curve for induced radioactivity in iron from the proton synchrotron.

As already mentioned, 100 magnet units are distributed around the ring and routine measurements of the radiation level are made for each such section.

Fig. 4 shows the dose rate measured at the different sections at a distance of 10 cm from the vacuum chamber. It is seen that the rate varies considerably from place to place around the ring, ranging up to 2 rem/hour near the targets.

Comparing curves taken at different times, it has been found that the shapes are very similar, but the values may well vary from time to time depending upon how the accelerator has been operating. The values of dose rate at 1 m from the vacuum tube indicate quite clearly that most of the PS machine ring is quite safe during shut-down, because the radiation level due to the induced radioactivity is low. In the target region, however, the level is higher, and precautions are taken when work is to be done. These precautions consist of placing barriers at a safe dose limit and of giving time-limited access inside them. The barriers are moved as the level falls.

The decay of the induced radioactivity in iron which forms the major part also of this machine, is shown in fig. 5. Again the short-life isotopes decay first and give rise to the form of the curve. It is also noticed that isotopes with relatively long half-lives are formed, and these will have the greatest influence on the future build-up of the radiation level of the accelerator.

It might also be suspected that the operation of the CERN particle accelerators gives rise to radioactive dust and air contamination. Dust samples taken periodically, however, have always shown a very low concentration of radioactivity, which may be explained by the good ventilation systems applied to both machines. Confirmation has been obtained from a whole-body measurement of an operator on the synchro-cyclotron, who showed no sign of radioactive contamination other than caesium-137 and potassium-40, which were both also normal and comparable with the values in people from Central Europe.

Radio-isotopes and radioactive waste products

Radioactive isotopes are frequently used at CERN for testing and calibration purposes, and so far more than 150 units have been bought by the Organization. Most of these are reactor-produced materials in the form of encapsulated sources. These are kept under control and also inspected from time to time. Most of them are kept in two special storage places, although a number of smaller sources are frequently in use at different laboratories on the site.

Targets, which have been exposed to the beams of the CERN machines and are quite radioactive, are frequently used for nuclear chemistry studies. This material is handled according to normal procedure and the chemistry carried out in a laboratory specially designed for radioactive materials.

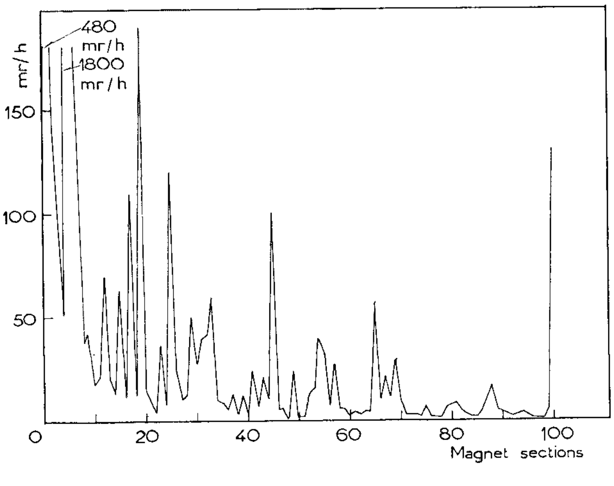


Fig. 4. Typical dose-rate distribution around the proton synchrotron.

Radioactive waste is composed mainly of parts taken out of the machines, and of liquids from the nuclear chemistry laboratory. The solid waste offers a greater problem from the point of view of contamination of radiation detecting devices than as a radiation hazard to people. This is due to the relatively low specific radioactivity found in the machine parts. All parts and materials taken out of the machine areas are inspected and permanent storage of the larger contaminated metal pieces is arranged on a concrete floor in the open air surrounded by a locked fence. Smaller pieces of metal, and other solid material, are kept in containers in a store used entirely for this purpose.

The liquid waste products are stored in special tanks which are emptied from time to time as the radioactivity decays. Before the liquid is released, samples are measured and a dilution is made such as to give a concentration of radioactivity lower by a factor of 10 than the values set forth by ICRP for drinking water. This factor of 10 is applied to follow the Swiss rules.

Personnel control

At present 800 out of 1400 people working at CERN are occupied with work involving some radiation exposure. These people work either directly with radiation or in areas where a radiation dose rate exceeding normal background has been measured. This group of people belongs to the category of occupationally exposed personnel and is therefore under continuous radiation control by means of film badges. The film badges are of two kinds, one for gamma radiation and one for fast neutrons. Gamma film badges are carried by all 800, while about 150 are also under neutron-film-badge control. The neutron films are only required for work in areas where a substantial neutron level has been measured ; at the same time, to have access to these areas people are required to carry neutron films.

The gamma films are, with the exception of those for a few groups of people, read every two weeks. Three to four groups, however, among those carrying out work on the SC machine have a weekly change of gamma films. The films are developed and read by l'Institut du Radium, in Geneva, which provides CERN with the results.

The film badges for fast neutrons are changed only once a month, as the fast-neutron exposure at CERN occurs usually at a rather low dose rate. These films are developed and read at CERN.

The information obtained from the film-badge readings gives an idea of the safety of CERN personnel against radiation. It should be looked upon in relation to the ICRP maximum permissible radiation exposure, which is 5 rem per year, not exceeding 3 rem for 13 consecutive weeks, and the results for 1960 are quite low :

0 - 1	rem	703 people
1 - 2	rem	72 people
2 - 3	rem	11 people
3 - 4	rem	4 people
4 - 5	rem	2 people
> 5	rem	1 person

In 1961 there seems to have been a somewhat increased exposure, especially of those groups carrying out maintenance work and repair of the SC accelerator. This fact can be seen from fig. 6, where the accumulated dose for the preceding 12 months is plotted as a function of time for the five most exposed people at present working on this machine. It is clearly seen that a change of exposure occurred around April/May, which can be explained by an improvement in the SC beam intensity. As a result of this, steps have been taken in order to distribute the work, and consequently also the radiation exposure, over more people.

Together with the personal monitoring of people for radiation exposure, there is a periodic medical check. This consists of blood and eye examinations, the eye examination being of special importance for cateract formation which is of concern in connexion with neutron exposure. The frequency of the medical inspection is determined by the radiation exposure, and takes place at least once a year.

From what has been said, it can be concluded that the CERN site represents an area with a low radiation level, considering the location of very high-energy accelerators. This is primarily due to the well-designed shielding arrangements applied to these machines. On the other hand, it should not be forgotten that our knowledge about the dosimetry, and also the radiobiology, of the great variety of particles produced especially by the PS machine is scarce, and represents a field of studies CERN is very interested in. In consequence, research problems in high-energy dosimetry form an additional part of the radiation-safety activity at CERN.

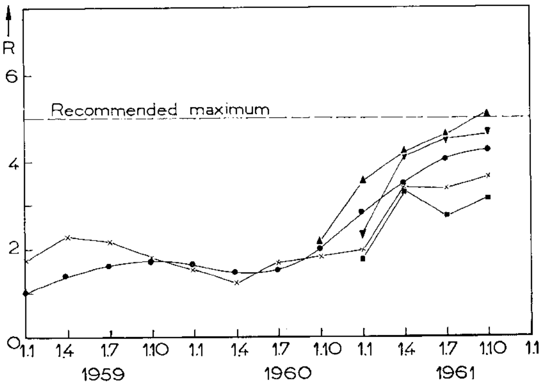
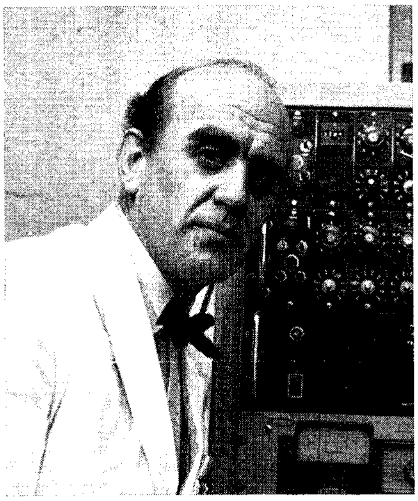


Fig. 6. Accumulated dose for preceding 12 months for 5 synchrocyclotron operators.

WHO'S WHO IN CERN

Johan BAARLI

Head of Health Physics



Johan Baarli, who arrived at CERN at the beginning of April, 1961, to take charge of Health Physics, was born in Norway on 23rd June, 1921. His birthplace, Eidsvoll, some 60 km North of Oslo, is of interest as the place where the constitution of Norway was drawn up in 1814.

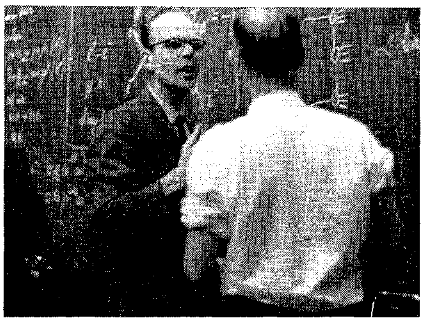
Upon leaving school he entered the University of Oslo as a student in the Faculty of Sciences, but his studies were interrupted when the occupation forces closed the University in 1943.

It was not until 1950 that he was able to conclude his studies with his thesis on 'The construction of a neutron generator and the study of neutrons from d-d reactions'. He then became a teacher at the University of Oslo.

In 1952 he left Norway and went to work with Prof. Zirkle at the Institute of Radiobiology and Biophysics of the University of Chicago, as a postdoctorate fellow financed by the Norwegian Cancer Society and the U.S. Atomic Energy Commission. Later he moved to the Argonne Cancer Research Hospital, at the same University, where he worked with Prof. Skaggs.

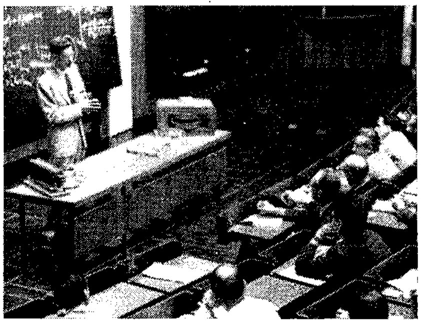
About this time Norsk Hydro's Institute for Cancer Research was created as part of the Norwegian Radium Hospital, and in the autumn of 1953 Dr. Baarli was asked to return to his native country to take charge of its Department of Biophysics. When he arrived, there was just an empty building. Now, the departments of biophysics — still the only one in Scandinavia —, biochemistry, and radiobiology, together employ some 60 people, of whom 20 are qualified scientists. The hospital itself has 310 beds, and its equipment includes a 31-MeV betatron together with more conventional x-ray equipment. In addition there are clinical irradiation sources utilizing radiocaesium, designed by Dr. Baarli and described by him in a paper to the Conference on the Peaceful Uses of Atomic Energy in Geneva in 1958. Among the other things he did whilst at the Institute were the development of new instruments for dosimetry ; the study of radiation effects on biological material, including the development of a light-scattering device and viscometer for studying radiation effects on large molecules ; and the development of new instruments for low-level counting of radiation used in studies of metabolism.

Dr. Baarli is still a member of the Scientific Advisory Council of Norsk Hydro's Institute for Cancer Research. He is also Secretary of the Nuclear Research Committee of the Royal Norwegian Council for Scientific and Industrial Research, Member of the Joint Committee on Scientific Institutes in Norway, Secretary to the Committee on Atomic Energy in Technological Studies, and past Vice-President of the Norwegian Physical Society.



CERN

Theoretical Conference



From 5 to 9 June 1961, a rather unusual conference was held at CERN. This was the 1961 International Conference on Theoretical Aspects of Very High Energy Phenomena, sponsored by the International Union of Pure and Applied Physics, which brought together with their CERN colleagues some 50 other physicists from over a dozen other countries. The discussions were mainly on theoretical subjects, but their aims were strictly practical — namely to try to determine which kinds of accelerating machines would be most useful in about 10 years' time. It is already obvious that the results from the present high-energy machines are only steps on the way to our fuller understanding of matter, and it is necessary to plan now the accelerators that will be needed to carry the results further in the 1970s.

'Very high energy', with reference to a system of nuclear reactions, is not easy to define. As Prof. Van Hove pointed out in his concluding lecture at the Conference, its appropriate lower limit depends very much on the processes being considered; in general it lies between 100 MeV and 1 GeV for weak and electromagnetic interactions, and at a few GeV (centre-of-mass energy) for strong interaction processes. Above these energies, the range extends into regions attainable at present only by cosmic rays, which involve energies sometimes of tens of thousands of GeV. *

The task of the theoreticians is to describe nuclear processes in mathematical terms. Their equations, evolved to explain current experimental results, suggest new experiments, which must be carried out to provide verification. The purpose of the CERN Conference was to review the latest theories in relation to the experimental results obtained with the largest present-day accelerators and with cosmic rays, and to suggest the most interesting experiments that could be used to test these theories.

Nuclear processes fall into three separate classes according to their probability of occurence. Thus we distinguish strong, electromagnetic, and weak interactions, and at the present time describe them by three different kinds of theory.

Weak interactions

Weak interactions are characterized by the beta-decay of radioactive nuclei, the decay of pions and muons, and the interactions of neutrinos with matter. The latter processes are of the greatest theoretical interest, particularly as the present 25-30 GeV accelerators can just provide sufficient neutrinos to make their study feasible. Papers from CERN contributing to the discussion of weak-interaction theory were read by S.M. Berman and by J. Nilsson and R.E. Marshak. The most interesting speculations, qualitatively, are on the existence of two distinct kinds of neutrino, and of a new particle (a boson with mass of the order of the nucleon mass or higher).

G. Bernardini reported on progress with the CERN experiment on the first of these. A search for the existence of self-interaction terms which arise in one form of the theory is also a possibility, as well as the quantitative study of weak lepton-nucleon coupling by means of the reactions between neutrinos and protons or neutrons.

'Two features appear highly desirable in future experimental work: great flexibility and good intensity. For many problems, one wants to go to high energies... but one gets the impression that energy increase should not go at the cost of the flexibility and intensity requirements. We have encountered only very few arguments to go to extremely high energies...

'We should stress, however, that such considerations are bound to be extremely conservative, since they are based on questions and problems suggested in the most immediate way by our present state of knowledge and since they do not take into account the well-known and drastic limitations of our power of imagination... As is often the case, unpredictable features may turn out to overshadow all present speculations and conjectures and open up an entirely new chapter of high-energy physics.'

From the concluding lecture given by L.Van Hove.

The cross-sections for all these reactions are very small, however (of the order 10^{-37} to 10^{-41} cm^2), and a high neutrino flux is vital.

Strong interactions

So far, the use of the larger machines to study strong interactions (those charcterized by collisions of nucleons and pions) has not revealed much that is remarkable. If one considers the most common, or 'dominant' processes, the experimental results can be understood on the basis of naive, simple considerations to within 5 or 10%. Attempts to understand the more detailed features, however, lead to considerable difficulty, and it becomes interesting to know whether the deviations from simple theory get worse at higher energies, or whether they disappear. Recent results obtained at CERN were presented in papers by G. Cocconi, K. Winter, and D.R.O. Morrison, while R. Hagedorn showed how these and other results were only partially described by the simplest theories of particle production in high-energy collisions.

Various new 'models' have been proposed in attempts to arrive at a better understanding of the experimental facts, and the 'one-pion-exchange model' was discussed by F. and G. Salzman (University of Colorado) and by F. Selleri and E. Ferrari. This theory refers to the phenomenon of multiple pion production, or 'pionization' as it was called by Cocconi. To explain the pronounced diffraction effects that occur in small-angle scattering of strongly interacting particles, the 'strip approximation in the Mandelstam representation' has

(Continued on p. 15)

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* On two occasions since May 1960, interactions involving at least 10^{10} GeV have been observed in New Mexico.

50th Anniversary of the Solvay Physics Meeting

Most scientific conferences nowadays seem to involve too many people; too many papers prepared in advance and read at great speed ; and too little time for thought. The 12th Solvay Physics Meeting, held at the Free University of Brussels from 9 to 13 October, 1961, was an exception. Like its predecessors, this meeting, held to mark the 50th anniversary of their foundation, had few participants, few formal papers, and plenty of time for informal discussion.

Ernest Solvay, who had made a very considerable fortune out of his invention of a new process for manufacturing soda, had a great interest in the advancement of learning and devoted a large part of his money to the foundation in his native Belgium of research institutions in the natural and social sciences. In 1910, his desire to establish International Institutes of Physics and Chemistry brought him into contact with various scientists of the day, and as a result of a meeting with Nernst the first of the 'Conseils de Physique Solvay' was arranged in the following year, from 30 October to 3 November in Brussels.

Solvay's idea was to gather together for one week a score or so of the leading scholars in some scientific field, and to give them the facilities for exchanging ideas without interruption. That idea is still followed today. The members who attended the recent meeting, to discuss the 'Quantum theory of fields', had the rather rare opportunity of being able to discuss among themselves not so much the latest theories but the whole recent development of this subject, thereby helping to put these theories in better perspective. Prepared papers were few, and in any case of a general survey nature, and most time was spent just on the exchange of ideas.

This fiftieth anniversary conference was especially interesting in that it brought together in equal numbers members of the 'pre-war' and of the 'post-war' eras of physics. The list is so short it is worth quoting in full : Bethe, N. Bohr, Gorter, Heisenberg, Heitler, O. Klein, Möller, Oppenheimer, F. Perrin, Rosenfeld, Wigner, and Yukawa, representing the generation that grew up with modern quantum mechanics ; Chew, Dyson, Feynman, Gell Mann, Goldberger, Källér, Mandelstam, Pais, Salam, Schwinger, Tomonaga, and Van Hove, leader of the theoretical physics division of CERN, representing the later generation that has developed modern field theory since 1947.

The theme was set by the prepared papers: Feynman on electrodynamics, Heitler also on electrodynamics, providing an interesting comparison ; Goldberger and Mandelstam on dispersion relations — an old concept recently applied in a new field ; Pais on the development of the theory of weak interactions in the five years since the discovery of the non-conservation of parity ; and so on. As discussion developed, however, ideas focussed on the concept of 'elementary' particles. Just how can one decide whether a particle is elementary or composite, when the number of new particles seems to be continually increasing, and structures are found for the old established ones ? How can a mathematical formulation be arrived at that will enable us to define these particles precisely ? Possible criteria were advanced and discussed. Possible exper-

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They worked at CERN

As is only to be expected of a unique laboratory serving a dozen European nations, the staff of CERN is not static. Many new scientists and engineers wish to come to take advantage of its special facilities ; but eventually most of them will go again, back to their own countries or perhaps further afield to gain even more experience. We could perhaps tell readers who the new members are, where they have come from, and what they have been doing, but it seems preferable instead to mention those who have left, what they have done at CERN, and how they will use this experience in future. Unfortunately we cannot mention everybody, and our selection is only a little better than random, but in the following paragraphs we have noted some of the those of whom we now have to say 'they worked at CERN'.

J. Leroux presenting J. B. Adams with a photo album autographed by all PS staff members (27 July 1961).

John B. ADAMS left the Organization on 1 August to become director of the Culham plasma physics laboratory of the U. K. Atomic Energy Authority. He was originally to have left a year earlier, but following the death of Prof. Bakker in April 1960, his stay was prolonged by his appointment as Director-General of CERN.

His reputation, however, is linked with that of the proton synchrotron. As director of the PS Division from 15 November 1953, he provided the knowledge, drive, and enthusiasm, to enable this machine, the first of its size in the world, to function so successfully immediately after its completion.

To mark the occasion of his departure a ceremony was held on the steps of the Administration Building. Speeches were made by Mr. Leroux and Prof. Bernardini. In the course of his reply, Dr. Adams expressed the hope that he could still help in the work of the CERN laboratory ; he has already attended a meeting of the Scientific Policy Committee in November.

iments were planned which might throw more light on the problem.

Of the types of experiment proposed, it is perhaps interesting to note that two of the most important ones are both being considered at CERN. In one case the energy dependence of the results of 'peripheral' collisions (which are thought to involve the transfer of a fundamental particle) can give information on the particle exchanged. In the other, elastic collisions between particles, with very high momentum transfer, will provide valuable information on the scattered particle.

The outcome of the Solvay meeting itself gives no special cause for excitement, though as Lorentz said in his presidential address to the first one, it is not possible to tell in advance whether great ideas will come out of such a meeting or whether they will perhaps come to some person alone, completely independently. Such an interchange of ideas cannot fail to have its effect, however, and the Solvay Physics Meetings have certainly marked the way taken by atomic and nuclear physics in the last fifty years. At the first, Planck's quantum law was discussed. At the fifth, in 1927, on 'Electrons and photons' the topic was the new quantum mechanics. At the seventh, in 1933 (the last before 1948) the subject was 'The structure and properties of atomic nuclei'.

Looking back on fifty years, and considering how puzzled theoretical physicists are today by the multitude of experimental phenomena now known to exist, it is interesting to recall some of Lorentz's words at that first meeting :

'We are far from the complete spiritual satisfaction that (we had) ten to twenty years ago. Instead, we now have the feeling of being up against a barrier ; the old theories have shown themselves more and more incapable of piercing the darkness that is closing in all around.'

He could go on to hail Planck's quantum hypothesis as 'a precious ray of light'. We, it seems, will have to wait a little longer for equivalent illumination.

Participants of the 1st Solvay Physics Meeting in 1911. Seated, from left to right: Nernst, Brillouin, Solvay, Lorentz, Warburg, Perrin, Wien, Mme Curie, Poincaré. Standing: Goldschmidt, Planck, Rubens, Sommerfeld, Lindemann, De Broglie, Knudsen, Hasenohrl, Hostelet, Herzen, Jeans, Rutherford, Kamerlingh Onnes, Einstein, Langevin.

André DECAE left CERN on 31 March to take up an appointment as Scientific Secretary in the Conseil International des Unions scientifiques at The Hague. This Council acts as a co-ordinating and advisory body for the international scientific unions and Mr. Decae is responsible for all matters concerning geodesy and geophysics. His office is moving to Rome in January 1962.

He and Jean Gervaise came to Geneva in December 1954 from the Institut Géographique National, in Paris, and began by conducting stability studies on the moraine before any buildings were begun. This work, which involved careful measurements lasting about a year, with accuracies of 0,1 mm, showed that the moraine was not sufficiently stable and that the PS machine foundations would have to be sunk to the underlying molasse rock. A further year's work, in collaboration with the seismographic station at Neuchâtel, showed that the molasse was subject to seismic vibration, and this led to the adoption of elastic supports for the foundation ring, designed to insulate the machine from such disturbances.

During the construction of the proton synchrotron André Decae and his team played a major part in the initial positioning of the magnets, and in their subsequent checking after excitation. An idea of their achievement here can be gained from the knowledge that the circle formed by the magnets was made true and level to within a few tenths of a millimetre over its whole diameter of 200 m. This vital contribution to the construction of the accelerator was proved by the circulation of the first beam in September 1959.

Mr. Decae was President of the Staff Association in 1960.

Pierre GUILLOT left CERN on 31 March 1961 for the Euratom nuclear research centre at Ispra, in Italy. There he will supervise the nuclear security system, thus occupying a similar post to that which he filled at CERN. Coming to Meyrin in January 1959, he was involved principally in the dosimetry of fast neutrons and in the spectrometry of stray radiation.

Dr. Guillot was born in 1930 at Hanoi, in Indochina, and studied principally in Paris at l'Ecole supérieure de Chimie et de Physique. He obtained his doctorat ès sciences in Paris, at l'Institut Pasteur.

Robert KELLER, who left on 30 April, had been a member of the CERN staff since July 1955, his first year being spent at the Carnegie Institute of Technology in Pittsburgh to gain experience with their 430-MeV synchro-cyclotron. Coming back to Geneva, he was concerned with the putting into operation of the SC machine, particularly in the development of the Penning ion source. Following the successful operation of the machine for nuclear-physics experiments, he turned to the production of polarized protons, and his method has been applied successfully at 4,5-MeV on the small cyclotron.

At the same time, he developed independently the idea of stochastic acceleration for synchro-cyclotrons, and one of his two proposed methods for increasing the beam intensity in this way has been tried out with success on the SC in 1961.

Dr. Keller has gone to Lausanne, where he is working with E. Weibel at the newly formed plasma physics research centre supported by the Fonds National Suisse de la Recherche Scientifique.

Alf ÖSTLUND left CERN on 31 July to become technical director of a new nuclear electronics firm in Geneva. Six years previously he had come from the University of Uppsula, where he had worked for 5 years on their 180-MeV cyclotron. At CERN he spent some time

Last year at CERN (cont.)

that the **Trieste** team returned home at the end of their experiment on charge-exchange scattering of negative pions in hydrogen ; after this, in August, came a new visiting team from **Argonne National Laboratory,** U.S.A., led by Prof. A. Roberts. Five thousand tons of shielding had to be placed in position when the **neutrino experiment** attempted to find whether the neutrino emitted in the decay of a pion is the same as that involved in nuclear beta decay. The new **CERN heavy-liquid bubble chamber** was used for this during May-July, together with the **Ecole Polytechnique (Paris) chamber,** using a multiplate cloud chamber and large-area scintillation and Cerenkov counters for background measurements. Unfortunately, the number of neutrinos, which are extremely non-reactive particles, proved to be much lower than originally expected, and insufficient to allow any results to be obtained. Only seven possible events were found among the 150 000 pictures taken, and revised estimates of the number of neutrinos available indicated that only 1 event in 100 days was to be expected. The experiment will be continued, using a **'magnetic horn'** to increase neutrino intensity, and a bigger detector, a **multi-ton spark chamber.**

Another search for something rare, or non-existent, resulted in the establishment of lower limits of between 10^{-35} and 10^{-39} cm^2 per nucleon for the production cross-section of **magnetic monopoles.**

Many experiments on the PS utilized **proton** or **pion** beams to carry out measurements of a number of different reaction cross-sections for these particles. Important studies were carried out on the quasi-elastic **small-angle scattering** of protons on protons. The absorption cross-section for 10 and 13,5 GeV **photons** was measured for a number of elements. An experiment of interest in connexion with cosmic-ray-induced activities in iron meteorites was the measurement of cross-sections for a number of **spallation products** from the action of high-energy protons on iron.

Many of the experiments using the synchro-cyclotron concerned **muons.** Further measurements on (g-2), the **anomalous magnetic moment** of the muon, were carried out to reduce the experimental error to ± 0,5 % and the final result was awaited at the end of the year. In another experiment, about 380 000 bubble-chamber pictures were obtained of muons stopping in highly purified hydrogen. X-rays emitted when muons are captured into **'atomic' orbits** have also been studied for two ranges of nuclear mass, to obtain information on nuclear radii.

Apart from carrying out measurements on tens of thousands of track-chamber photographs already taken, the **Data Handling Division** actively pursued the development of more automatic machines that would be able to handle greater numbers in future. The 'Mark O' version of the **Iep Y,** or Hough-Powell flying-spot apparatus, was tested in May by a team composed of personnel from Brookhaven and Berkeley, in the U.S.A., and the Rutherford Laboratory in England, as well as CERN. Further tests were carried out in June, and construction of the 'Mark I' working version was at an advanced stage at the end of the year. Design studies by the **Accelerator Research Division** have continued on the two **proton storage rings,** proposed for the CERN proton synchrotron to give two colliding beams of particles. This would enable, for instance, proton-proton collisions to be investigated in the region of 50 GeV centre-of-mass energy. Construction of the **electron beam-stacking model** has suffered some setbacks because of delayed deliveries, but the RF system is ready and much progress has been made with the all-important ultra-high vacuum.

Some controversy exists over the relative value of colliding beams, and the Division has also made a start on the study of an alternative suggestion of building a **new synchrotron** giving much greater energy. Accelerated protons of over 1000 GeV would be needed, however, to give the same centre-of-mass energy for the proton-proton

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working on the construction of a magnet regulator for the synchro-cyclotron and was then responsible for the formation of an electronics maintenance section. This was originally for the SC machine, but it is now concerned with the repair, checking, and calibration of electronics instruments used throughout CERN.

Christoph C. SCHMELZER, one of the earliest CERN staff members, left on 22 March to return to Heidelberg University, where he began studies on the acceleration system of the future European synchrotron as far back as the end of 1952. This followed his work under Prof. Bothe, when he made a study of phase stability in microtrons and played an important part in the redesign of the Heidelberg cyclotron.

After coming to Geneva in 1954, he became responsible for the design, development, construction and final testing of the PS acceleration system, and was also deputy to the Division Director. The results of his work were seen on 24 November, 1959, when the first beam was accelerated to full energy so soon after completion of the machine construction. He then continued with studies of radio-frequency systems both for the PS and for other accelerators. During his stay at CERN he was also at some time a member of the Leading Board and of the library committee.

At Heidelberg, where he occupies the chair of applied physics at the Max Planck Institute, Prof. Schmelzer is still concerned with accelerator development. He is a consultant to CERN, and also chairman of the Wissenschaftlicher Rat (scientific council) which advises on the 6-GeV DESY (Deutsches Elektronen-Synchrotron) accelerator at Hamburg.

Frederick A. R. WEBB returned to England at the end of December after being at CERN since 1 October 1956. Originally released for a period of two years from the Ministry of Works in the United Kingdom, he has stayed to see the putting into operation of the 28-GeV PS accelerator, and the beginning of further expansion on the site. As Site Engineer, and later Deputy Leader of the Site and Buildings Division, he has been responsible for all the civil, mechanical, and electrical engineering installations and maintenance, and for the overall control of transport, security and fire services. As chairman of the organization's Safety Committee he was responsible for the preparation of the Safety Codes now in use.

Like many British engineers, Mr. Webb received his early training as an apprentice in an industrial works, studying part-time at a Technical College as an external student of London University. Subsequently he became an Associate Member both of the Institution of Civil Engineers and the Institution of Mechanical Engineers, and in the course of a varied career first in industry and then in Government service was one of the original design engineers for the Atomic Energy Research Establishment at Harwell.

On 15 August, Dr. **Toyio YAMAGUCHI** left CERN for his home country, where he has been appointed to the Chair of Physics at the University of Tokyo.

Born on 29 January, 1930, Dr. Yamaguchi received his education in Japan, where he was a student of Prof. Toganaka. He obtained his Doctorate in Physics, with a thesis on the 'Theory of mesons'.

Dr. Yamaguchi had been at CERN since 1957, with a Fellowship from the Ford Foundation. As a member of the Theoretical Physics Division he carried out a number of studies, mainly on the subject of weak interactions.

experiments. The **Theory Division** arranged an International Conference in the summer (as reported on p. 9) to clarify ideas on the most useful types of machine to aim at, from the point of view of the physicists.

The total number of **people working at CERN**, including fellows, supernumeraries, and visitors, was 1459 in mid November. Visitors coming from 33 countries worked at CERN last year.

In 1961, the laboratories used about :

35 500 000 kWh of electricity,
3 438 000 m³ of cooling water,
15 000 litres liquid hydrogen,
370 000 litres liquid nitrogen.

7,3 km of cable trays have been laid in the PS East experimental area.

In the six months from May to November the **Scientific Information Service** produced 1,8 million pages of offset.

The **Engineering workshop** worked 17 070 man hours, and the **SB Main workshop** 50 498 man hours.

The **Mail Office** handled 31 000 letters per month and distributed internally 70 000 items per month.

576 visitors per month were shown over the Organization by the **Public Information Office** alone.

The total **floor area** in offices and laboratories is now 65 000 m².

This last year, the CERN staff was grieved to loose three of its members:

Gilbert LAILLY, from the Site and Buildings Division, killed in an accident on 4 March 1961;

André TOURNIER-COLETTA, from the Accelerator Research Division, who died on 1 August after a long illness ;

Léon FLATOT, from the Data Handling Division, who was killed with his wife in a car accident on 3 November.

During the same period, on 17 May, **Paul CHARRIER,** working for a Parisian contractor on the site of the Organization, was killed as a result of a fall.

CERN COURIER extends to their families the deepest sympathy of those who, in one way or another, had the privilege to be their friends or colleagues.

Many new features added to the CERN site in 1961 appear in this picture, mainly the East experimental area of the PS (centre).

19th Session of CERN Council

Mr. Jean Willems (Belgium), presided over the 19th meeting of the Council, held at CERN on the 2 June 1961, at which the following delegates and advisers took part:

Austria:
Prof. W. Thirring
Prof. F. Regler
Mr. E. M. Schmid
Mr. H. Vavrik
Belgium:
Prof. J. Serpe
Prof. J. Franeau
Mr. M. Freson
Denmark:
Prof. J. K. Böggild
Mr. O. Obling
Federal Republic of Germany:
Prof. W. Heisenberg
Dr. A. Hocker
Prof. W. Jentschke
Prof. W. Paul
France:
Mr. F. de Rose
Prof. F. Perrin
M. F. Neumann
Mr. J. Courtillet
Greece:
Mr. A. Vlachos
Prof. A. Embiricos
Prof. Th. Kouyoumzelis
Prof. Th. Kanellopoulos
Mr. S. Boukis
Italy:
Mr. G. B. Toffolo
Prof. E. Amaldi
Dr. C. C. Bertoni
Mr. M. Sabelli
Netherlands:
Mr. J. H. Bannier
Prof. S. A. Wouthuysen
Mr. C. E. I. M. Hoogeweegen
Prof. H. J. Groenewold
Norway:
Prof. H. Wergeland
Mr. M. Huslid
Spain:
Prof. J. Otero-Navascues
Mr. J. M. Aniel-Quiroga
Mr. P. Temboury
Miss A. Vigon
Mr. R. Ortiz
Sweden:
Dr. G. Funke
Prof. I. Waller
Switzerland:
Prof. P. Scherrer
Mr. A. de Senarclens
Mr. R. Bieri
United Kingdom:
Sir Harry Melville
Sir John Cockcroft
Mr. S. H. Smith
Prof. C. F. Powell
Mr. G. Hubbard
Mr. R. G. Elkington
Yugoslavia:
Prof. E. Supek
Mr. B. Komatina

Mr. F. Alaçâm (Turkey), observer, and Mr. A. Baumann, from the Swiss Finance Audit, also attended.

Among items on the agenda considered by the representatives of the 14 Member States were :

— the progress reports of the Director-General and the Heads of Divisions,
— the admission of Turkey as an observer to the Council,
— the long-term scientific policy,
— the election of a new member to the Scientific Advisory Committee (Prof. W. Gentner taking the place of Prof. W. Heisenberg).

A plaque to the memory of Prof. C. J. Bakker was inaugurated in the lobby bordering the Council Room.

Nuclear Emulsion work at CERN

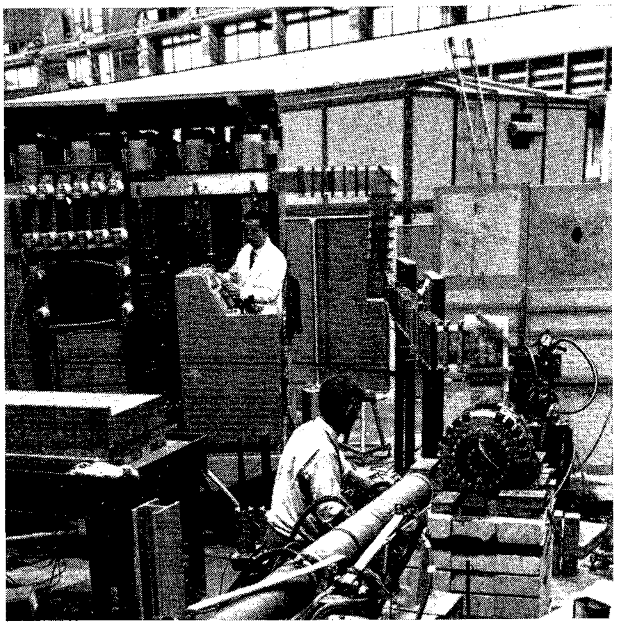
by J. COMBE and W.O. LOCK, Secretaries of the Emulsion Experiments Committee

The Group at CERN using the nuclear emulsion technique has, by its intrinsic nature, and by the functions of CERN, a triple task to fulfil :

a) To make use of the two CERN accelerators to carry out research in high energy nuclear physics using the emulsion technique. Some experiments may be carried out in collaboration with groups from member and other States.
b) Being involved in the general activity of CERN, it must always be ready to help other research groups, who from time to time, may have occasion to use the emulsion technique.
c) To give all possible help to outside 'Emulsion Groups' to carry out the experiments they propose and carry out independently.

All proposals for experiments from either the CERN Group or outside groups, are received by the Secretaries of the Emulsion Experiments Committee. The Committee considers the scientific value of each experiment before submitting it to the Nuclear Physics Research Committee. After a proposal has been accepted by the two Committees, the CERN Group considers how best the proposed experiment can be carried out in relation to the general programme of the two accelerators, and to its own programme. If all the practical conditions are satisfied, there are two ways of carrying out an experiment through the CERN Group:

1) **A collaboration** may be set up between the CERN Group and one or more outside Groups, arising from a common agreement between the teams on the lines of research that they wish to follow. One or more of the physicists of the CERN Group take part in the experiment and assume complete responsibility for it with respect to the CERN authorities. In fact, all the experiments undertaken by the CERN Group have been carried out in this type of collaboration. The Group has developed alone two techniques which are available for the use of outside groups : the pulsed magnet equipment (which can yield fields of 200 000 gauss) and the extensive facilities for the processing of nuclear emulsions.



The 200 000 gauss pulsed magnet (right) was used by the CERN Nuclear Emulsion Group in 1961.

This introduction to one of the three experimental techniques used at CERN (nuclear emulsions, electronic counters and track chambers) will be followed by other texts on the most important technical aspects of the 'Emulsion' work.

Some of the experiments carried out in collaboration with outside groups (between parenthesis) are :

a) Study of the processes by which a high energy pi-meson produces two other pi-mesons with a small energy transfer to the nucleus (Bari, Bristol, CERN, Lahore, Milan). At the same time studies have been made of the production of electron pairs by pi-mesons.
b) Search for magnetic monopoles (Berkeley, CERN, Rome).
c) Measurement of the lambda-zero magnetic moment (CERN, Lausanne collaboration for the test run, which will be carried out at the PS in January 1962, using a pulsed magnet-coil).
d) Study of antiproton-proton elastic scattering in the energy region of 10-50 MeV (CERN-Lahore collaboration).
e) Exposure of emulsion stacks, principally to proton and pion beams, for many laboratories : last year for 26 laboratories in member States and 11 in other countries.

2) **All the responsibility,** with respect to CERN, for an experiment and its realization is taken by the outside group which proposed the experiment. A physicist of the CERN Group acts then as a linkman between the outside group, the Divisions responsible for the two accelerators, and the Emulsion Group, who of necessity are involved in the execution of any experiment. This physicist will try to assist in solving the technical problems which arise. In general this scientific and administrative aid can be considered as part of the general facilities which CERN makes available to its member States and, in a certain measure, to non-member States.

The following experiments fall in this category :

a) The experiment proposed by Prof. B. Peters of Copenhagen on the production of hyperons and the study of their properties.
b) Study of different reactions produced by 1,5 GEV/c separated negative K-mesons in nuclear emulsions. This experiment, foreseen for Spring 1962, is entirely under the responsibility of about twelve outside laboratories.
c) Studies of fission phenomena induced by pi-mesons and protons in heavy elements, such as uranium, thorium and bismuth (Rome, Naples).

The CERN emulsion group is also engaged, from time to time, with problems which are principally of interest to other groups in CERN, for instance :

a) for the neutrino experiment, in July 1961, the emulsion technique was used to determine the energy and intensity distributions of the pi-mesons coming from a PS target ;
b) measurements have been made on the attenuation of protons in concrete shielding blocks. The results are of interest to CERN, and to those laboratories which are constructing large accelerators (Harwell, Hamburg, Stanford, etc.) ;
c) measurements have been made also of the radiation pattern at the junction of the PS ring with the new East experimental area.

CERN Theoretical Conference (cont.)

been devised, with considerable success, and this was described by D. Amati and S. Fubini.

As well as the dominant processes there are also less-frequent 'exceptional' processes that are still due to strong interactions. Among these, an interesting class at present being studied is that of 'peripheral collisions' these being inelastic collisions involving a relatively small transfer of momentum and energy. Current experimental results can be partially explained by either the one-pion-exchange model or by 'diffraction dissociation'. This was discussed by B.T. Feld. More experiments in other energy ranges are necessary to test those theories further.

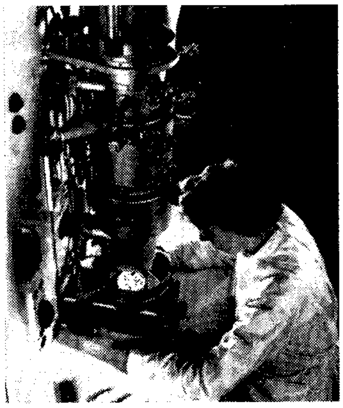
Electromagnetic interactions

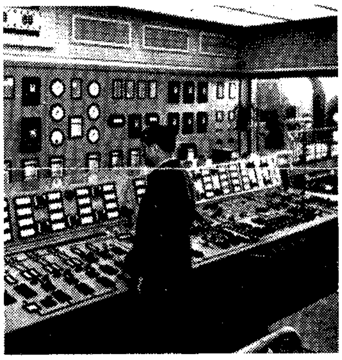
Agreement between theory and experiment is very much better in the study of electromagnetic interactions, and the main interest is in trying to extend the limits within which the theory can be said to be correct. Progress on the preparation of electron-scattering experiments with colliding beams was reported from Stanford (U.S.A.) and from Rome.

Conclusions

Apart from those mentioned above, further contributions from CERN were given in papers by T. Ericson, F. Cerulus, and J.D. Dowell, B. Leontic, A. Lundby, R. Meunier, G. Petmezas, J.P. Stroot and M. Szeptycka. A. Schoch reported on the possible future facilities for producing the phenomena of interest to the physicists.

Although no clear-cut decision on a future accelerator, could be arrived at, ideas were clarified and the main lines of approach seen more clearly, as shown by the extract we have given of L. Van Hove's concluding lecture.





NIELS BOHR

Photo: H. & H. Jacobsen, Copenhague

Hommage par le Prof. V.F. Weisskopf, Directeur général, prononcé devant le personnel de l'Organisation Européenne pour la Recherche Nucléaire (CERN), le 23 novembre 1962.

Chers Amis et Collaborateurs,

Nous sommes réunis cet après-midi pour rendre hommage à Niels Bohr. Niels Bohr est pour nous le symbole, la source et l'architecte principal de nos travaux. C'est grâce à lui, par lui et avec lui que les bases sur lesquelles reposent nos travaux et notre existence ont été créées. C'était un grand homme. Comment définir la grandeur ? Celui qui ouvre de nouvelles voies et qui crée une nouvelle façon de penser peut être qualifié de grand homme; en vérité, Niels Bohr, par sa personne et par sa vie, répond à cette définition. L'influence de ses travaux est ressentie dans chaque aspect de notre vie. La science moderne a transformé notre monde. Elle est devenue le facteur prédominant de notre pensée, de notre culture, de la politique même, et elle commande l'orientation de l'humanité pour les prochaines décades. Nous ne pouvons pas encore évaluer la signification réelle du développement engendré par les travaux de Niels Bohr. Nous sommes trop proches de sa vie. On ne réalise que de loin combien le Mont-Blanc domine les autres montagnes des Alpes.

C'est en 1885 que naquit Niels Bohr. Sa carrière de savant débuta en 1905 environ et continua jusqu'à sa mort. Quelle époque pour un physicien ! Il commença ses travaux alors qu'on ne connaissait rien de la structure de l'atome et les termina lorsque la physique atomique, créée par lui, avait atteint sa maturité. En 1905, la science, et notamment la physique, n'étaient pas ce qu'elles sont à l'heure actuelle. Examinons comment se présentait la physique à cette époque.

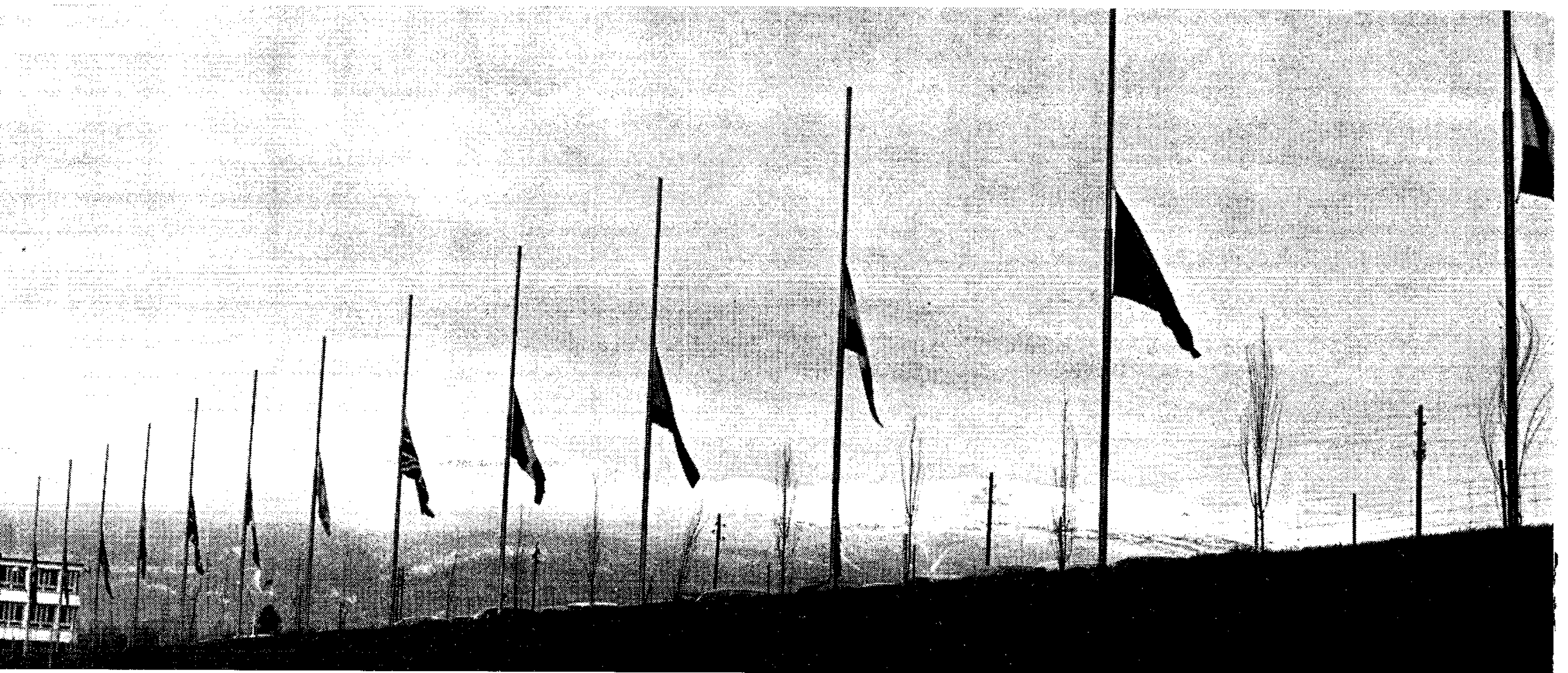
C'était une époque intéressante. C'était l'année où Einstein énonçait son concept de la relativité spéciale et où une multitude de phénomènes nouveaux étaient découverts, mais non expliqués. C'était l'époque, quelques années plus tard seulement — de la grande découverte du quantum d'action par Planck. Rares étaient ceux qui avaient remarqué le nouveau document de Planck et encore plus rares ceux qui en avaient saisi la signification. C'était une époque où les domaines de la chimie et de la physique étaient éloignés l'un de l'autre. La chimie, d'une part, représentait la science de la matière et de ses propriétés spécifiques. L'atome était un concept de chimie — les atomes de l'or, de l'oxygène, de l'argent, constituaient autant d'entités spécifiques dont l'existence était admise sans être comprise. La physique, d'autre part, était une science de propriétés générales, du mouvement, du rapport de la tension à la déformation, des champs électriques et magnétiques. Les deux disciplines étaient très éloignées. On ne pouvait pas encore répondre à la question : « Quelle est la source des propriétés de la matière ? ». Bohr eut la grande chance de se trouver au début, peut-être devrions-nous dire plutôt que l'humanité eut la grande chance qu'il fût là à ce moment crucial.

Les travaux de Niels Bohr peuvent être divisés en trois périodes. Au cours de chacune d'elles, il exerça une influence considérable sur le développement de la science moderne, de trois manières différentes et à trois moments différents. La première période s'étend de 1912, année de sa rencontre avec Rutherford, à 1923. Elle débute en 1913 avec la publication de ses travaux sur les orbites quantiques de l'atome d'hydrogène. Bohr se proposait d'expliquer les propriétés inconnues de l'atome en utilisant le concept des états quantiques — un concept déjà établi par Planck et Einstein, et qu'il appliqua à la structure de l'atome. Je ne pense pas qu'il existe dans la littérature de la physique un document qui engendra un si grand nombre d'idées nouvelles et duquel découlèrent autant de découvertes. Il est difficile de rencontrer un être plus révolutionnaire. Son concept des états quantiques de l'atome était selon toute évidence en contradiction totale avec le schéma du système planétaire que les expériences de Rutherford avaient permis d'établir. Mais les réponses aux principaux problèmes fondamentaux étaient contenues dans cette contradiction même.

Ce document célèbre marqua le début d'une série de nouvelles découvertes. Au cours des dix années qui suivirent sa parution, plusieurs phénomènes, jusqu'alors inexpliqués, trouvèrent leur place; la structure des spectres des éléments, le processus d'absorption et d'émission de la lumière, les causes qui régissent le schéma périodique des éléments, la séquence curieuse des propriétés des 92 différents éléments atomiques. C'est la période où la qualité, la spécificité des substances chimiques ont été réduites à des données quantitatives, au nombre d'électrons qui gravitaient autour de chaque atome. Tout cela reposait sur l'hypothèse des quanta appuyée par Bohr, qui n'était alors qu'une hypothèse provisoire. Toutefois, les contemporains de Bohr adoptèrent à la lettre les orbites quantifiées de l'électron permises ou non, bien que Bohr les ait mis en garde dans ses documents et à des réunions que cela ne pouvait être l'explication finale, que la découverte d'un principe fondamental s'imposait d'abord pour comprendre réellement le processus de la quantification de l'atome.

Nous abordons maintenant la deuxième période de ses travaux; les années 1923 à 1932. Ce fut la grande période pendant laquelle le principe du quantum fut expliqué. Une période héroïque, sans pareille dans l'histoire de la science, la plus fructueuse et la plus passionnante de la physique moderne. On ne trouve aucun document écrit par Niels Bohr seul pour caractériser cette période comme le document de 1913 pour la première période. Bohr avait trouvé une nouvelle méthode de travail. Il ne travaillait plus seul, mais en collaboration avec d'autres savants. Sa plus grande force était de rassembler autour de lui les physiciens les plus actifs, les plus doués, les plus intuitifs du monde. Pendant cette période, on trouve aux côtés de Bohr, dans son célèbre Institut de Physique théorique à Copenhague, des hommes comme Klein, Kramers, Pauli, Heisenberg, Ehrenfest, Gamow, Bloch, Casimir, Landau et d'autres encore. C'est à ce moment et avec ces physiciens que les bases de la théorie des quanta furent jetées, que le principe d'incertitude fut énoncé et discuté pour la première fois, que l'antinomie particule-onde fut comprise pour la première fois. Les problèmes fondamentaux relatifs à la structure de la matière furent éclaircis au cours de discussions animées entre deux ou plusieurs personnes. C'est là que l'influence de Bohr se fit le mieux sentir. C'est là qu'il créa son « Kopenhagener Geist », style qu'il imposa à la physique — un style d'un caractère très particulier. On pouvait le voir, le premier entre ses égaux, travaillant, discutant, vivant avec un groupe de personnes jeunes, optimistes, enjouées et enthousiastes, abordant les plus importants problèmes de la nature avec un esprit d'attaque, un esprit libre de tout lien conventionnel, avec une allégresse qu'il est difficile de décrire. Lorsque très jeune, j'eus le privilège d'être reçu à l'Institut, je fus quelque peu surpris par les plaisanteries qui s'élevaient pendant les discussions, et cela me sembla un manque de respect. Faisant part de mes sentiments à Niels Bohr, celui-ci me répondit : « Certaines choses sont tellement sérieuses que l'on ne peut qu'en plaisanter ».

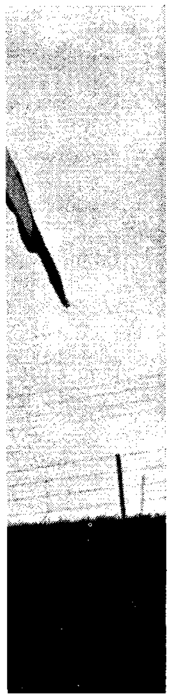
Durant cette période marquante de la physique, Bohr et ses disciples pénétrèrent les secrets profonds de l'univers. Les secrets de la Nature cachés jusqu'à ce jour furent percés par les facultés intellectuelles de l'homme.



La théorie des états quantiques fut solidement établie, de même que son intégralité fondamentale et son indivisibilité qui pourtant échappent à l'observation ordinaire d'une manière particulière, puisque le fait même de l'observer ferait disparaître les conditions de son existence. Bohr, dont les capacités pénétrantes d'analyse contribuèrent à un tel degré à éclaircir ces problèmes, appela cette situation extraordinaire « la complémentarité ». Ce mot met au défi une description imagée en nos termes classiques habituels de physique, mais révèle du même coup un monde beaucoup plus riche que notre expérience classique ne nous permet de percevoir.

Lorsque les principes fondamentaux de la mécanique atomique furent établis, il se révéla possible de comprendre et de calculer presque tous les phénomènes du monde des atomes tels que les radiations atomiques la liaison chimique, la structure des cristaux, l'état métallique et de nombreux autres. Avant cette époque, le monde se composait de nombreuses forces : électrique, adhésive, chimique et élastique; dès lors, toutes ces forces se trouvèrent rassemblées en une seule : la force électromagnétique. En quelques années seulement, les bases d'une science des phénomènes atomiques furent jetées et engendrèrent les connaissances profondes que nous possédons aujourd'hui. Jamais auparavant, tant ne fut réalisé par si peu d'hommes en si peu de temps.

Vint ensuite la troisième période des travaux de Bohr: les années 1932 à 1940. L'année 1932 fut importante pour le développement de la physique : on enregistra la découverte du neutron, du positron et de la radioactivité artificielle, et le premier accélérateur de particules entra en service. L'institut de Bohr, de renommée mondiale à l'heure actuelle, devint le centre des études de physique théorique. Le problème fondamental du quantum ayant été résolu, les travaux de physique théorique continuèrent dans deux directions. La première était l'application des théories des quanta dans le domaine des champs, électromagnétiques d'abord et nucléaires par la suite. Les travaux entrepris dans cette direction ne sont pas encore terminés à l'heure actuelle et de nombreux problèmes fondamentaux relatifs à la structure des particules élémentaires, qui sont à l'origine des champs, ne sont pas encore résolus. Pendant cette période, ces travaux se poursuivirent activement à Copenhague en étroite collaboration avec Pauli, Dirac et Heisenberg. Bohr, lui-même, dans un document célèbre publié en collaboration avec Rosenfeld, établit la base physique des nouveaux concepts de quantification des champs. Ce document constitue un exemple typique de l'intérêt que Bohr témoignait à la teneur en physique des théories mathématiques.



La deuxième direction dans laquelle étaient orientées les recherches était l'exploration de la partie la plus secrète de l'atome, le noyau atomique. Antérieurement, on considérait que le noyau était seulement la masse centrale de l'atome. Au cours de la troisième période, la structure du noyau suscita un vif intérêt, car un nombre toujours plus grand de faits relatifs aux phénomènes étroitement liés avec les parties les plus secrètes de l'atome furent révélés. Ces faits étaient troublants à l'origine, mais sous la conduite active de Bohr, on découvrit rapidement que l'univers du noyau était gouverné par les mêmes lois que la mécanique quantique. Toutefois, dans ce cas, on se heurta à un problème plus complexe en raison de l'apparition de forces nouvelles et plus puissantes qui maintenaient l'unité du noyau, à savoir les forces nucléaires. Lorsque le nombre considérable des états quantiques trouvés dans les réactions nucléaires posèrent des problèmes au monde des physiciens, ce fut encore le concept de Bohr du « noyau composé » qui permit de comprendre comment le grand nombre d'états est lié à l'interaction forte entre les parties composantes du noyau. Les travaux de Bohr et l'esprit stimulant issus des discussions qui avaient lieu à l'Institut de Bohr créèrent une nouvelle science de la structure nucléaire qui permit de comprendre les phénomènes nucléaires et aussi un problème déjà ancien : les sources d'énergie du soleil et des étoiles.

Nous approchons maintenant de l'année 1940, le début de la deuxième guerre mondiale. Les épisodes qui suivront dans la vie de Bohr sont, sous certains aspects, un témoignage encore plus important de la grandeur de cet homme. On ne peut les décrire en termes purement scientifiques. Bohr n'était pas seulement un grand savant, il était aussi un homme d'une sensibilité exceptionnelle à l'égard du monde qui l'entourait. Les rapports entre l'homme et la science revêtaient pour lui une importance capitale. Il fut conscient, avant les autres, du rôle décisif que la physique atomique jouait et continuerait à jouer dans la civilisation et le destin de l'homme — que la science ne pouvait pas être isolée du reste du monde. Par la suite, les événements de l'histoire du monde soutinrent ce point de vue plus tôt qu'on ne l'aurait pensé. Dans les années 1930 déjà, une brèche s'ouvrit dans la tour d'ivoire de la science pure. Le régime nazi dirigeait l'Allemagne et un flot de savants se réfugièrent à Copenhague où Bohr les recueillit et les secourut. Il demanda à certains d'entre eux de rester avec lui ; pour James Frank, Hevesy, Placzek, Frisch et beaucoup d'autres, Copenhague fut un havre où ils purent continuer leurs travaux scientifiques. En outre, l'Institut de Bohr était le centre pour tous ceux qui s'intéressaient à la science et qui avaient besoin d'aide, et plus d'un savant put obtenir un refuge — en Angleterre ou aux États-Unis — grâce à l'assistance accordée personnellement par Bohr. Puis, vinrent les années de guerre ; le Danemark fut occupé en avril 1940 par les Nazis ; la science pure était morte. Bohr travaillait étroitement avec la résistance danoise. Il refusa de collaborer avec les autorités nazies. Il fut bientôt obligé de quitter le Danemark, de fuir en Suède et arriva aux États-Unis en passant par l'Angleterre.

Aux États-Unis, à Los Alamos, il se joignit à un groupe important de savants qui travaillaient alors à des recherches sur l'exploitation de l'énergie nucléaire à des fins militaires. Il ne se déroba pas à cet aspect le plus problématique des activités scientifiques. Il aborda le problème carrément comme une nécessité ;

mais parallèlement, c'est son idéalisme, son esprit de prévoyance et son espoir en la paix qui incitèrent de nombreuses personnes de ce centre militaire à penser à l'avenir et à préparer leurs esprits pour les travaux futurs. Il nous aida à voir que, malgré la mort et la destruction, un avenir positif existait pour l'humanité que les connaissances scientifiques avaient transformée. Il fit encore plus. Il eut des contacts avec les hommes qui tenaient le pouvoir ; il vit Roosevelt, il vit Churchill. Il fit une foule de choses qui, aujourd'hui, nous paraîtraient naïves. Nous étions d'ailleurs tous naïfs lorsque nous pensions que la bombe serait abolie après la guerre et qu'une paix durable serait établie ; mais c'est cette naïveté même qui permet d'avoir l'espoir et la force nécessaires à un avenir pacifique. Nous devons être conscients à l'heure actuelle que c'est cette attitude ainsi que les discussions et les activités qui s'effectuèrent grâce à cet espoir qui ont contribué aux réalités actuelles et peut-être au fait que nous soyons encore vivants et capables de regarder l'avenir avec confiance.

Puis vinrent les années d'après guerre : de 1945 à sa mort. La physique n'avait plus le même aspect. La guerre avait fait ressortir, de manière cruelle, que la science est d'une importance immédiate et directe pour chacun. Le caractère de la physique avait changé. La physique devint une vaste entreprise : pour effectuer des recherches dans ce domaine, il fallait beaucoup de monde et de grandes machines. Bohr admit ce changement comme une suite logique des travaux qu'il avait entrepris avec ses amis. Les nouvelles idées qu'il avait émises dépassaient la tour d'ivoire des universités dans lesquelles certains auraient souhaité enfermer leurs connaissances. Il comprit que de ces idées se développerait une grande réalisation qui couvrirait tous les domaines des activités humaines ; il vit ainsi la nécessité de faire de la physique sur une grande échelle, voire sur une échelle internationale. Dans aucun autre effort humain, les limites étroites imposées par les nationalités et la politique ne sont plus désuètes et ridicules que dans le domaine de la science. Bohr était donc toujours conscient du rôle important que la science doit jouer en créant un lien durable qui dépasse les limites nationales et politiques et en créant les débuts d'une société supranationale d'êtres humains sur la terre. Voilà pourquoi il s'occupa activement de la création de centres internationaux de recherche scientifique: le centre scandinave, NORDITA, à Copenhague et enfin le centre dans lequel nous travaillons. C'est grâce à Bohr que le CERN existe. C'est la personnalité de Niels Bohr, son influence et ses travaux qui ont permis de créer le Laboratoire. D'autres savants éminents conçurent l'idée du CERN. Leur enthousiasme et leurs idées n'auraient pas suffi s'ils n'avaient pas été appuyés par un tel homme, qui ne se contentait pas seulement de les appuyer mais participait activement à chaque stade important de la création et du développement de cette œuvre, uni dans un commun effort avec les autres pour discuter et s'inquiéter de chaque détail. Voilà ce qu'était Niels Bohr.

La grandeur de cet homme se fait sentir dans cette période plus que dans toute autre. A soixante ans, Bohr était pleinement conscient des nouveaux développements de la physique, de la nouvelle phase commencée dix ans plus tôt, lorsque la possibilité d'obtenir des faisceaux de hautes énergies permit d'aller plus loin que la structure du noyau et d'explorer la structure des constituantes du noyau : le monde du proton et du neutron. Cette nouvelle étape de la science n'est que la suite du courant immense que les travaux de Bohr avaient engendré. Bohr en était conscient et c'était la raison pour laquelle il avait donné l'appui de son enthousiasme, de sa joie de vivre, de son attitude positive à ce nouveau développement et en particulier à la nouvelle poussée de la physique fondamentale en Europe. Je me rappelle un exemple qui montre combien il s'intéressait aux activités du CERN. Il y a un an environ, Bohr avait été prié d'apporter son concours à la solution d'un problème budgétaire. Il vint au CERN et son aide fut précieuse pour régler la question ; après la réunion qui dura toute la journée, et lorsque tous étaient fatigués, il pria un des membres de l'accompagner pour une promenade ; il passa deux heures à Genève sous la pluie, expliquant ses vues sur la situation actuelle. On comprend difficilement comment un homme de cet âge pouvait avoir cette énergie, cet intérêt enthousiaste de la vie ; c'était toutefois une condition nécessaire pour que se réalisent ses travaux. Il nous a donné cet accroissement immense de notre vision de la réalité, qui fit trembler les fondations du monde, mais par ailleurs c'est son optimisme et son enthousiasme qui nous permettent de surmonter les difficultés auxquelles nous nous heurtons.


Photo : M. Benarie, Tel-Aviv

Avec la mort de Niels Bohr, une époque s'achève — l'époque des grands hommes qui créèrent notre science. Mais Niels Bohr lui-même a participé à la création des bases pour la continuation future de travaux dans son esprit ; notre institution, le CERN, en est un témoignage. Il nous contraint à continuer les travaux qu'il souhaitait entreprendre.

Il est mort comme il a vécu. Deux semaines avant sa mort, il rentrait de vacances, entièrement remis d'une légère attaque qu'il avait eue l'an dernier ; ses médecins lui avaient permis de reprendre son travail. Il le fit et s'en porta bien ; deux jours avant sa mort, le vendredi, il présida même une réunion de l'Académie royale des Sciences du Danemark ; le dimanche, il avait invité quelques amis chez lui. Il était heureux et en bonne santé mais après s'être étendu pour quelques moments de repos, il ne se réveilla pas. Qu'une telle vie ait été vécue et puisse l'être à l'heure actuelle est un grand encouragement pour nous tous ●

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