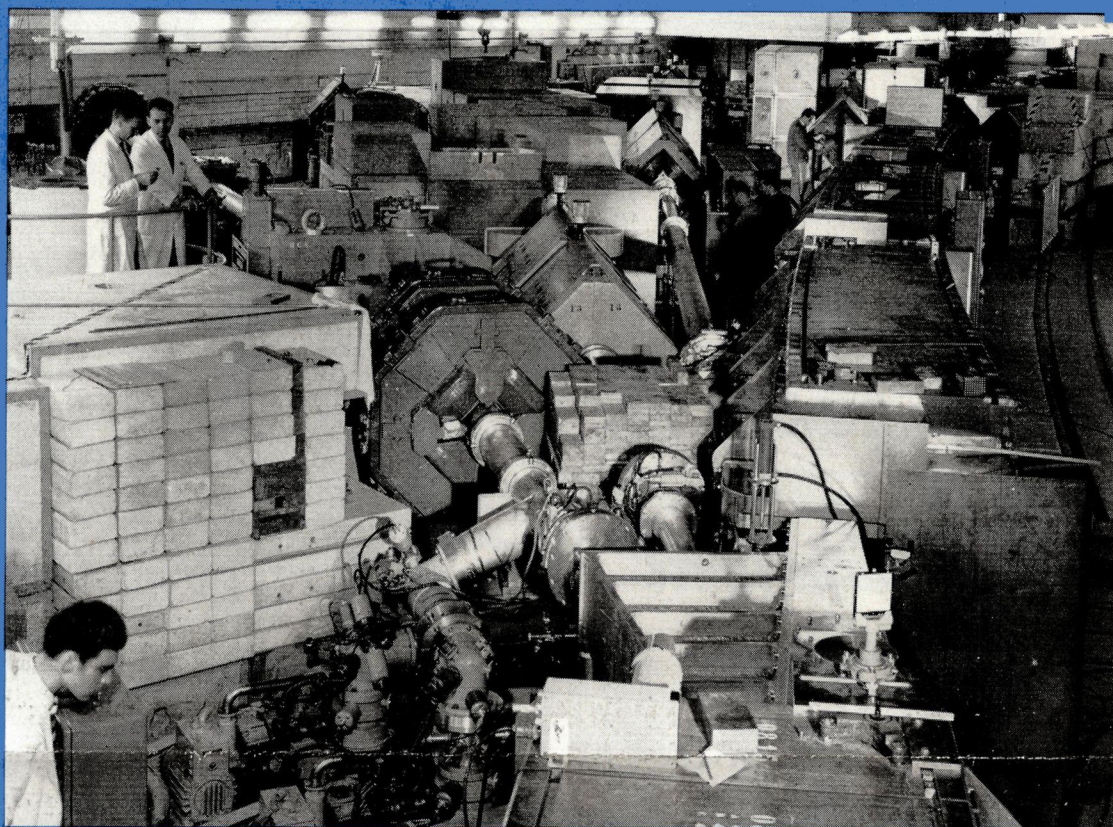


# COURIER INTERN



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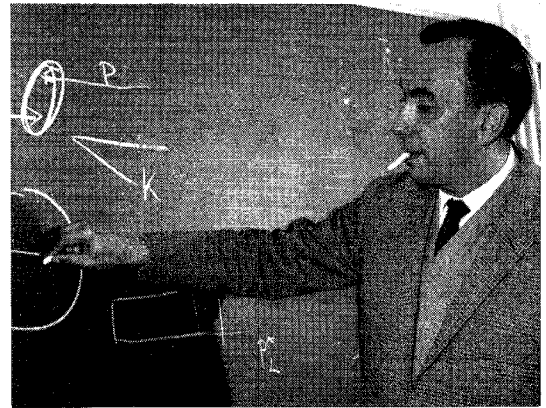
**VOL. 2**

**February 1962**

**EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**

# Charles PEYROU

Leader, Track Chambers Division



One of the major contributions to the rapid expansion of high-energy physics research in the last few years has been made by the bubble chamber, which allows one to photograph tracks made by the otherwise invisible particles taking part in nuclear reactions and so to deduce their properties.

At CERN, bubble chambers filled with liquid hydrogen are the concern of the Track Chambers Division, and of its Leader, Prof. Ch. Peyrou.

Charles Peyrou was born at Oloron Ste Marie, in the West Pyrenees, in 1918. He studied there and in Paris, at the Ecole Polytechnique, and while still a student worked in the Laboratory under Prof. L. Leprince-Ringuet. The war interrupted this, but afterwards he returned to do experiments on cosmic rays using cloud chambers — which also allow one to photograph tracks of particles.

His most important studies, in which he collaborated with A. Lagarrigue, were on the properties of mu-mesons: their mass and the energy spectrum of the electrons which arise from their decay. Some of the experiments were done in Paris, but pleasant summers were also spent at L'Argentière, La Bessée, near Briançon in the Hautes Alpes, where they obtained electric current for the cloud-chamber magnet from a nearby aluminium works.

In 1952 he went to the U.S.A. for a year, to M.I.T., the Massachusetts Institute of Technology, to investigate 'strange particles' with Prof. B. Rossi. Both before and after this, he worked with B. Gregory, A. Lagarrigue, and F. Müller (all three now part-time at CERN as visitors), to set up and operate two big cloud chambers at the Observatory of Pic du Midi,

for the study of strange particles, particularly K-mesons, occurring in cosmic rays. In 1954 he was appointed Professor at Berne University.

Prof. Peyrou's association with CERN began when he became consultant on cloud chambers and bubble chambers while still at Berne. Then in March 1957 he came to Meyrin, joining the then Scientific and Technical Services Division to lead the group working on the design and construction of CERN's 32-cm hydrogen bubble chamber.

Now the group has grown to a Division which is playing a large part in the Organization's experimental programme and will continue to do so in the future, when its 2-m liquid-hydrogen bubble chamber, now under construction, becomes available. Moreover the Division acts as host to several outside teams who bring their own equipment to CERN — the Saclay 81-cm hydrogen bubble chamber, for instance, and later on the British 150-cm chamber, the magnet for which has already arrived. The experiments with these chambers are planned and executed in common, and the photographs are distributed to a large number of groups throughout Europe.

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The cover photograph shows the start of some of the secondary particle beams produced by the 28-GeV proton synchrotron. On the left, shielding bricks form a collimator; to their right are vacuum pipes, passing through guiding lenses and magnets, for beams of charged particles (see plan on centre pages).

Photo credits: all photos by CERN/PIO.

## CERN COURIER

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## Last month at CERN

Most members of the Laboratory were able to enjoy a holiday from Christmas to the New Year, but among the changes they found on their return were new telephone numbers. Between 26 and 29 December, S.B. Division Technical Services had installed a new **telephone exchange**, increasing the number of available lines from 700 to 1100.

The **proton synchrotron** was shut down from 23 December to 16 January for routine maintenance and for carrying out a number of improvements. Among the latter, the 500-kV **pre-injector** system was re-aligned mechanically, and no correction currents are now required in the steering coils. Back-leg windings were installed on 60 **magnet** units and the

**counter cable** network in the South hall almost doubled. The first remote-control units for the **radio-frequency system** have been installed in the Main Control Room.

A more rapid change of **target units** has been made possible by modifications to the accelerator vacuum system, and a new **vacuum box** in straight-section no. 1 allows the extraction of secondary beams at a greater angle than previously.

Three new **beams** were installed during the shutdown:

q<sub>1</sub> — 1.15 GeV/c negative pions, using 4 lenses and a bending magnet;

s<sub>2</sub> — a 30° neutral beam with adjustable collimators on each side of the shielding wall;

v<sub>1</sub> — similar to s<sub>2</sub>, but at 45°.

# 20th Session of CERN Council

On 19 December, 1961, forty-six delegates and advisers from CERN's fourteen Member States met at Geneva for the 20th Session of Council, exactly ten years after the first meeting of the 'Provisional Council' at UNESCO House, in Paris.

After the presentation and discussion of the Division Leaders' progress reports came an item on the Agenda of much concern to CERN and the people who work here — the Budget for 1962. Although considerably above the figure for 1961, the sum of 78 million Swiss francs finally proposed as the total of contributions from the Member States was below that envisaged earlier in the year, and in fact was regarded as the minimum possible if the Laboratory is not to fall behind in its development as a leader of high-energy physics research. In the event, the proposed figure was approved by a majority of delegates. It was also recommended that a study of the future expansion of the activities of CERN, and of its rate of expenditure, be prepared for the Council before next April by a working party presided over by Mr. Jan H. Bannier (Netherlands).

Mr. Jean Willems (Belgium) was re-elected President of the Council for 1962, and one of Sweden's representatives, Dr. Gösta Funke, was elected Chairman of the Finance Committee. He replaces Dr. W. H. A. Hocker, (Fed. Rep. of Germany) who has left the Federal Ministry for Atomic Energy



A typical scene in the Council Chamber on 19 December, showing some of the new banners — one for each Member State — which added extra colour to the proceedings.

to become Chief Administrator of the nuclear research centre at Jülich.

At the conclusion of the meeting, presentations were made to Mr. H. L. Verry, a United Kingdom delegate to Council for many years, and to Dr. J. B. Adams, formerly Director-General and now one of the U. K. Delegates ●

## PARTICIPANTS

President: Mr. J. Willems (Belgium)

### Austria

Prof. W. Thirring  
Prof. F. Regler  
Mr. H. Vavrik \*

### Belgium

Prof. J. Serpe

### Denmark

Prof. J.K. Bøggild  
Mr. O. Obling

### Federal Republic of Germany

Prof. W. Heisenberg  
Dr. A. Hocker  
Prof. W. Jenischke \*  
Prof. W. Gentner \*  
Dr. W. Schulte-Meermann \*

### France

Mr. F. de Rose  
Prof. F. Perrin  
Mr. J. Courfillet \*  
Mr. J. Martin \*

### Greece

Mr. A. Vlachos  
Prof. Th. Kouyoumzelis  
Prof. Th. Kanellopoulos \*

### Italy

Prof. E. Ippolito  
Prof. E. Amaldi  
Mr. F. Lucio Ottieri \*

### Netherlands

Mr. J.H. Bannier  
Prof. S.A. Wouthuysen  
Mr. C.E.I.M. Hoogeweegen \*  
Prof. A.H. Wapstra \*

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### Spain

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Mr. J.M. Aniel-Quiroga  
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Mr. J.A. Ruiz Lopez Rua \*  
Mr. P. Temboury \*

### Sweden

Dr. G. Funke  
Prof. I. Waller

### Switzerland

Prof. P. Scherrer  
Mr. A. de Senarclens  
Mr. S. Campiche \*  
Mr. R. Bieri \*

### United Kingdom

Sir Harry Melville  
Dr. J.B. Adams  
Mr. S.H. Smith \*\*  
Mr. R.C. Griffiths \*  
Mr. J. Hubbard \*

### Yugoslavia

Prof. I. Supek  
Mr. S. Soc

Mr. H. Fahir Alaçam (Observer from Turkey), Prof. C.F. Powell (Chairman of the Scientific Policy Committee), and M. H.L. Verry also attended, as well as the Directorate and Division Leaders of the Laboratory.

\* Adviser \*\* Alternate

The new beams and the positioning of the NPA electrostatic separator in the South Hall, have led to considerable alterations in the layout of the **shielding**. Much of the shielding previously arranged for the **neutrino experiment** has now been removed, and the **1-m heavy-liquid bubble chamber** has been removed to the NPA building for modifications.

Among experiments that followed the shut-down was the second run of the 81-cm hydrogen bubble chamber in the **separated antiproton beam**, following the first one just before Christmas. In the two weeks, photographs have been obtained of about one million antiprotons crossing the chamber at 3 GeV and half a million at 3.6 GeV. The long-awaited replacements for the **magnet coils** of the CERN 32-cm hydrogen bubble chamber arrived just too late, the

run in the 1.5-GeV K<sup>-</sup> beam having been interrupted at an early stage by failure of one of the existing coils.

During the Christmas shut-down at the **synchro-cyclotron**, work included the installation of new equipment to improve the cooling facilities for **beam-transport** magnets and lenses, allowing greater possibilities for experimental groups to work in parallel. The opportunity was also taken for a further investigation of the **radioactivity** of the machine. At the beginning of December an interesting new bubble chamber was installed — the 20-cm **liquid-helium chamber** operated by R. Bizzarri's Group from **Rome** University, here since last July. They are at present investigating muon capture by helium nuclei. The **Darmstadt** Group left at the end of the year, having completed their experiments on mu-mesic x-rays.

The **Track Chambers Division** has taken over its new building, across the road from the SC. This accommodates about 1/3 of the staff, with offices upstairs, and 12 scanning tables on the ground floor.

The **Health Physics Group**, now totalling 14 people, has also moved into new quarters — the former Wilson Chamber Barracks.

G. Auberson, J. Baarli, M. Barbier, J. Dutrannois, J. Y. Freeman, K. H. Reich, and P. H. Standley attended the '**International colloquium on shielding around large accelerators**', at Orsay and Saclay from 18-20 January. This was the first time a conference on such a scale had been held to deal with the radiation problems of present and future accelerators.

(continued on p. 12)

# CERN and high-energy physics

by V. F. WEISSKOPF, Director-General

## PRESENT STATE OF HIGH-ENERGY PHYSICS

The main aim of high-energy physics is the study of the properties of elementary particles. The knowledge acquired by this study will give us an understanding of what elementary particles are, and thus of the basic facts upon which all the rest of our science and technology is built. This is the present phase of that great development of human knowledge, which has descended from Galileo and Newton, and which has resulted in our recognition of the nature of electricity and magnetism, of relativity theory and quantum mechanics, of atoms and the structure of matter. Indeed, this development has immensely augmented Man's understanding and mastery of the world of which we are a part.

The new phase of fundamental research requires large high-energy installations because of a basic law of nature regarding the stability of atomic objects: the smaller the object, the higher is the energy required to penetrate into its structure. It was found in the 1930s, using small accelerators, that the elementary particles of which atoms and nuclei are made are protons and neutrons (called 'nucleons') and electrons. The object of modern high-energy physics is the exploration of the nature and structure of these particles and of their inter-relations.

The results of these studies to date are most exciting. They do not yet give us satisfactory answers as to the structure of the particles; however, they have revealed an unexpected wealth of phenomena which represent a new aspect of nature, very different from our experiences at lower energies. This is an aspect most relevant for the understanding of the basic facts of nature.

The phenomena can be very tentatively divided into four groups: nucleon structure, strange particles, weak interactions, and antimatter.

### Nucleon structure

The nucleon is the source of a strong nuclear force field, which is transmitted by pi-mesons. In loose terms: the nucleon is surrounded by a cloud of pi-mesons. Many most interesting properties of this pion cloud have been studied by bombarding nucleons with particles able to transmit energies roughly between 200 and 2000 MeV. Because of this relatively low energy, it is the 'outside' of nucleons which is studied here. Let us call the investigation of these phenomena 'pion physics'. The penetration into the 'inside' parts of the nucleons requires much higher energies. These have become available only recently at CERN and elsewhere and will soon create an interesting new field of inquiry — the physics of the nucleon core.

### Strange particles

Nucleons can be changed into slightly heavier particles called hyperons, such a change being accompanied by the production of another variety of meson — the K-meson. Hyperons and K-mesons are called 'strange particles'. New types have been detected recently. This

*This is the first part of an article based on a paper prepared by the Director-General for the 20th Session of Council in December 1961. The second part, dealing with the rôle of CERN in European high-energy physics and probable future trends, will be published in the March issue of CERN COURIER.*

field of phenomena, 'strange-particle physics', is in a state of rapid development at present. Its phenomena are observed in the energy region of a few GeV and higher.

### Weak interactions

All the new entities discovered in this research — hyperons, different kinds of mesons, etc. — are unstable. This means that they disintegrate after a certain time into pairs, or triplets, or even larger numbers of lighter particles. The process of disintegration is very little understood. It can be related, however, to certain weak interactions between particles, and it is most probable that it is also related to the ordinary process of radioactivity. A characteristic feature is the occurrence in most, but not all, disintegrations of a special particle — the neutrino, a particle of zero charge and zero mass. This particle is known to be emitted also by ordinary radioactive substances. Another surprising feature is the occurrence in these decays of a heavy electron (the so-called mu-meson; this is a misnomer, it should not have been called a meson). It differs from an ordinary electron only by its larger mass, as far as we know today. The study of these particle disintegrations and of related phenomena is the field of 'weak-interaction physics'. This weak interaction which causes these decays is in striking contrast to the 'strong interaction' between nucleons and hyperons of which the nuclear force is one realization.

### Antimatter

Since we are working today with energies much larger than the mass energy of the elementary particles under study, the phenomenon of antimatter plays an important rôle. The beams of our large accelerator produce antimatter; they create pairs, each of a particle and an antiparticle. Thus antiprotons, antineutrons, antihyperons, etc., are constantly produced. Whenever



'It differs from an ordinary electron only by its larger mass'... Horst Blaha (foreground) and André Kupferschmid are seen here in the SC control room during the g-2 experiment which made this statement possible.

an antiparticle hits ordinary matter, an 'annihilation' process sets in which transforms the mass energy into other forms; mostly into mesons. This process is important for the study of the way in which large amounts of energy can be transformed, a field of study we may call 'particle annihilation physics'.

## HIGH-ENERGY RESEARCH CENTRES

Let us now consider the activities of the different high-energy research centres. No attempt is made to give a complete account; we mention only contributions which have opened new avenues of research or revealed decisive results.

In the past, most new discoveries in this field were first made with **cosmic rays**. High-energy machines served mostly to support these initial discoveries and to perform quantitative measurements. Europe has always played an important rôle in cosmic-ray research, and the pioneering contributions of England, France, and Italy in this field are well known. Unfortunately the intensity of cosmic rays falls off strongly with increasing energy, so that we can no longer rely upon this natural supply of high-energy particles for further discoveries.

**Pion physics** was developed ten to twelve years ago, mainly at Chicago and Berkeley, when machines in the region of several hundred MeV were first put into use. High-energy installations in England and France have recently also contributed important work in this field.

**Strange-particle physics** needs machines of somewhat higher energy, and therefore its development took place mostly at Berkeley and Brookhaven. The 3-GeV machine at Saclay has also been used for this kind of investigation.

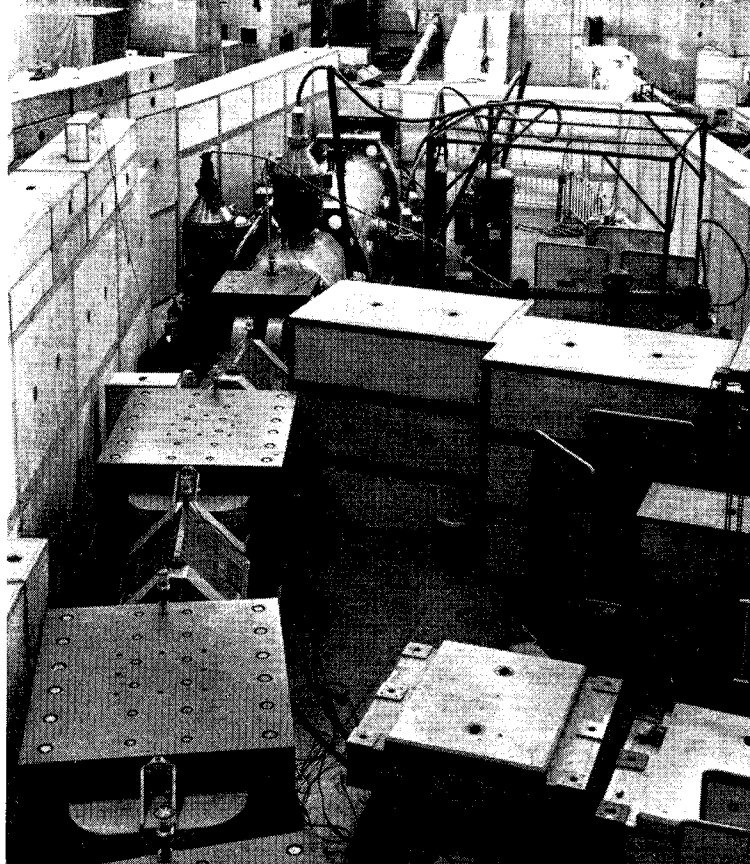
Today the field of strange particles has become of special interest since new hyperonic states have recently been discovered. The world of strange particles has turned out to be much more varied and more intricate than expected.

**Weak-interaction physics** requires the production of unstable particles, and therefore studies in this field are made wherever such particles are available. Clearly the higher the energy of the machine, the better can the studies be performed, since not only are more different kinds of unstable particles produced at higher energy, but they are also produced in greater quantities. This is why the important experiments have been made mostly at Berkeley, Brookhaven, and also Saclay. The most important one, however, the discovery of the parity violation in weak interactions, was made at Columbia first, without a high-energy machine, with ordinary radioactive substances; its application to high-energy phenomena was shown by experiments with the Columbia accelerator, which is not unlike our small SC machine at CERN.

**Particle annihilation physics** can only be carried out at centres which have enough energy to produce antimatter. Until recently such work was restricted to Berkeley.

## CERN'S PRESENT POSITION

Where does the research work at CERN fit into this picture? CERN's contributions to physics had a conspicuous start with the work done using the **synchrocyclotron** (SC), which was ready for research 2½



'The beams of our large accelerator produce antimatter'... This is how antiprotons with an energy of 3.6 GeV are separated from other particles produced by the PS beam and directed towards the bubble chamber where their annihilation is studied..

years before the larger proton synchrotron. This work with the SC accelerator was directed mainly towards weak-interaction physics. The first important contribution was the discovery of the electron decay of the pion in 1958, but most of the other important work has been devoted to the exploration of the heavy electron. For this purpose, the SC machine has been equipped with a unique feature: the muon channel, which is the strongest and cleanest source of heavy electrons anywhere in the world. The first measurement of the anomalous magnetic moment of the muon was made here — one of the most fundamental experiments concerning this particle. Studies concerning the absence of its radiative decay, and its scattering by atomic nuclei, are other achievements. At present, measurements of its capture by hydrogen are under way, the results of which will be of fundamental importance. So will be the results of a planned experiment on the radioactive decay of the pion.

**Elementary particles** are, in the first instance, the basic constituents of the atoms that make up all matter. The name is also applied to other entities thought to play an essential part in nuclear interactions.

An **antiparticle** corresponds to each particle. It has opposite electric charge and/or magnetic moment to its corresponding particle, but is otherwise identical to it.

One **electronvolt** (eV) is the energy gained by a particle with elementary electric charge (for example, an electron or a proton) accelerated by a potential difference of 1 volt. **1 MeV** is a million (or  $10^6$ ) electronvolts. **1 GeV** is a thousand million ( $10^9$  or U.S. billion) electronvolts.

The **mass energy** of a particle is the energy equivalent to its mass; mass and energy are interconvertible.

The **cross-section** of a nuclear reaction is a measure of its probability of occurrence.

Altogether the work at the SC alone in the last three years has raised CERN to world importance in high-energy physics. The reason for this splendid success lies not only in the excellence of the machine and the inventiveness of the CERN scientific staff; it also stems noticeably from the fact that outstanding American visitors were attracted by the excellent research conditions and participated in the planning and execution of the experiments. It must also be said that the SC is a machine small enough to admit of a style of research work not too dissimilar to pre-war physics, in which Europe has had much experience.

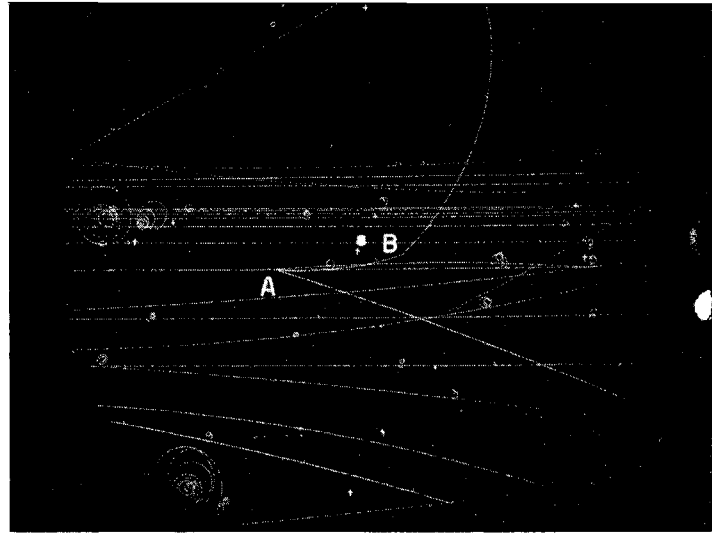
The task of keeping CERN in the forefront of physics became quite different when the **proton synchrotron** (PS) was ready for research in 1960. On the one hand, CERN possessed the only machine in the world of that energy until the beginning of 1961; on the other hand, the CERN staff had to adjust itself to completely new problems arising from a machine of that size, a process which was aggravated by the fact that the machine could be used effectively earlier than anyone had anticipated. Both circumstances mean that it has taken time to reach the most effective exploitation of the machine. The first led to a quick skimming of the easiest results, partly as a training phase; the second presented a difficult problem of scientific organization, in particular because of the fact that auxiliary experimental equipment was not ready when the machine started operation.

In spite of these difficulties the record of the first year of the PS is not unimpressive. The first observations of particles produced in collisions of 25-GeV protons with nuclei revealed the interesting fact that strange particles and antinucleons were produced copiously, but not as plentifully as one had expected on the basis of theoretical considerations. A large yield of deuterons also caused some interest. The systematic work on total cross-section for collisions between protons and the newly produced particles was an important contribution, since no measurements had been made before in that energy region, and it also revealed unexpected features.

Soon after the PS started working, it was realized (mainly by a group from the University of Berne) that, by scattering the protons in an internal target, a very convenient, though weak, beam of protons with full energy could be made available for experiments outside the ring. This beam initiated a series of experiments which has opened up a new approach to high-energy collisions — the study of **peripheral collisions**. It belongs to pion physics, and is the study of effects taking place if the edge of the meson cloud of a very fast nucleon sweeps over a stationary nucleon. A number of new phenomena have been found which are relevant for the understanding of the pion-cloud structure — phenomena which had never been observed before.

Exposures of the 32-cm bubble chamber (the only one available in the first year of running) gave an interesting new insight into strange-particle production at high energy. An investigation of the magnetic properties of the heavy electrons coming from the decay of fast pi-mesons yielded fundamental information about parity violation in pion decay, and thus represents an important contribution to weak-interaction physics.

In the second year of running, most of the research projects were continued but a number of large new



'A new approach to high-energy collisions' . . . This photograph, taken with the CERN 32-cm hydrogen bubble chamber, shows an example of a 'peripheral collision'—indicated by the narrow spread of the particles produced. A 16-GeV pi-meson collides with a proton at A to give four particles, one of which decays at B into a charged pion and a neutral particle which leaves no track.

ones were started. The 81-cm hydrogen bubble chamber from Saclay became available and was put to use in several runs, the most important of which was a run in a beam of separated slow antiprotons. The separators for this beam were provided by the University of Padua, while the pictures are now being evaluated by the Universities of Padua, Cambridge, Oxford, Trieste, and Rome. Here we have a good example of co-operation between CERN and its Member States. In a two-week run, perfect photographs of about 400 000 antiproton annihilations were taken. This collection is by far the largest in existence and CERN has 'cornered the market' of antiproton annihilations at rest. The evaluation of these pictures will take many months, but much new information will result from this unique contribution to annihilation physics.

It was planned to devote a great deal of effort with the PS to a special experiment in weak-interaction physics, the neutrino experiment. When fast pions produced in a target decay in their flight, neutrinos are created which form a neutrino beam of high energy. This beam, when isolated from all other particles by heavy shielding, is of unusual interest for the study of weak interactions and their behaviour at high energy. Some of the most fundamental questions in this field, such as that of the existence of several kinds of neutrinos, could be answered. Attempts in this direction were made in the spring of 1961, but they proved unsuccessful because the neutrino beam turned out to be weaker than anticipated. However, the experience gained will make it possible to prepare a much better attempt at a later date.

Experiments planned for the immediate future include several runs with the 81-cm bubble chamber in a separated antiproton beam of more than 3 GeV, in order to get pictures of annihilations of fast antiprotons and their by-products. Two new beams of K-mesons will supply large numbers to perform experiments on strange-particle physics and on K-meson decay. This type of experiment has just been begun at Berkeley and also with the Brookhaven Cosmotron. The higher energy of our machine should make it possible to produce stronger and more flexible K-meson beams. It can be expected that important new results will be found, in particular with respect to the new types of hyperon states and with respect to the laws of weak interaction in the case of strange particles.

During the year 1961, the American counterpart to the PS, the alternating gradient synchrotron (AGS), was put into running condition at Brookhaven. Its performance is now equal to that of the CERN PS, and its yield is somewhat larger since it is a slightly bigger machine. Hence, the CERN accelerator no longer enjoys a unique position. There is no reason to fear, however, that the research activities at the AGS will from now on make it impossible for the PS to remain in a leading position with regard to fundamental physics. The field is wide enough to keep two machines of this type busy for a long time, particularly in view of the new perspectives seen now in strange-particle physics, which indicate that the region of a few thousand million volts is in fact much richer in phenomena than anticipated.

The work carried out so far at the AGS reflects both the experience acquired at Brookhaven in the running of the Cosmotron and the high quality of the staff. For instance, their investigations of the composition of the secondary beams coming from internal targets have been done more systematically than at CERN. The results will be very useful for them and, to some extent, also to CERN in the planning of future experiments. So far, they have repeated with better accuracy and extended to higher energy the total-cross-section measurements of secondary particles with hydrogen. They have also undertaken an antiproton annihilation run in a hydrogen bubble chamber at 3-GeV energy, similar to the next annihilation run scheduled at CERN. They also plan to carry out a neutrino experiment in the immediate future, the planning of which has been partially based on the experience of CERN's abortive attempt. It is probable that they will succeed in their aim to solve the fundamental question of the existence of one or more types of neutrino. If the neutrino experiment is considered as a race between the AGS and the PS, they would, in this case, have won the first lap. It should not be considered in this light, however; it is rather a double attempt to penetrate into a new area of knowledge, not unlike two climbers on one rope. The first climber tries a difficult stretch and fails; whereupon the second climber tries again and, with the help of the negative experience of the

first one, avoids the worst pitfalls, and succeeds. In either case, the mountain is much higher than the first pitch.

The existence and the vigorous growth of another research centre similar to CERN does pose certain problems, however. To remain with our metaphor, the two climbers will continue to scale new heights together only if they remain on good terms and if both remain on roughly the same level of excellence. In order to ensure the first condition, we envisage close contacts between the two laboratories in our planning of research programmes and we hope to exchange scientists in a systematic way. The second condition is harder to fulfil. We do not have, here in Europe, the experience in this field which the American physicists have acquired working with big machines for many years. It should be remembered that the Cosmotron and the Bevatron were both operating in the U.S.A. before the CERN Convention was ratified, and that our own SC had run for less than 2½ years when experiments could start with the PS. Consequently, we do not so far have a comparable number of people capable of making the best use of our facilities. For lack of this experience we have also found that it is more difficult here than in the U.S.A. to introduce new methods of research; the spark-chamber technique, for example, which will probably acquire an importance comparable to that of bubble chambers, was taken up rather late at CERN.

We have, however, an enthusiastic group and a large number of most promising young physicists and engineers. If we provide our staff with the means necessary to build the most modern equipment, and if we create an atmosphere in which the newest ideas in this field are readily caught and exploited, then CERN will not lose the eminent position which it now possesses. What is needed, therefore, is the collaboration of the best physicists of Europe, within and outside CERN, for a successful exploitation of the facilities, and a generous use of the intellectual advantages which CERN provides as a gathering place for the most active high-energy physicists of the entire world●

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## Fission and Spallation

From 26-29 September, 1961, a **Conference on fission and spallation phenomena and their application to cosmic rays** was held at CERN, arranged by the Organization's Nuclear Chemistry and Spallation Groups jointly with the Max Planck Institute for Nuclear Physics, Heidelberg.

*Fission* is the division of an atomic nucleus into two approximately equal parts. *Spallation* is a phenomenon in which relatively small fragments are ejected, leaving one larger residual nucleus. Both fission and spallation can be produced in many nuclei by high-energy particles from accelerators, and at CERN such reactions are studied by the two groups that held the conference.

The first part of the conference dealt with the fundamental features of fission and spallation phenomena, especially when induced at high energy, while the second part was devoted to the discussion of some of the results of these reactions, particularly of spallation, found in Nature.

Spallation reactions are induced in meteorites by cosmic rays. Investigations of the relative quantities of different isotopes found in meteorites can help to show their age and possible mode of formation, or give information on the constancy of cosmic radiation with time.

Interest in the conference, the first of its kind to be held in Europe, far surpassed original expectations, and over 100 outside participants joined those from CERN to hear and discuss more than 50

papers presented under the following headings:

- Theory,
- Fission,
- Spallation,
- Recoil experiments,
- Monitor reactions,
- Chemical methods,
- Cosmic-ray-produced isotopes,
- Other isotopic variations,
- Exposure age of meteorites,
- Tektites.

Relief from the very full programme was provided on one afternoon by a boat cruise on Lac Lemman, but even here enthusiasts were still able to attend a special session on tektites, glassy pieces of matter of obscure origins●

# Layout of Beams for the proton synchrotron

Most nuclear-physics experiments carried out with the aid of the 28-GeV proton synchrotron require a 'beam' of particles, selected from the multitude produced by the impact of the primary proton beam on an internal target.

The construction of these beams is the responsibility of the MPS Division's Apparatus Layout Group — usually abbreviated to ALO —, led by F. Bonaudi. Their work begins in discussing with the experimental teams and the planning group the setting up of any particular beam — what is required, if and how it would interfere with other beams, existing or planned, etc. Then, once agreed upon, the beam must be built, with collimators to define it, 'lenses' (focussing magnets) to prevent it from spreading, and bending magnets to turn it in the required direction. The alignment of this guiding equipment has to be done to a high order of accuracy, so that careful surveying is essential. Then, when the equipment is in position, the necessary electric current, cooling water, and other supplies must be provided.

Shielding is required around the beams, partly to protect the experimenters from too much radiation, but more often to prevent one experiment from interfering with another. ALO arranges all this, on the advice of the Health Physics Group, and as requested by the physicists — bearing in mind always the feasibility from an engineering point of view, shielding blocks being very heavy items to stack on any floor.

In addition, the Group carries out monitoring investigations on the various beams, to keep a check on their composition and to obtain ideas for future beams.

It also employs a hydrogen safety officer, who is responsible for the safe operation of all equipment using liquid hydrogen in the region of the PS.

The work involved in setting up the beams requires many working drawings, to ensure that the proposals can be carried through successfully. Apart from these, two final drawings (one covering the North hall and one the South hall), accurately scaled to 1:100, are produced and widely distributed each week. These show not only the positions of the beams, with all the magnets, etc., properly numbered, but also auxiliary data of use to the machine operators and experimental teams — positions and numbers of telephones, power-supply terminal boxes, and so on.

These two drawings, for the week beginning 5 February, have here been combined into one and reproduced on a smaller scale. The beams shown are as follows :

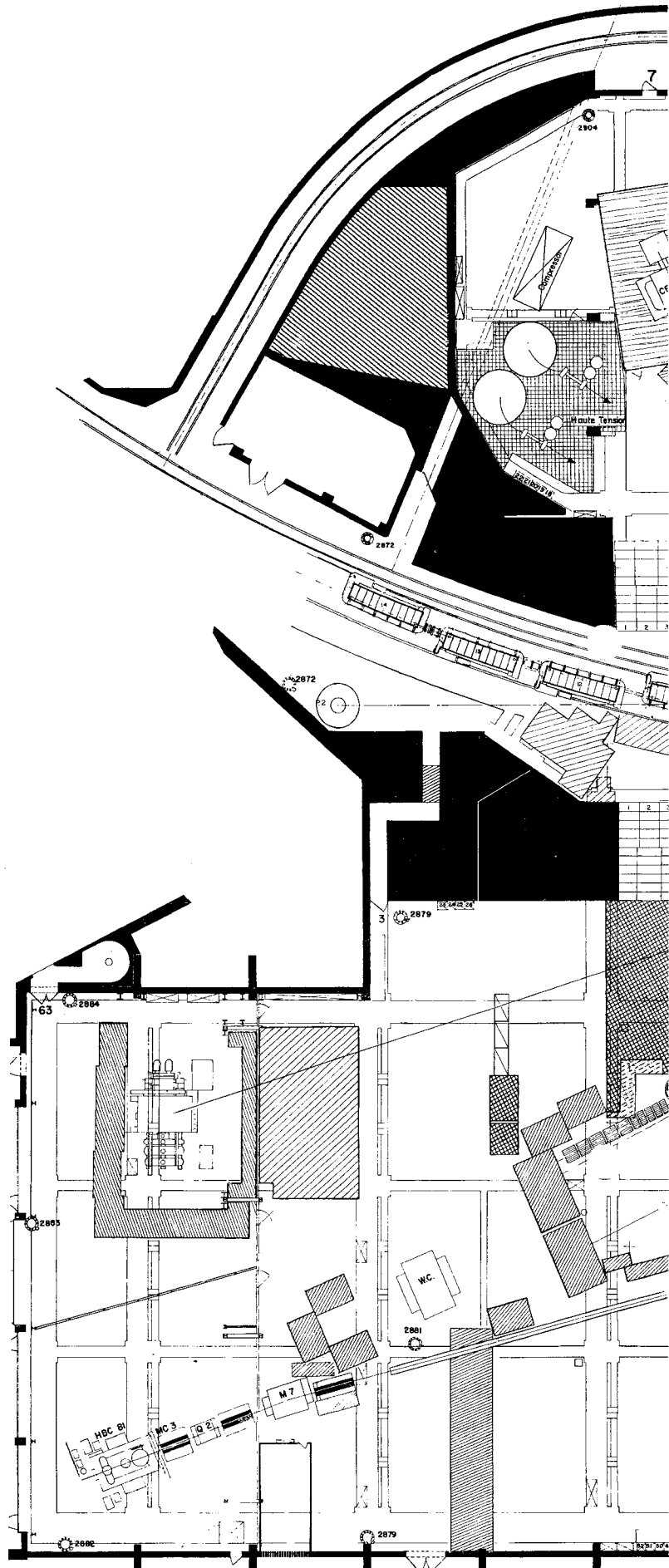
## South hall :

- c<sub>3</sub> — scattered protons ;
- c<sub>4</sub> — same as c<sub>3</sub>, but magnetic deflexion angle is greater ;
- d<sub>10</sub> — charged particles ;
- m<sub>1</sub> — separated beam of positive or negative pions, negative kaons, or antiprotons ;
- q<sub>1</sub> — negative pions ;
- s<sub>2</sub> — neutral beam ;
- v<sub>1</sub> — neutral beam.

## North hall :

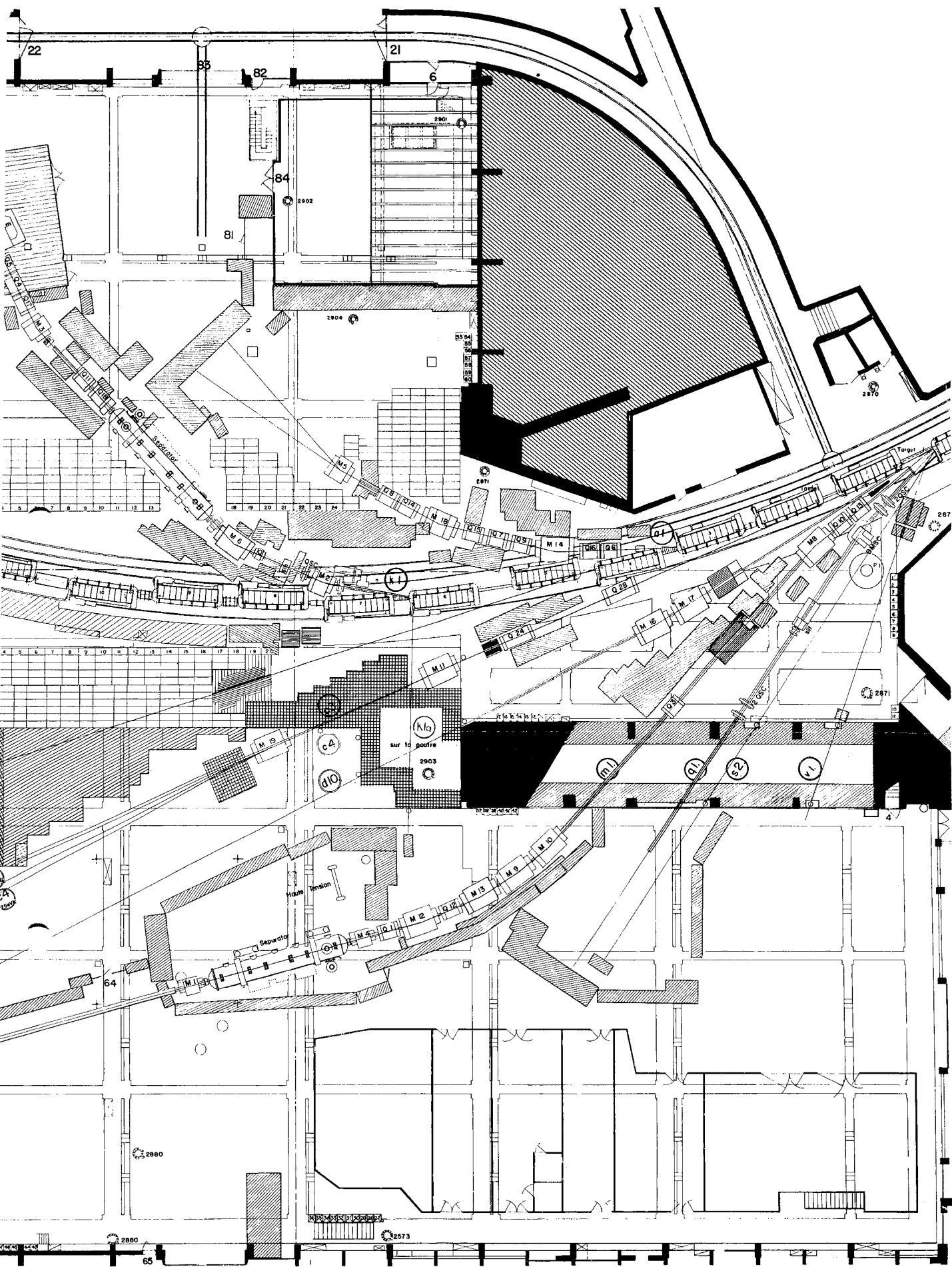
- a<sub>1</sub> — positive or negative pions ;
- k<sub>1</sub> — separated beam of positive or negative kaons.

Not all the beams are in use together, and in some cases the composition of the beam, and the particle momentum, can be changed to suit a particular experiment ●






CBH 30 cm	CERN 32-cm hydrogen bubble chamber	SEPARATC
HBC 81	81-cm hydrogen bubble chamber of Saclay and Ecole Polytechnique, Paris	O
W.C.	CERN Wilson cloud chamber (temporary position)	M





**KEY**

- electrostatic separator
- quadrupole magnet, or 'lens'
- bending magnet

-  concrete shielding
-  concrete collimator
-  lead collimator

0 1 2 3 4 5 6 7 8 9 10

20mètres

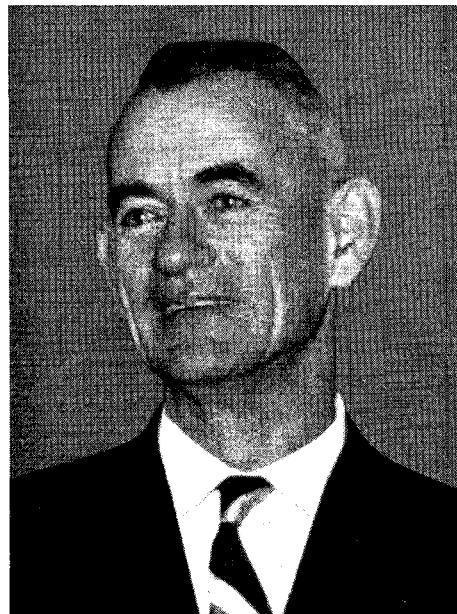
# 'Resonant States' at the Aix-en-Provence Conference

## New outlook in elementary-particle physics

by Louis LEPRINCE-RINGUET

*Prof. Leprince-Ringuet, who is a Professor of Physics at the Ecole Polytechnique, Paris, has been vice-chairman of CERN's Scientific Policy Committee since its formation in 1954. He is a member of the Académie des Sciences.*

*This article first appeared (in French) in La Revue de Paris in December 1961, and we are grateful to the publishers and to Prof. Leprince-Ringuet for the opportunity of including it in CERN COURIER.*



The memory of the splendid Physics Conference that was held last September at Aix-en-Provence will take a long time to fade. Everything was in its favour : the gathering of five hundred nuclear physicists, nearly all of them very young, engaged on elementary-particle research in all the universities of Europe ; the interest of the working meetings, and of the impressive plenary sessions which ended the Conference like a firework display in the hands of some of the great stars of the world of physics ; the most friendly welcome of the University of Aix-Marseilles, of the Municipality of Aix, of the Navy, who arranged the sea cruise on Sunday ; and of course the charm of this region of Provence in mid-September.

This was the first time that all the young nuclear physicists of Europe had met together ; those whose work is concerned with the great European Organization for Nuclear Research and its giant accelerator at Geneva, those from the important national centres, which certainly have their place, and also those from the less-endowed laboratories of the provincial universities. For the problem is this : a great new movement has sprung to life in European scientific research, developed during the last few years solely through the notable achievements of CERN, which has succeeded in raising the level of science in Europe to that of the two great blocs. CERN is not alone in Europe, however ; in several large institutes important work may well give results of international standing from time to time. Then we have the main bulk of European universities, which are in a difficult situation. It is not easy for them to participate in the big experiments, which need so much experience and equipment and require the collaboration of large and strong teams. Sometimes they are not even aware of what is going on in the larger centres ; they do not know which methods are used or even the subjects of research. On the whole they ignore the spirited nature of present-day research and the way the

principal items on the programme change so rapidly. Whilst the physicists who work at the frontiers of scientific progress see the centre of interest in elementary-particle physics shifting from year to year, and beset it constantly with significant experiments, the physicists who are somewhat isolated in their universities, and often more attached to their teaching duties than to the possibilities of research, see science flowing along with a slower and a quieter rhythm.

To animate these universities, who not only wish to bring themselves up to date in the marvellous developments of modern physics, but would also like to take some part in them, it is necessary above all to lay the foundations for a lively relationship between them and the other groups. That was the basic idea of the Conference at Aix.

It is well known that for more than ten years a large international gathering has been held each year in the United States, at Rochester, on the shores of Lake Ontario, bringing together the most famous physicists in the world. Very few young people have been there ; it was felt that the meeting should not be allowed to grow too large, becoming a kind of fair on the model of some of the large assemblies of the American Physical or Chemical Societies. Hence only a few representatives of the biggest centres were present. Between 1945 and 1957, never more than three to five Frenchmen were invited each year. In these limited conferences, which might almost be called summit conferences, the latest events were discussed by the leading specialists. In this way the Rochester Conferences have marked the stages in the principal developments of physics since the war. There the classification of heavy mesons and hyperons was considered ; there the difficult notion of strangeness\* took shape before the audience

\* In order to explain the properties of strange particles, that is the newly discovered heavy mesons and hyperons, it was necessary to give them an additional quantum number, which was called **strangeness**.

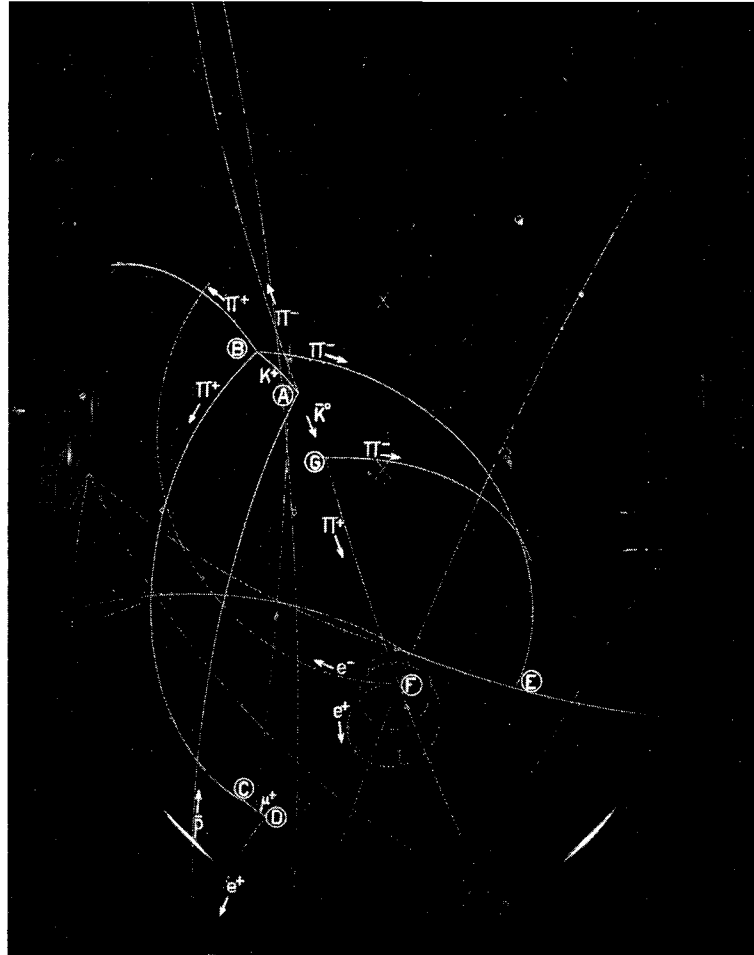
of physicists; there the problems of parity were discussed. Rochester certainly marked the turning points of physics.

In the last few years, the icy, inhospitable banks of Lake Ontario in winter have sometimes been replaced by others — those of Lake Geneva or of the Dnieper. It is becoming customary to meet successively at Rochester, at CERN, and in Russia, the symbols of the three great scientific entities of our time. But the younger generation can have only a small part in such gatherings. They can of course read the enormous volumes of proceedings that appear three months later, but these are heavy, and sometimes indigestible for those who are not already very familiar with the subject. Now, this year, everything favoured a meeting of the young scientists: the organizers themselves were newly appointed French professors at the Ecole Polytechnique, Saclay, Orsay, Marseilles, and CERN (which was also able to supply the necessary secretariat). Where should the meeting be held, though? Geneva was a possibility: the facilities at CERN are admirable and many physicists work there already. But no, one feels a little uneasy in Geneva, everything is almost too well organized, one enters automatically into a sort of mould; the charm of Provence is missing, the pleasantness of a small university town, not too big, but more human. Geneva should be left to the big formal meetings, to the interminable political discussions on nuclear disarmament. For young physicists, who are so informal, who worry so little about their ties, who are so scornful of ceremony, the wonderful opportunities of Aix and of Provence are so much better.

Everybody came, all these young scientists; many of them by car, so that between the sessions and during the 'break' on Sunday they could amble through the countryside, around the mountain of Saint-Victoire in the light of Cezanne, dear to many of us, in the home of the liqueurs of Cassis and Bandol. A few older scientists, carefully chosen from among the small group at the head of international physics, had agreed to come to discuss their work and also, in the form of reviews, to put it into focus in a very dignified, exact, and instructive way. Thus Heisenberg and Lee, both Nobel Prizewinners, came most readily. Thus Feynman, the famous theoretician from California, closed the Conference with a scintillating talk on theoretical physics.

A great deal of work was done at Aix. The sessions covered four hours in the morning, and at least as many in the afternoon, and you may well imagine the considerable effort represented by eight hours of difficult physics. For this reason the Conference was opened on the Thursday, to allow for a day and a half of welcome relaxation in the middle of the programme. During the first two days there were specialized sessions in which each group reviewed its recent work. A hundred and fifty papers were presented in this way, but for this it was necessary to split the meeting into parallel sessions. Simultaneously, in four different rooms, questions of low energy, very high energy, form factors, theory, experimental methods, interactions of classical particles, and interactions of strange particles, were successively developed, hardly any communication lasting longer than fifteen minutes. In this way, by Saturday, 16th September, two days after the start of the Conference, all the specialized contributions had been presented, and everything was ready for the plenary sessions. None of the young speakers had to worry still about a contribution to come. All the discussions that inevitably accompany an incomplete presentation were over. A feeling of relaxation was now able to spread among the members of the conference, and they could look forward to listening to the dozen great addresses which were to succeed each other until the following Wednesday, to put the current problems into better perspective.

I do not think many of the physicists in the audience, in spite of their ability, understood very much of some of the theoretical expositions, but there is no doubt that they sensed



Hundreds of photographs like this one, taken with the Ecole-Polytechnique/Saclay 81-cm hydrogen bubble chamber at CERN, are needed to provide data from which the existence of resonant states may be deduced. Here, an antiproton stops in the hydrogen at A and 'annihilates' with a proton to give a positive kaon, a negative pion, and a neutral antikaon. Two of these particles may possibly start life together in a resonant state. The kaon then disintegrates at B into three pions, of which one decays at C into a muon which decays to a positron at D, and another reacts with a proton at E to give a neutron and a neutral pion (neither of which give tracks). This pion is converted into two gamma rays, one of which gives an electron pair at F. The antikaon (also leaving no track disintegrates into a pair of pions at G. The tracks are curved because the chamber is placed within a magnetic field.

the distinction and power of the developments considered, and they will have the chance in the course of the year, re-reading the texts of the papers, discussing them among themselves, studying them in the course of later colloquia, to arrive little by little at a slightly better understanding of this difficult science.

Each year sees the adoption of a new point of view in physics. A main problem arises each year, and it is during a big conference that rapid or spectacular developments are sometimes made, where before there was stagnation because of the multitude of possibilities.

This year was the year of *resonant states* or *isobars*. The Aix Conference was the conference of super-unstable particles: they were discovered everywhere — a pi-meson and a proton, a pi-meson and a neutron, a hyperon and a pi-meson, and even three pi-mesons, can unite to form a true particle during a very short time. They choose for this combination a certain *state*, which has well-defined properties of nuclear force, relative motion, and orientation of the spin of each particle. Thus a *state* of two particles can be defined, in much the same way as a state can be defined corresponding to the two stars of a double star, where each star has a mass and a definite motion with respect to the other, as well as a self-rotation similar to the spin of a nuclear particle. Transferring this to the domain of elementary particles, however rough

the comparison may be, it is conceivable that two particles can exist in an ephemeral manner in a certain state characterized by well-defined quantum numbers.

It is very striking that such complexes are formed in so many reactions. They are called *resonant states* (between pi-meson and proton, for example, or between hyperon and pi-meson). What is most extraordinary is the frightfully unstable nature of these complex particles. The discovery of this instability seems in itself miraculous. It is quite amazing that one can be so certain that the particles disintegrate after a time of the order of  $10^{-22}$  second. I do not know if the reader is able to comprehend the meaning of such a short time: he must consider the fact that a thousand-millionth of a second, already a very short time, is at the limit of production possible with the most refined electronics, and then  $10^{-22}$  second is still less than a millionth of a millionth of this limit.

How then can we know that a particle lives for a time of this order? For no direct measurement of time is capable of showing such a short interval.

We know well, by direct measurements, that the average life of mesons is of the order of a hundred-millionth of a second. We know equally well that the mean life of hyperons is a little shorter, but we do not go any further with direct measurements. There is, therefore, an enormous jump to be made; an extraordinary interval has to be spanned. The answer is simple, however. It lies in the celebrated uncertainty relations, which link every variation of energy to a variation of time. There is a measurable uncertainty in the energy of the resonant state formed during certain interactions, and it is this which gives the mean life of the resonant state.

I would like to enlarge upon this somewhat obscure statement. Suppose that an event, for instance the annihilation of an antiproton and a proton, gives birth to two particles. I assume that everything happens at rest, that is to say, the disintegration arises from an antiproton and a proton at rest, with no velocity. The nuclear reaction (annihilation in the case we are considering) will produce energy. If then one of the particles created goes off in one direction, the other will always go in the opposite direction. The energies of the two particles will be completely determined, with no uncertainty.

But if one of the particles is very unstable and disintegrates very soon after its production, the other one will be aware of this, and its energy will no longer be completely determined. The change of energy will be linked to the lifetime of the unstable particle.

As an example, consider a reaction giving a hyperon, a positive pi-meson and a negative pi-meson. If one looks at the energy spectrum of the positive pi-mesons, one finds, instead of a classical continuous spectrum corresponding to a three-body disintegration, a spectrum with a very pronounced hump at a particular energy, the hump itself having a certain width. From these data one can say that the hyperon and the negative pi-meson have gone in the opposite direction not as a stable element but with an extra-short life, defined by the uncertainty in energy of the measured band.

These are the problems of today: this is wonderful physics. On the experimental level, it brings into play the great accelerators with all their power, since distributions of all sorts of particles in all possible reactions need to be studied, to see if the same complexes can be found using different methods. It is equally wonderful physics because the theoretical interpretation of all these investigations gives rise to a considerable number of questions, in particular on the connexion between the nuclear forces that may link mesons, nucleons, hyperons, heavy mesons, etc. Finally, the discovery of states in which these ultra-unstable particles are formed, the defining of these states as functions of the observed properties, all this brings into play the most wonderful and complicated machinery of experiment and theory in modern physics●

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## Last month at CERN (cont.)

**Peter T. Kirstein**, of Accelerator Research Division, and **Karl-Martin Vahlbruch**, Nuclear Physics Apparatus Division, left towards the end of January for the Joint Institute for Nuclear Research at Dubna, U.S.S.R. They expect to be there for about six months, under the exchange scheme which brought **Vladimir Nikitin** (Track Chambers), **Adolf Mukhin** (Nuclear Physics), and **Walter Zöllner** (Theory) to CERN a short while ago.

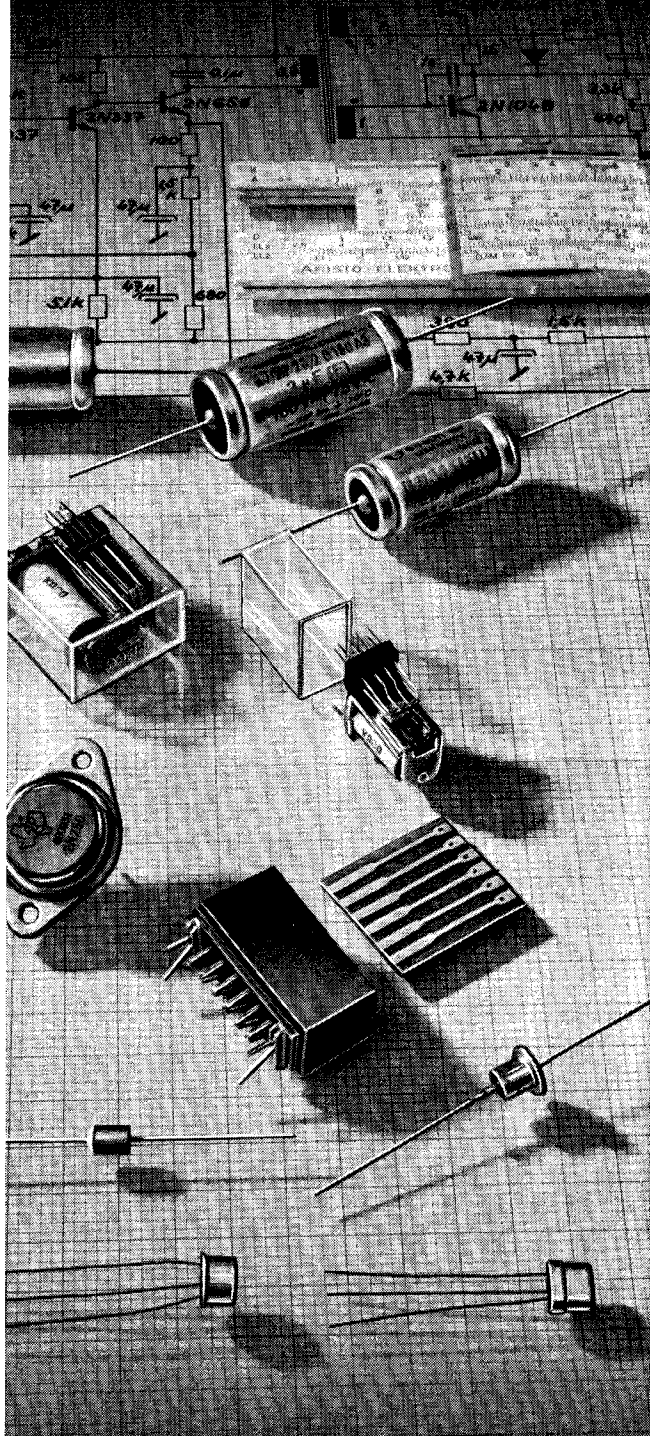
Among the visitors to CERN during January were the Hon. **Graham A. Martin**, U. S. Ambassador to the European Office of the United Nations.

'**Matter in Question**' the 35-minute colour film of the Organization, has been awarded First Prize in its Class at the 2nd International Festival of Technical and Scientific Films held in Budapest last November.

\* \* \*

Lastly, a correction to the report in last month's issue: owing to a cumulation of errors the figure for the consumption of **liquid hydrogen** at CERN last year was given as 15 000 litres, whereas it should have been **83 000** litres. Our apologies to the Track Chambers Division for appearing to underestimate their efforts●

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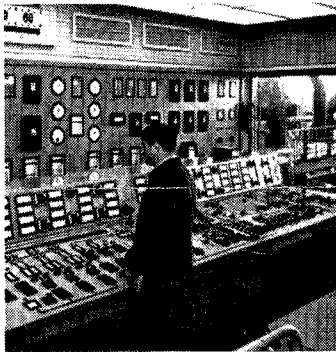
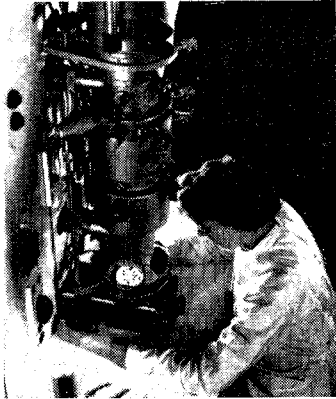
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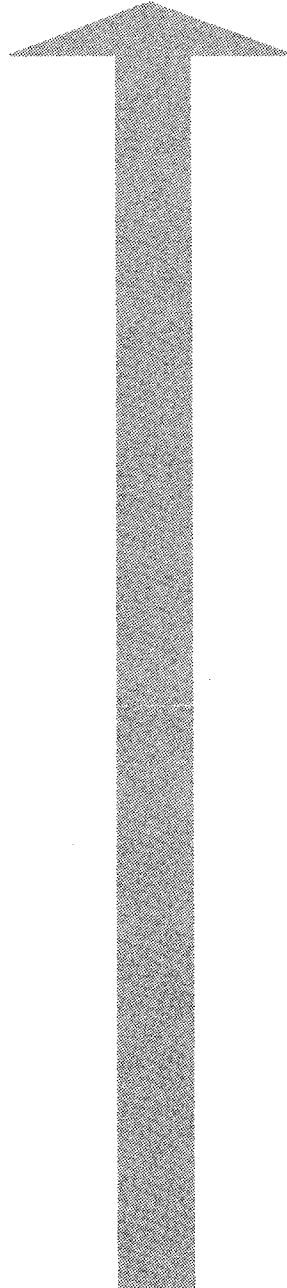
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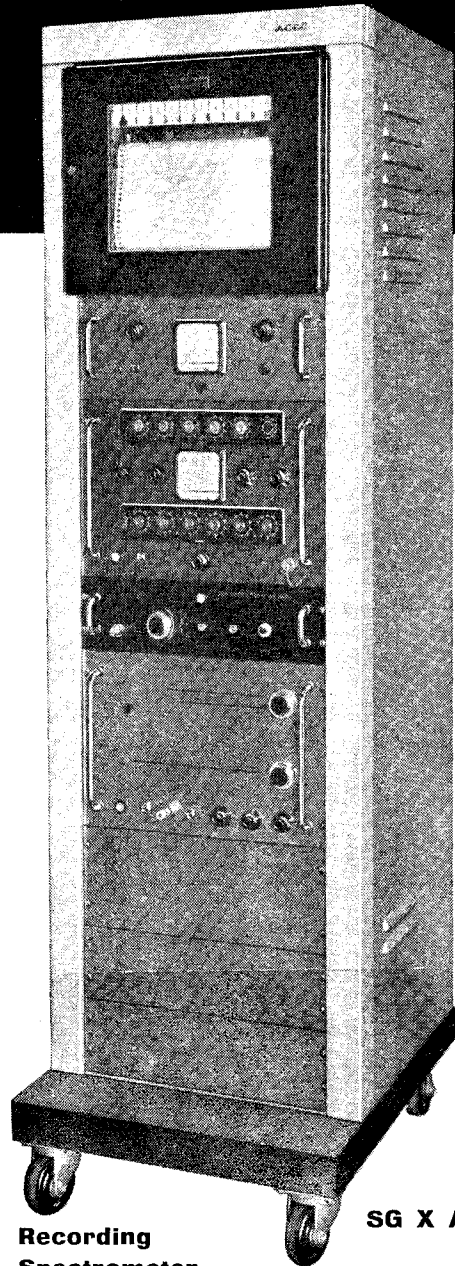
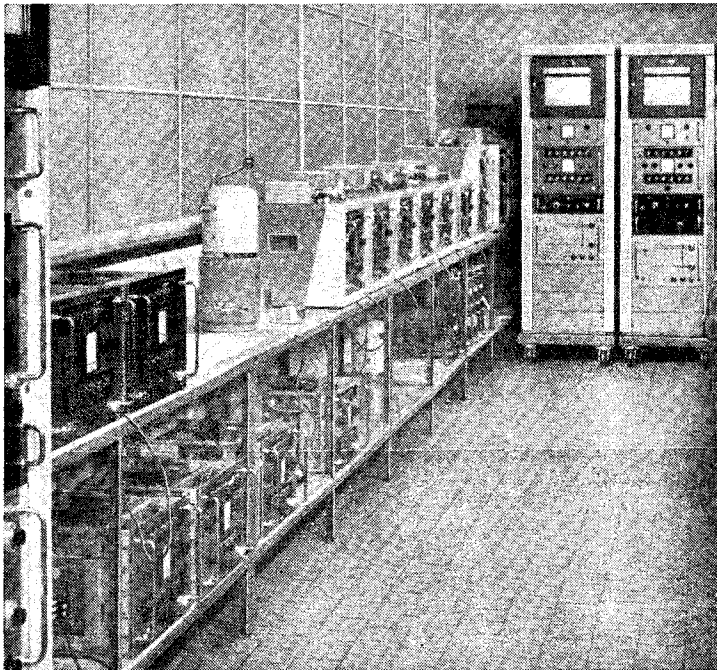
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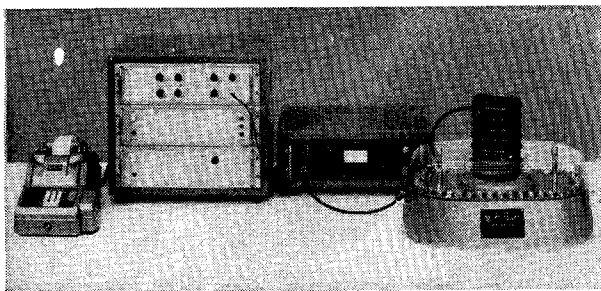
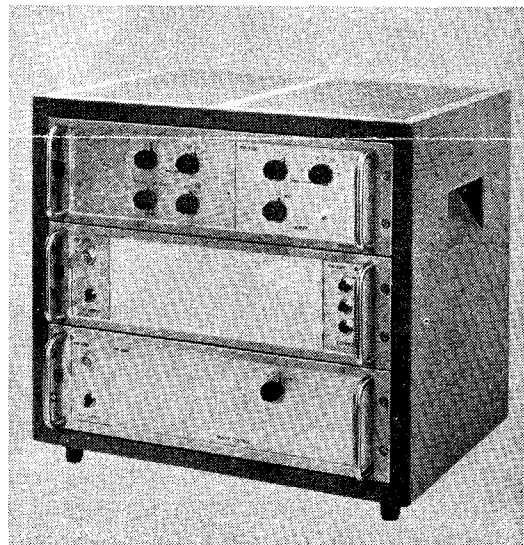
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