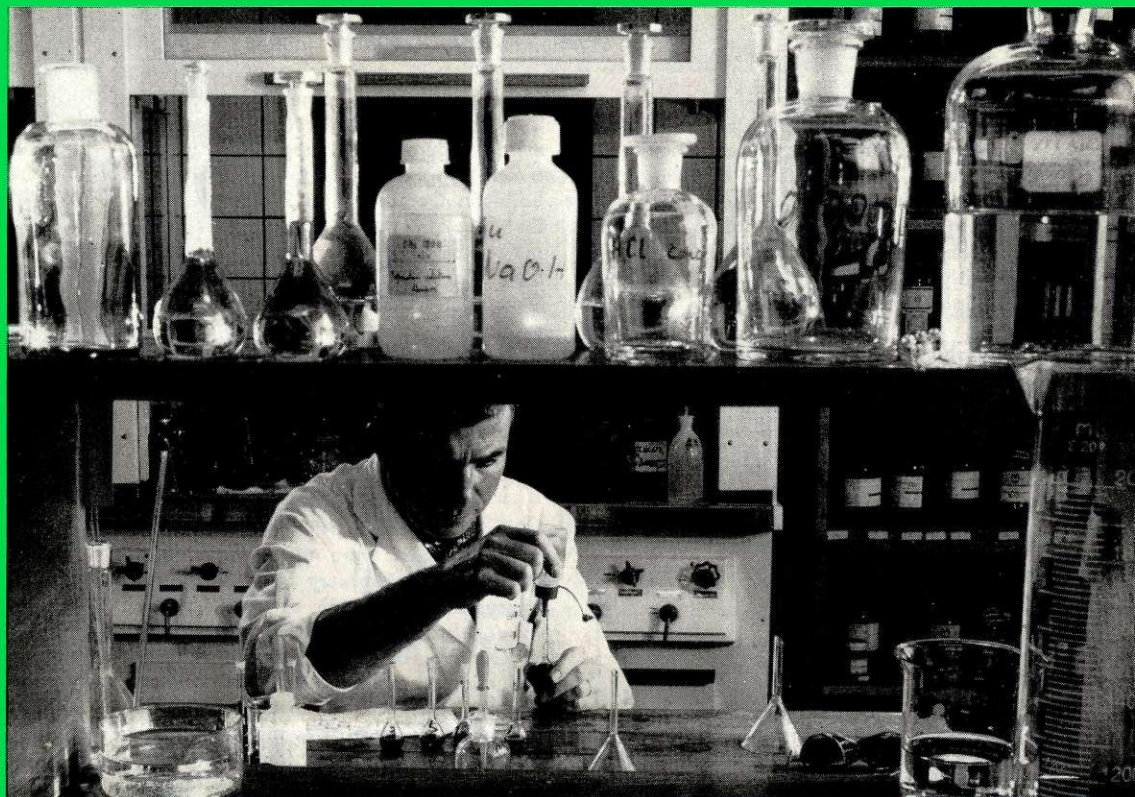


# COURIER CERN



CERN/PI 130.3.63

# 3

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March 1963

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

The European Organization for Nuclear Research (CERN) came into being in 1954 as a co-operative enterprise among European governments in order to regain a first-rank position in nuclear science. At present it is supported by 13 Member States, with contributions according to their national revenues: Austria (1.92%), Belgium (3.78), Denmark (2.05), Federal Republic of Germany (22.47), France (18.34), Greece (0.60), Italy (10.65), Netherlands (3.87), Norway (1.46), Spain (3.36), Sweden (4.18), Switzerland (3.15), United Kingdom (24.17). Contributions for 1963 total 92.5 million Swiss francs.

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

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

## Last month at CERN

During January and February, the **electric power supply** to CERN was considerably disturbed, as a result of distribution difficulties suffered by the whole Swiss network. Owing to the dry summer last year and the exceptionally cold winter, the water level in the reservoirs supplying the hydroelectric generating stations had become generally low, and this, coupled with the difficulties of supplying coal to the thermal power stations, had reduced the capacity available. The situation became critical at the beginning of 1963.

On 17 January, as mentioned in the last issue of *CERN COURIER*, there was a total failure of the supply, due to the overloading of a high-tension cable between Germany and Switzerland. At that time, this cable was providing the major part of the energy used in Switzerland. During the next few weeks, the general demand in Switzerland remained at a very high level as a result of the cold, whilst production fell considerably in all parts of Europe. Switzerland's neighbours, France, Italy and Germany, had to interrupt or to cut down considerably their deliveries of power.

Under these circumstances, major users such as CERN were requested at the beginning of February to reduce their consumption as much as possible. On the 6 February, the 'Services Industriels', in Geneva, began to impose voltage reductions amounting to five or ten per cent over the whole of their 18-kV network. For CERN, this meant that all, over the site, systems for maintaining the voltage at a constant value had to be readjusted. From 8 February a programme of restricted use was put into operation, with the approval of the 'Services Industriels', limiting the overall power consumption at CERN to 5 MW.

To fit into this overall load, about a quarter of the usual requirements, the Directorate decided on various cuts in the experimental programme, and precise limits had to be enforced to control the overall power consumption of the accelerators and associated equipment. For example, tests on the magnet for the **1.5-m British bubble chamber** had to be postponed until 25 March, as the power that would have been consumed was too high.

One result of these difficulties with the main power supply was that the operating period of the **proton synchrotron** for the first fortnight of the month was extended by 24 hours, over Sunday 10 February, giving a total running time for that period of 280 hours.

The accelerator then had to remain out of operation for practically the whole of the following week, start-up being postponed until the Friday afternoon, 16 February. At the end of this run, on 25 February, a long **shut-down** period began, during which the

fast ejection system is being installed, final preparations for the neutrino experiments are being made, and targets and beams are being installed in the new East experimental area.

Although much of the development effort on both accelerators is directed towards increased beam intensity, there are occasional opportunities for ingenuity in the other direction. One of these was when the Wilson cloud chamber, operating on only one pulse in 50 in the  $a_3$  pion beam, required a specially small number of particles per burst, whereas users of the other 49 pulses wanted as many as they could get. As a result, when the accelerator was started up on 15 February, it was with a **programming system for the proton beam in the linac**, ensuring that every 50th pulse was automatically reduced in intensity by two-thirds.

Another interesting installation on the accelerator, tried out for the first time in February, was a method for **recording beam intensities on punched paper tape** suitable for feeding into the 'Mercury' computer. The current in the third tank of the linac (just before injection into the synchrotron itself), and the final accelerated beam intensity were recorded separately, so as to obtain a detailed pulse-by-pulse comparison from which the degree of correlation between them could be deduced.

The **synchro-cyclotron**, too, suffered from the power restrictions, and no experiments were possible during the week 15-22 February. However, although this was a set-back for the physicists, good use was made of the opportunity for maintenance and other work on the accelerator. In particular, the decreased radioactivity of the vacuum tank towards the end of the week made possible a new set of measurements of the magnetic field at different currents.

For practically the whole operating period of the synchrotron during February, the **Saclay/École Polytechnique 81-cm hydrogen bubble chamber** was in use in the  $m_2$  beam, photographing interactions of positive and negative kaons with protons. In three weeks, 386 000 good-quality pictures were obtained, each showing the tracks of about ten incident kaons. The momentum of the kaons was the highest yet

Continued on page 36

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The cover photograph illustrates one of the less well-known aspects of research at CERN, the studies carried out by the Nuclear Chemistry Group of the Nuclear Physics Division. Framed by the bottles and flasks appropriate to this subject, Henri Bersinger works on a chemical analysis.

## CERN COURIER

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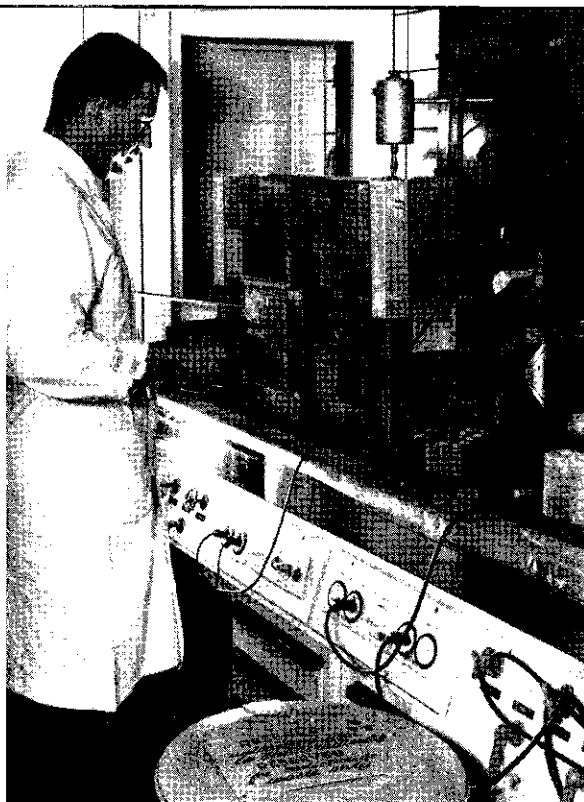
### PUBLIC INFORMATION

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1. Many chemical operations in the high-activity laboratory have to be carried out by remote control behind screens of lead bricks. Only a small amount of radiation gets through the bricks, but Henri Bersinger, seen here dissolving an irradiated target, wears a film badge on his cuff to measure it.

# Nuclear Chemistry at CERN

by **G. RUDSTAM**

Group Leader, Nuclear Chemistry ;  
Nuclear Physics Division

Some people may be surprised to learn that in a laboratory devoted to high-energy physics, there are also some chemists. It is a fact, however, and Dr. Rudstam, the leader of the group, here gives a survey of the work that they do. Starting with an explanation of the term 'nuclear chemistry', he goes on to describe some typical experiments carried out by the group, and their relation to the high-energy-physics problems, mentioning in particular the electromagnetic isotope separator used in many studies. He concludes with some ideas on the sort of experiments that could be carried out at CERN in the future, particularly if the intensity of the synchro-cyclotron beam could be further increased.

## WHAT IS NUCLEAR CHEMISTRY ?

The big accelerators at CERN, the proton synchrotron and the synchro-cyclotron, offer almost unique possibilities for research not only in the field of high-energy physics but also for the branch of chemistry known as nuclear chemistry. A group of nuclear chemists has therefore been formed at CERN in order to take advantage of this opportunity to study nuclear reactions induced by high-energy particles. As would be expected, the experiments include what might be called 'typical' nuclear-chemistry problems, such as **spallation** and fission (the 'chipping off' of fragments from a nucleus and the splitting of a nucleus into two approximately equal parts). In addition, however, the chemical approach to the study of nuclear reactions can give information about interactions between elementary particles, and nuclear chemistry thus serves as a complement to the physicists' experiments in studying such phenomena.

It is perhaps worth while to begin by stating what is meant by the term **nuclear chemistry**. A clear definition of this has been given by Friedlander and Kennedy in their well-known textbook *Nuclear and Radiochemistry*: **'To our minds, nuclear chemistry emphasizes the reactions of nuclei and the properties of resulting nuclear species, just as organic chemistry is concerned with reactions and properties of organic compounds'**. Nuclear chemistry should not be confused with **radiochemistry**, which uses methods similar to those of nuclear chemistry to solve problems of a chemical nature in other scientific or technical fields (and thus might be called applied nuclear chemistry). To avoid misunderstanding it should also be pointed out that nuclear chemistry bears no relation to **radiation chemistry**. There, one is concerned with the chemical effects of radiation.

## NUCLEAR CHEMISTRY AND NUCLEAR PHYSICS

Both nuclear chemists and nuclear physicists are evidently interested in nuclear reactions. What, then,

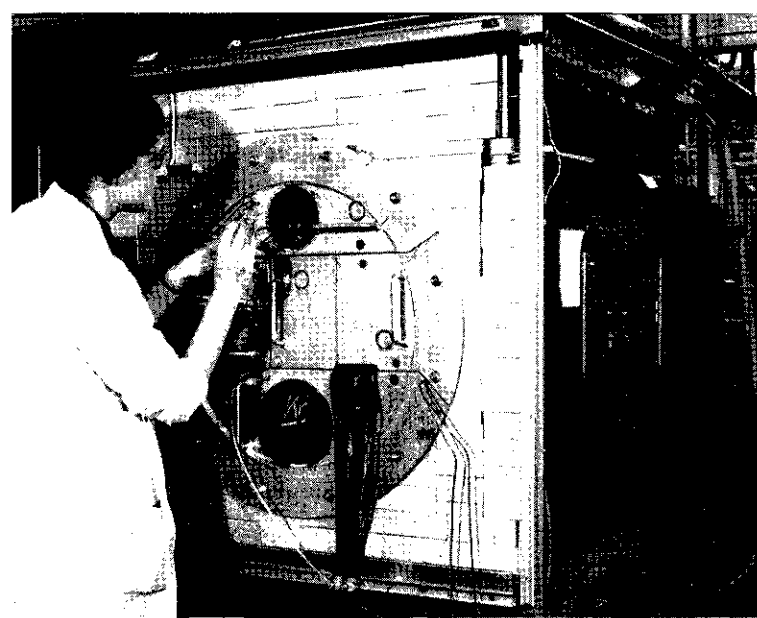
is the difference between them? It is really only a difference in the methods used to solve scientific problems. Often the chemist and the physicist want to investigate the same effect. The physicist does it using physical methods whereas the chemist falls back upon chemical means. The aim is the same but the approach is different.

Some properties of nuclear reactions can best be studied using physical methods, while for others chemical ones are more appropriate. Thus by chemistry it is possible to get a very detailed picture of the distribution of the heavier products remaining, whereas the various light particles emitted in the reaction are measured by physical methods. A complete description of the reaction is obtained by combining the results of both kinds of investigation.

## EXPERIMENTS UNDER STUDY

For practical reasons, the experiments carried out by the Nuclear Chemistry group at CERN have to be divided into two categories, namely those involving small amounts of radioactivity and those with high activities. These two kinds of experiment must be kept well apart, for the very simple reason that a minute contamination from experiments with high radioactivities might completely destroy the results of an experiment where only very low activities are produced. Therefore, the experiments are carried out in different laboratories, and no highly active samples are ever introduced into the space utilized for work with low activities. Fig. 1 shows part of an experiment in a so-called 'hot' laboratory for high-activity experiments. Also, the instrumentation for the experiments differs. Low-active work requires special counters with low 'background' — one count every few minutes (fig. 2). On the other hand, most of the instruments used for measuring higher activities have background rates too high for samples of low activity.

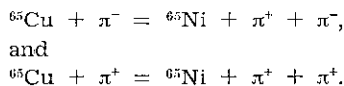
**Experiments using external beams** from accelerators tend to yield rather weak samples. An example of



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2. Waltraut Riezler replaces part of a low-background counter inside its heavy shield of steel and lead bricks.

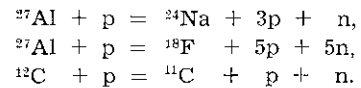
such an experiment is the study of the following pion-induced reactions in a copper target, giving as product the radioactive nuclide nickel-65 ( $^{65}\text{Ni}$ , the symbols are explained in the 'box' opposite) :



These reactions have been investigated, using positive and negative pions of energy 2.7 GeV, to obtain information on the interactions between pi-mesons, namely the total cross-sections for the interaction of  $\pi^+$  with  $\pi^+$  and of  $\pi^+$  with  $\pi^-$ . This is an example of the formation of reaction products of low activity. For example, the initial activity of the nickel-65 resulting from the reaction of negative pions on copper was about ten disintegrations per minute, whilst that from the reaction of positive pions was only three disintegrations per minute.

Another experiment under way using an external beam is the absolute determination of the cross-

sections of some reactions which would be suitable to monitor beams of 19 - 24 GeV protons. The reactions chosen for measurement are :



The reaction products sodium-24, fluorine-18 and carbon-11 are radioactive, so that the number of such atoms produced in a target of aluminium or carbon can be measured by particle counting. The cross-section represents the probability that an incident proton will induce a particular reaction, so that if the cross-section is known the total number of incident protons can be deduced from the activity measured.

It is quite evident that experiments of the kind mentioned above require collaboration between physicists and chemists, and for this reason the Nuclear Chemistry group also contains some physicists.

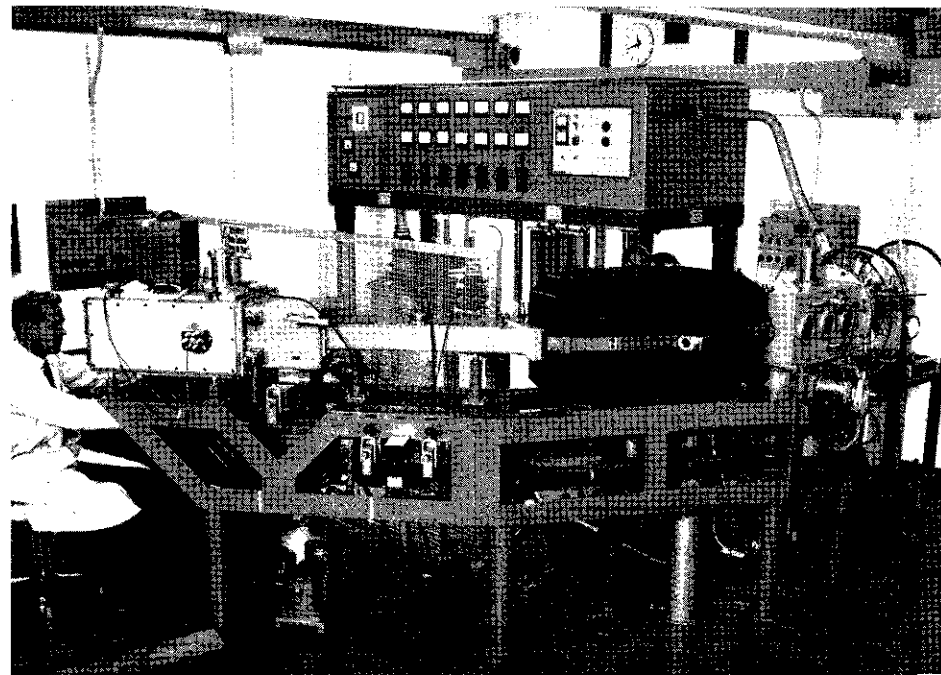
**Irradiation of targets inside the CERN accelerators** gives rise to high activities. These machines are thus being used for a series of experiments on fission and spallation phenomena, intended to give information about the :

- cross sections for the formation of the various nuclides produced ;
- linear momentum of the product nuclides ;
- angular momentum (or spin) of the product nuclides.

Such studies involve measurements of the yields of the products, their range (the distance they travel before being brought to rest), and the proportions in which various isomers, or different states of the same nuclide, are found.

Measurements of reaction yields can now be carried out with a much higher accuracy than earlier, thanks to the electromagnetic isotope separator belonging to the group (fig. 3). This apparatus was constructed especially for the study of nuclear reaction products.

CERN/PI 4820



3. In this picture of the electromagnetic isotope separator, the ion source is at the right-hand edge and the magnet is the large black object to its left. Stig Sundell is seen making some adjustments at the collector end of the instrument.

It is a two-dimensionally focusing machine, giving well-separated samples of a convenient size (fig. 4). The isotopes are collected on thin aluminium foils, an arrangement which is very well suited for activity measurements (negligible thickness, thin backing, small size — diameter about 2 mm). This and the extremely important fact that each sample only contains one activity (and possible decay products) are the reasons for the high accuracy attainable.

The technique used for reaction-yield studies is briefly the following. After irradiation of the target material in the accelerator a large variety of products is formed. The irradiated target is thus first dissolved in a suitable solvent and the element to be studied separated by chemical means from the bulk of the products. After conversion to a suitable form, the element is introduced into the ion source of the isotope separa-

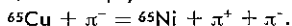
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5. Inge Jarstorff checks on the position of one of the samples in the automatic sample changer. Each opening round the rim can take one sample, which is automatically brought under the counter — marked with the figure 9 — for a predetermined time. The electronic scalars, recorders and other equipment are in the rack to the right.

### SOME NOTES OF EXPLANATION

As in ordinary chemistry, it would take too much space and become very confusing to write the description of each reaction in words. Instead, appropriate **symbols** are used and any reaction can be expressed in the form of an equation, which is much simpler. Thus, instead of writing 'the isotope of copper with an atomic mass of 65 units, reacting with a negative pion, results in an isotope of nickel with atomic mass 65 together with the emission of a positive pion and a negative pion', one simply has :



In the examples quoted in the article, Cu stands for copper, Ni for nickel, Al for aluminium, Na for sodium, F for fluorine, and C for carbon;  $\pi$  is the pi-meson, or pion, p the proton and n the neutron, and 5p means five protons. The number written as a superscript is the 'atomic mass' (roughly, the amount of matter in the nucleus relative to that in a proton or hydrogen nucleus), and the + or — sign represents the electric charge, when it is necessary to state it explicitly. These symbols are standardized, so that once known they can be used and understood universally.

A **beta counter** is used for measuring the *rate of emission* of beta particles from radioactive nuclei.

A **beta spectrometer** measures the *energies* of the beta particles. A scintillation spectrometer is one employing scintillation detectors.

**Gamma counters** and **gamma spectrometers** perform the same duty for gamma rays.

**Nuclear spectroscopy** is concerned with the various states in which a nucleus may exist, analogous to the investigation of atomic energy states in optical spectroscopy. Thus, the radiations emitted by excited nuclei are studied in place of the light emitted by excited atoms.

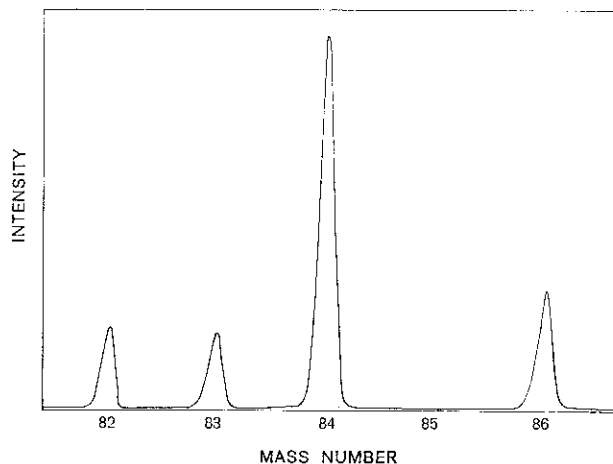
A **nuclide** is a particular species of atom, having a specified number of protons and neutrons in its nucleus.

**Isotopes** are nuclides of the same chemical element, that is with the same number of protons but different numbers of neutrons in their nuclei. (The term 'isotope' is still in fact commonly used as a synonym for the newer word 'nuclide'.)

tor. The separation of the isotopes is carried out — sometimes in a few minutes —, the collectors (one collector for each isotope of interest) are removed, and the activity of each sample is measured. Different kinds of counters are used for this, including beta and gamma counters and beta and gamma scintillation spectrometers. For convenience in counting, an automatic sample changer, which can be loaded with up to 40 samples, has been constructed by the Electronics group at CERN. With this apparatus the samples are counted one after the other and continuously recycled (fig. 5) to give the decrease of counting rate with time.

An example of the results obtained using these techniques is given in fig. 6, which shows the relative amounts of some thirteen different iodine isotopes formed in the fission of uranium by 600-MeV protons.

As the determination of reaction yields is based on measuring the decay rates of radioactive nuclides, the decay modes of the nuclides of interest have to be known. It is thus also necessary to do some work on the spectroscopy of those which have not been studied before. To a certain extent such investigations are



4. Graph showing the result of separating the isotopes of krypton. At the end of the separator the atoms differing by a mass number of one unit are about 10 mm apart.

# Gösta RUDSTAM

Leader of the Nuclear Chemistry Group  
in the Nuclear Physics Division



CERN/PI 4.4.63

Sven Gösta Rudstam was born in central Sweden, in the region of Uppsala, in 1925. Entering the University of Uppsala in 1945, he studied mathematics, theoretical physics, physics and chemistry, and then, after taking his Master's degree, turned to nuclear chemistry, still at the University. His first experience of working with high-energy machines came during 1950, when he spent half a year at the Lawrence Radiation Laboratory in Berkeley, U.S.A., working under Prof. G. T. Seaborg.

Then, the following year, the synchro-cyclotron at the Gustav Werner Institute of the University of Uppsala began operation. Capable of accelerating protons to an energy of 185 MeV, it was at that time the most powerful in Europe. Working from then on with this machine, mainly on spallation experiments, Gösta Rudstam obtained his Doctorate in 1957.

By then CERN was beginning to get well-established. The head of the Gustav Werner Institute, Prof. The. Svedberg, suggested the setting

up of a nuclear-chemistry group, and one of those who advised on the planning of the group was Prof. Pappas, of the University of Oslo, with whom Dr. Rudstam had worked in Uppsala. He was thus in close contact with this new development, and in January 1959 he arrived at Meyrin as Leader of the newly formed group.

Some of the work that they do, and how it fits in with high-energy physics as such, he has described in the accompanying article.

carried out by the CERN group, but for accurate spectroscopic work the instrumentation is not yet adequate. In particular, there is a need for an electromagnetic beta spectrometer.

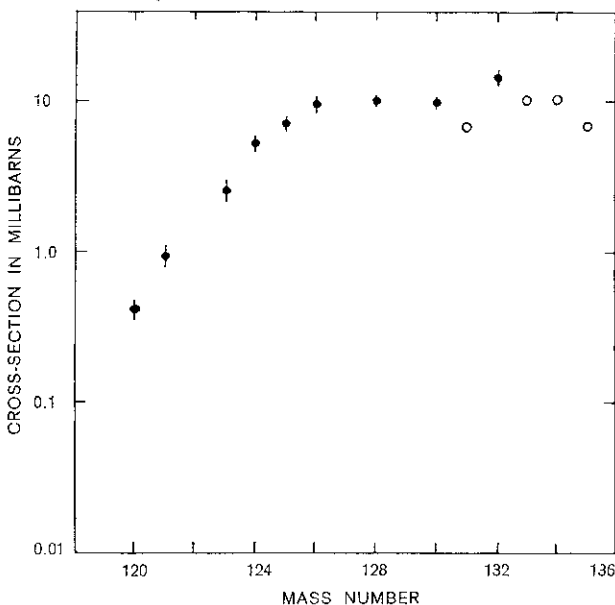
## FUTURE PROGRAMME

For the future programme of the Nuclear Chemistry group, a number of interesting experiments are under consideration. Worth particular mention are the study

of nuclear reactions induced by negative muons\* (pure capture of the muon and capture followed by the emission of several nucleons) and an investigation of the type of reaction, still unexplained, called 'fragmentation' (the 'explosion' of a nucleus into several large pieces).

There is also the possibility of extending the research field of the group towards nuclear spectroscopy. The synchro-cyclotron at CERN is a very efficient machine for the production of almost any nuclide in good yield. An isotope separator exists already, as do beta and gamma scintillation spectrometers, although it is clear that serious work in this direction would necessitate more elaborate spectroscopic instrumentation.

A particularly interesting field of investigation would be to attach an isotope separator directly to the synchro-cyclotron and bombard, with the external proton beam, a target already connected to the ion source of the separator. By choosing a suitable target temperature and composition, certain elements will quickly diffuse out of the target, enter the ion source, and be separated into their isotopes. Element separation can be achieved using a variety of methods (cold traps, gas chromatography, etc.) in a separate step between the target and the ion source. If suitable counters or nuclear spectrometers were connected directly to the collector for the separated isotopes, very short-lived reaction products could be studied. This would open an immense field of investigation. Such a development becomes especially interesting now that the intensity of the external beam of the synchro-cyclotron is being increased ●



6. This graph shows the primary cross-sections of the iodine isotopes formed in the fission of uranium by 600-MeV protons. As an example, it can be seen that there are ten times more iodine-126 atoms produced than iodine-121 atoms. (The circles indicate preliminary values.)

\* Some preliminary runs have already been carried out.

International Conference on

# High-Energy Physics and Nuclear Structure

Reviewed by **H. FESHBACH**,  
Ford Visiting Scientist, Theory Division

This was a comparatively small conference as conferences go nowadays, with only about one hundred invitees from outside CERN. Free and frank discussion was the rule and the meeting had more the character of a rather large seminar than a small conference.

From a somewhat narrow point of view the participants were concerned, on one side, with the possible uses of particles produced by high-energy machines for the investigation of the structure of atomic nuclei and, on the other, with the fact that it might also be possible to discover properties of elementary particles by observing how they interact with complex nuclei. But there was an additional motivation. It was hoped that by bringing together physicists concerned with nuclear structure and physicists interested in 'elementary particles', to discuss problems which both could find interesting, the developing chasm between the two fields could be bridged and its growth arrested. There are specialists or experts in both camps, and like specialists in other fields they naturally tend to become parochial in their interests and limited in their outlook. This is unfortunate even if it is natural. Breadth of interest is important for physicists if they are to avoid becoming mere adepts in technique. Without it, even progress in their own field is slowed, for concepts and methods which have been developed in other fields can often suggest wholly new insights as well as areas for investigation.

Be that as it may, the conference demonstrated the very wide range of experiments on nuclear structure which could be performed at high-energy machines. In many of these, high-energy particles such as electrons or protons can be used directly. In recent years electron scattering has provided us with much information on how the electric charge inside nuclei is distributed. One finds that it is fairly uniform over most of the nuclear volume, decreasing fairly rapidly to zero at the surface. Now some information on the electric currents inside the nucleus is becoming available. These are properties which characterize the whole nucleus. Obtaining fine-structure details is much more difficult, but very worth while because it tests our understanding of nuclear structure in a very fundamental way. Both electron and proton scattering offer possibilities of measuring the 'graininess' of nuclei — the tendency of the nucleons inside the nucleus to form 'clusters'. Where will these clusters be found, inside the nucleus or on the nuclear surface?

With the aid of high-energy machines it becomes possible to make exotic nuclei which are not found in nature. For example when a gamma ray is absorbed by a nucleus of helium-4, a positive pion and a new nucleus, hydrogen-4, are produced. Hydrogen-4 consists of three neutrons and one proton. In another process, yet to be observed, a negative pion could be absorbed by helium-4 and a positive pion emitted. The resultant residual nucleus would be composed of four neutrons. On the other hand, if helium-4 absorbs a

From 25 February to 2 March, an 'International conference on high-energy physics and nuclear structure' was held at CERN, organized in co-operation with the Chaim Weizmann Institute at Rehovoth, Israel. As the name suggests, the main purpose of the conference was to review a comparatively new field of research, where high-energy physics — essentially the study of elementary particles **outside** the atomic nucleus — overlaps the older field of nuclear physics, which is more concerned with particles **inside** the nucleus.

In the accompanying review, Prof. H. Feshbach, at present at CERN on leave from the Massachusetts Institute of Technology, highlights some of the interesting topics discussed at the conference and indicates some possible new developments.

positive pion and emits a negative one, the residual nucleus consists of four protons! It is easy to construct many other examples. Most importantly, however, these processes provide tools by means of which nuclei outside the stable valley can be produced and their properties studied. We thus have a new dimension in which to study nuclear structure.

A large number of very exciting experiments will be possible when beams of strange particles, K mesons and lambda hyperons, of sufficient intensity become available. These can then be directed against nuclei and studies made of the various reactions which result. New possibilities are opened because, for instance, although the lambda particle is of roughly the same mass as a nucleon, it is not identical with the nucleons in the target nucleus. The processes it can undergo are thus in no way limited by the Pauli exclusion principle, to which the nucleons are subject. A lambda incident upon a nucleus can undergo transitions, and even end up in the same orbit as one of the nucleons. An incident nucleon cannot do the same and so a whole new set of phenomena becomes possible. We need not fire lambdas at nuclei; negative kaons will do just as well, for these will combine with a proton in the nucleus to form a lambda. We can then observe the subsequent transitions of the lambda and so obtain information both on the initial state of the proton and on the structure of the 'hypernucleus' which is formed. The pionic decay of the hypernucleus, that is, decay of the lambda particle in the hypernucleus back into a proton and a negative pion, would provide information on the state of the lambda.

Turn about is fair play, and one may perhaps also be able to employ known nuclear properties to study the properties of elementary particles. From the binding energy of hypernuclei we gain knowledge about the interaction of lambda particles and nucleons. At the conference, the first recorded event was presented in which a nucleus containing two lambdas was detected. In this case we can for the first time begin studying the forces between strange particles! Complex nuclei act as virtual sources of elementary particles. For example such a nucleus forms a source of electromagnetic field, and therefore gives the possibility of producing neutral pions when an incident photon collides with one of the virtual photons in the nucleus. This is in fact the inverse of pi-zero decay and this experiment is at present the best way of measuring the pi-zero lifetime! Another device is to compare nuclear processes — for example beta decay with other weak-interaction processes such as muon capture. There are many, many examples.

It is clear that there are a great number of important experiments to be done, numerous opportunities for fundamental discoveries. The major effect of this most successful conference was to increase markedly the probability that these experiments will be performed soon ●

## Last month at CERN (cont.)

affained in a separated beam, and the photographs include tracks of some 1 150 000 positive kaons at 3 GeV/c, 1 210 000 negative kaons at 3 GeV/c, and 1 500 000 negative kaons at 3.5 GeV/c. The background of other particles, even at the highest momentum, was less than 20 %.

The objects of the experiment are to search for the existence of a new particle (the omega hyperon,  $\Omega$ , with a 'strangeness' number of  $-3$ ), and to gain further information on known aspects of kaon-proton interactions and the properties of the xi hyperons. Investigation and analysis of the photographs is being shared among ten laboratories: University of Amsterdam, University of Bologna, a British group (Universities of Birmingham, Glasgow, and Oxford, Imperial College of London University, and the Rutherford Laboratory), 'École Polytechnique', Paris, 'Centre d'Études Nucléaires', Saclay, and University of Stockholm.

The **École Polytechnique 1-m heavy-liquid bubble chamber** also obtained some 250 000 photographs showing interactions of positive kaons stopping in the liquid, continuing an experiment on 'selection rules' in kaon decay, together with some 30 000 pictures of stopped negative kaons for the investigation of hyperfragments. Unfortunately, operation of this chamber had to be limited, because of the shortage of electricity, and the higher values of magnetic field could not be used even when the chamber was running.

Among the other experiments at the synchrotron in February was the first use at CERN of **acoustic spark chambers**. This type of detection instrument is similar to the spark chambers currently used, consisting basically of a set of parallel plates in which alternate ones can be pulsed to a high voltage. The pulse is applied after the passage of a specified charged particle and the spark that then occurs in each gap follows the track of the particle. In this case, however, the sound wave from each spark is detected by four miniature microphones placed some 10 cm or more from each edge of the gap. The time between the application of the high voltage and the arrival of the sound at each microphone is measured electronically, and from the four values obtained the position of the spark in each gap can be calculated, in practice by feeding the information into an electronic computer.

These measurements were a test run of the apparatus for an experiment to measure the elastic and near-elastic proton-proton scattering at very small angles. Six chambers were used, in conjunction with analysing magnets and scintillation counters. The time measurements from each chamber were recorded on punched paper tape and ana-

lysed on the Mercury computer, the position in space of each proton track being obtained to an accuracy of  $\pm 0.25$  mm.

From 25 February to 2 March, an **International conference on high-energy physics and nuclear structure** was held at CERN, organized in co-operation with the Weizmann Institute at Rehovoth, Israel. The conference, which was attended by about 100 scientists from 13 different countries, in addition to those at CERN, is described more fully on page 35 of this issue.

His Excellency Mr. **Gaston Palewski**, the French Minister of State for Scientific Research, paid a visit to CERN on the afternoon of 14 February as the guest of Mr. François de Rose (Ministre plénipotentiaire and Representative of France on the CERN Council), Prof. L. Leprince-Ringuet (Vice-president of the Scientific Policy Committee), and Prof. V.F. Weisskopf (Director-general). Also in the party were Mr. Philippe Baudet, Ambassador of France to Switzerland, Mr. Gabriel Ardant and Mr. Tezenas du Montcel.

Many of the delegates to the United Nations Conference on Science and Technology, held in Geneva early in February, also took the opportunity to visit CERN. Prominent among these was Mr. **René Maheu**, Directeur-general of UNESCO, who was shown around on 12 February, accompanied by Prof. Paulo B. de Carneiro, President of the General Conference of UNESCO, Prof. V.A. Kovda, Director of its Department of Natural Sciences, and Mr. Y. de Hemplinne, Secretary of the Department. On the 15 February, **Lord Casey**, Chairman of the Commonwealth Scientific and Industrial Research Organization and Leader of the Australian delegation to the U.N. conference, visited the Laboratory, with Mr. G.B. Gresford and Mr. C. Magee.

Members of CERN also had a chance to get to know something of the U.N. conference when a symposium, **'Techniques for tomorrow's world'**, was organized on 14 February by the Staff Association, in the current series of evening lectures on subjects of general interest. Under the chairmanship of Prof. Marussi, of the University of Trieste, the leaders of the Delegations from India, Prof. H. Bhabha, the United States, Dr. MacDermott, and the Soviet-Union, Dr. Fedorov, exposed in a highly interesting way their own thoughts on the conference and answered many questions from the audience on the applications of science and technology in the less developed areas of the world.

Earlier in the month, from 5 to 7 February, CERN was host to the **'European Organization for astronomical research in the southern hemisphere'** (ESO), whose Council met here under the chairmanship of Prof. J.H. Oort

(Netherlands). The organization at present includes Belgium, the Federal Republic of Germany, France, the Netherlands and Sweden as member states, with Denmark as an observer. It has been set up primarily to instal powerful optical instruments in the southern hemisphere, so that that part of the galaxy can be studied to an extent comparable with what is already possible in the northern hemisphere.

This is the second time that members of a new European scientific organization have used CERN as a meeting place as well as an example, the first being the meeting which led to the formation of the European Space Research Organization.

The Director-general and a number of senior physicists from CERN took part in a two-day discussion meeting at the Royal Society, in London, on the 21 and 22 February. With the title **'Recent European contributions to the development of the physics of elementary particles'**, the meeting had been organized by Prof. C.F. Powell, of the University of Bristol and present chairman of CERN's Scientific Policy Committee, to give the Fellows of the Society a review of the present state of knowledge of elementary particles and the prospects for the development of the subject in the future.

Out of fifteen papers presented, six were by scientists now at CERN: Prof. V.F. Weisskopf gave the opening talk on 'Elementary particle physics — its development and future', Prof. G. Bernardini spoke on 'Neutrino and muon physics', Prof. E.H.S. Burhop on 'Recent experiments with emulsions', Prof. L. Van Hove on 'Progress in our theoretical understanding of elementary particles', Dr. K. Johnsen on 'Features of the next generation of proton accelerators', and Dr. C. Rubbia on 'Recent experiments with the CERN synchro-cyclotron'. In addition, Prof. B. Gregory of the École Polytechnique, Paris, who is closely concerned with bubble-chamber experiments at CERN, spoke on 'Recent experiments with bubble chambers', and Dr. J.B. Adams, formerly Director-general, described the 'Design and performance of the CERN proton synchrotron'. All the papers presented, which were framed so as to be intelligible to scientists outside the particular field of high-energy physics, are being published by the Royal Society.

During his visit to London, Prof. Weisskopf was guest of honour at the Annual Luncheon of the **Parliamentary and Scientific Committee**, on 21 February. The Committee is an unofficial group bringing together members of both British Houses of Parliament and representatives of industry and of scientific and technical institutions. With all shades of political opinion represented, it acts as a common meeting ground for parliamentarians and scientists ●



## News from abroad

### Tests of British National Hydrogen Bubble Chamber

In the East bubble-chamber building at CERN two impressive-looking magnets have been assembled for some time, and other work is proceeding steadily towards the completion of two new very large bubble chambers.

One of these, the 1.5-metre British National Hydrogen Bubble Chamber, has now been successfully tested in England (without its magnet), and the way is now clear for it to be transferred to CERN. After installation in the magnet, the parts of which arrived from England at the end of 1961, it will be operated with a new beam to be constructed in the East experimental area of the proton synchrotron. Tests with protons and pions will probably be carried out later this year, and experiments will then follow, using mainly high-energy kaons and antiprotons.

Preliminary design studies began on the BNHBC in 1957 and work began on the chamber early in 1959. The construction has been a collaborative effort between Imperial College, London, Birmingham University, Liverpool University, and the National Institute for Research in Nuclear Science (N.I.R.N.S.). Also represented on the Management Committee, under the chairmanship of Prof. C.C. Butler, of Imperial College, are University College, London, and the Universities of Cambridge, Glasgow and Oxford. Although all the early experiments will be carried out at CERN, the chamber will eventually return to England for operation

with the 7-GeV 'Nimrod' synchrotron at the N.I.R.N.S. Rutherford High Energy Laboratory, Chilton\*, in Berkshire.

Although the 72-inch (183-cm) chamber at Berkeley, U.S.A., is longer, this is at present the largest liquid-hydrogen bubble chamber in the world from the point of view of the volume of liquid hydrogen in which tracks can occur and be photographed. This volume is roughly rectangular in section, 150 cm long and 50 cm high, with a depth of 45 cm. Some 500 litres of liquid hydrogen are used altogether in the chamber, kept at a temperature of  $-247^{\circ}$  C and under a pressure of about 6 atmospheres in the main chamber body. It is when this pressure is decreased suddenly to 3 atmospheres that minute bubbles form along the tracks of any ionizing particles that have just passed through.

For the recent tests, the chamber was assembled in a special building at the Rutherford Laboratory, with appropriate high-pressure hydrogen and other supplies. Control systems and other parts are now being transferred to CERN at the rate of about two lorry loads per week. The bridge will be transported in one piece, followed by the complete chamber assembly — travelling at a maximum speed of 8 km per hour!

\* The postal address of the laboratory has recently been changed, but it is still next door to the Atomic Energy Research Establishment at Harwell.

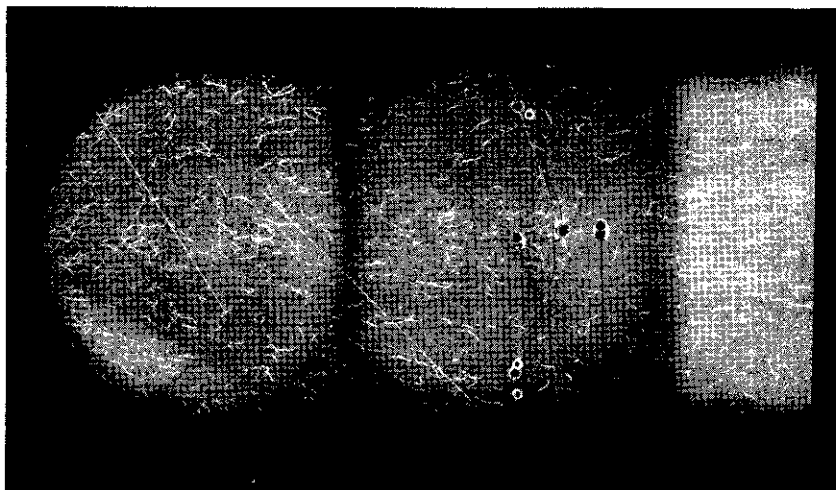


Photo N.I.R.N.S. (U.K.) — 12

One of the photos taken during tests of the British National Hydrogen Bubble Chamber, indicating the uniformity of sensitivity and visibility over the complete volume. The short tracks are those of electrons produced by a pulsed beam of gamma rays originating from a cobalt-60 source; the three zones apparent in the picture arise from the splitting of the illumination system into three parts. Three straight tracks, also visible, are probably muons from cosmic rays. The black discs and wires are thermocouples temporarily fixed to the chamber windows.

### Oxford Helium Bubble Chamber

An announcement by N.I.R.N.S. at the end of January gave the news that a contract had been placed for the construction of the refrigeration system of a large helium bubble chamber. The refrigerator will be one of the largest of its kind to operate at liquid-helium temperatures and will maintain the temperature of the chamber at a value of about  $-270^{\circ}$  C, constant to plus or minus  $0.05^{\circ}$  C, over periods of thirty days of continuous operation. The principal feature of the refrigeration cycle is the use of expansion turbines, with bearings lubricated by helium gas, running at

speeds of up to 350 000 revolutions per minute. The thermodynamic efficiency will be high and no precooling fluids such as liquid nitrogen or liquid oxygen will be required.

*George Chadwick, of the University of Oxford, was at CERN during February and kindly provided CERN COURIER with the following information on the helium chamber itself.*

The Oxford Helium Bubble Chamber is being designed and built by a joint team from the Department of Nuclear

Physics at Oxford University and the Rutherford High Energy Laboratory. The chamber dimensions will be 80 cm × 40 cm × 40 cm and it will be operated in a magnetic field of about 20 000 gauss. It will be used at the Rutherford Laboratory's accelerator 'Nimrod', to study the lighter hyper-fragments, to use the simple quantum numbers of helium as an aid in determining the properties of particles and resonances, and to provide an efficient analyser for polarization measurements.

The special problems associated with so large a volume of helium are to maintain temperature stability, so near absolute zero, and to avoid turbulence due to the extremely low velocity of sound in this fluid — pressure waves will travel across the chamber in a time comparable to the total sensitive time. The first problem is handled by direct cooling of the chamber by a refrigerator-liquifier (detailed above) attached to the magnet. This also makes the chamber a self-sufficient unit, easily transported. The second problem should be overcome by the rectangular design of the chamber and the method of expansion adopted. An entire side wall will be attached by a bellows, and moved in a direction normal to its plane by means of a mechanical linkage. Thus plane pressure waves will be launched, which will be reflected coherently and not break into turbulence. Construction is made easier by the low working pressure of half an atmosphere.

The target date for completion is late 1964. Costing about £ 400 000, the chamber will be the largest of its type in the world.

## Berkeley Bevatron operating again

After being shut down since July last year, while extensive modifications were carried out, the Bevatron, the 6.2-GeV proton accelerator at the University of California's Lawrence Radiation Laboratory at Berkeley, U.S.A., was successfully put back into operation during February. The full experimental programme should begin again in March.

Ideas for the alterations began to take shape as far back as 1958 and work has been going on since 1960, when 9.6 million dollars was appropriated for the project by the U.S. Congress. The most basic modification has been the installation of an entirely new proton injection system, consisting of a 480-kV Cockcroft-Walton set and a 19-MeV strong-focusing linear accelerator. By this means, the intensity of the input beam to the synchrotron is expected to be raised by a factor of 20 or more, with a corresponding increase in the full accelerated beam intensity. Closely linked with this is the installation of facilities for an external proton beam. This will have the major advantage of providing secondary beams of positively charged particles outside the accelerator ring, instead of within the cramped and inaccessible hub area. Other benefits will be obtained in the study of short-lived particles, down to lifetimes of around  $10^{-10}$  second, since detectors can now be placed much nearer to the targets.

Increased beam intensity means more background radiation, with the result that the shielding of the accelerator has

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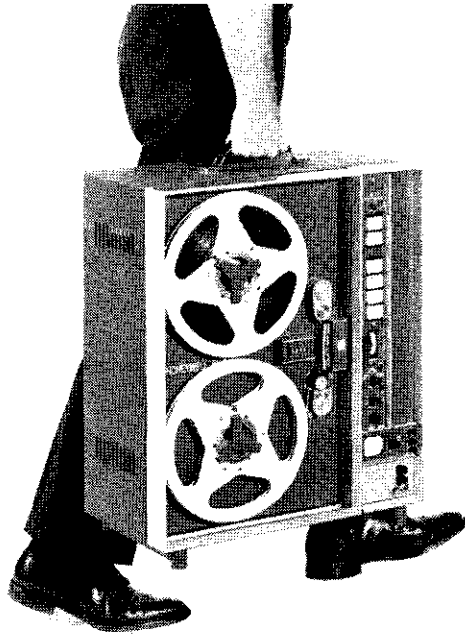
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had to be considerably increased. The concrete ring surrounding it has been brought up to a uniform thickness of 3 metres, and a concrete 'igloo' enclosing experimental apparatus has been placed at the hub. Moreover, the entire ring-shaped accelerator has been covered by massive concrete roof beams over 2 metres thick. To support all this shielding, a tunnel was first constructed under the machine and then filled with concrete into which steel uprights were embedded.

Changes to reduce maintenance inside the accelerator to a minimum and to improve the efficiency of operation include new fully insulated pole-face windings on the magnets and remote control of internal targets. Among other work carried out during the shut-down was a complete overhaul of the high-level radiofrequency system, modifications to the low-level radiofrequency system, the installation of new feedback systems for beam control and the provision of a 'flat top' for the magnetic-field variation.\*

A new fast negative kaon beam has been set up for the 72-inch hydrogen bubble chamber and a slow positive kaon beam will be used with the laboratory's heavy-liquid chamber. This latter has been made twice as deep as before, and now has a useful volume of some 760 mm x 500 mm x 300 mm ●

\* Most of the information given here was taken from the L.R.L. journal 'The Magnet', February 1963.




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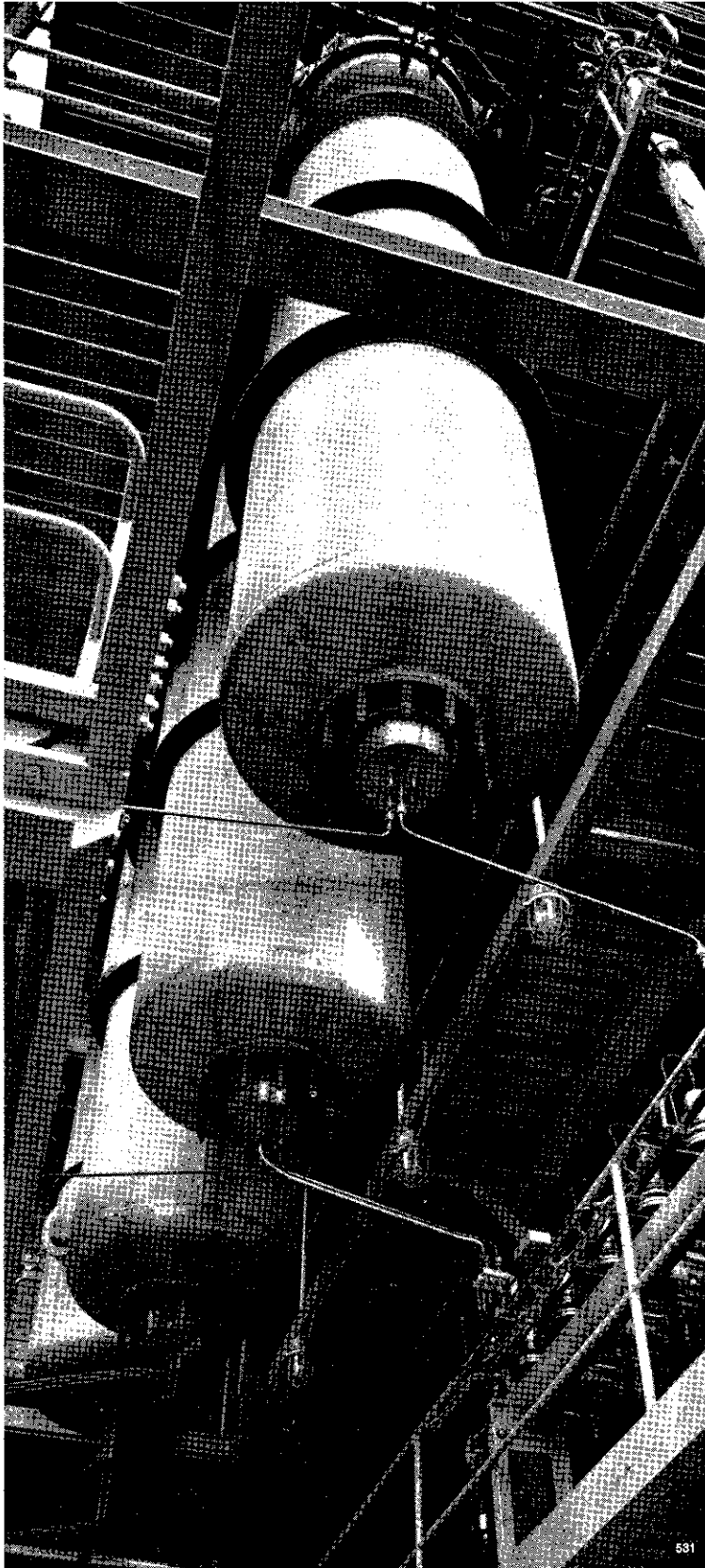
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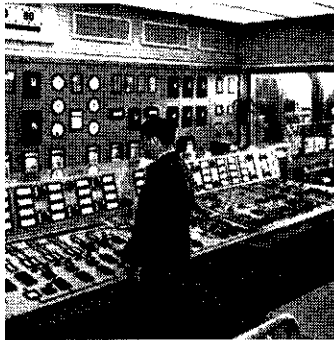
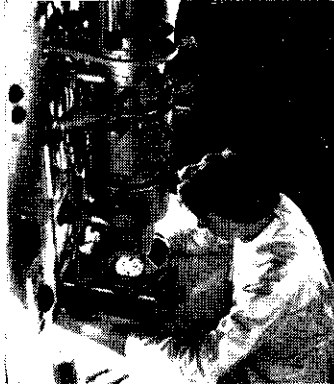
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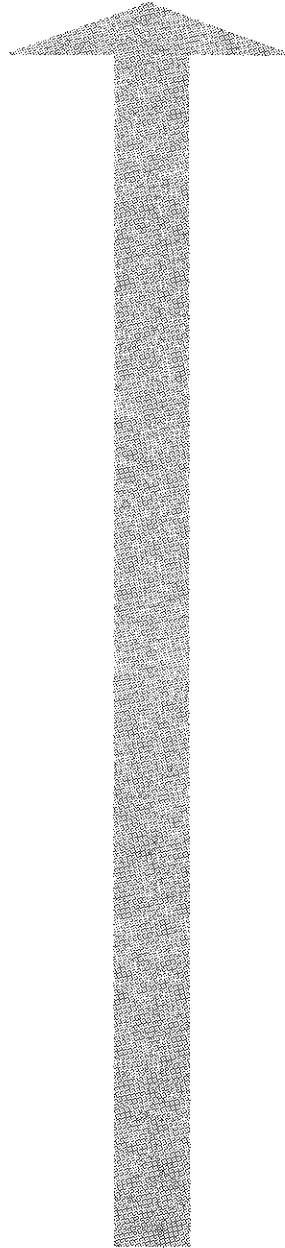
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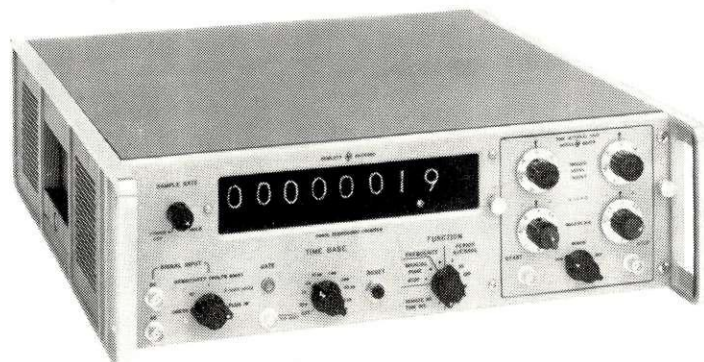
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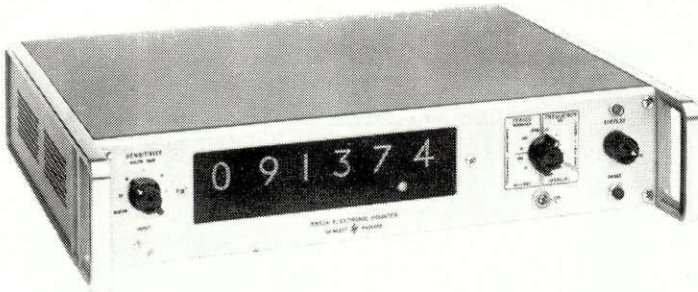
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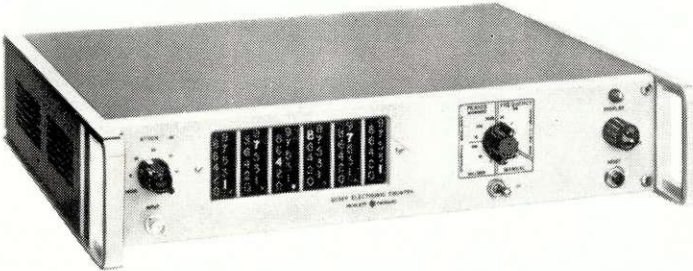


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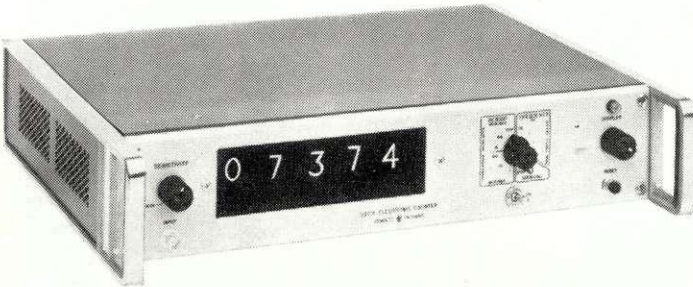


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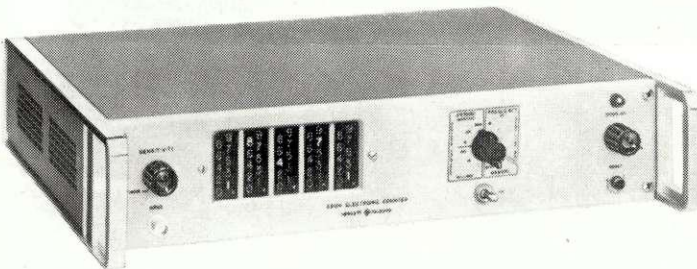


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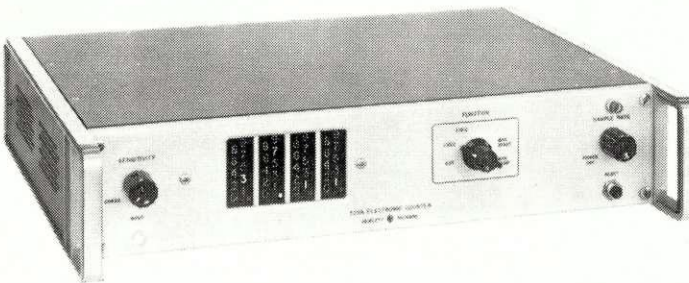


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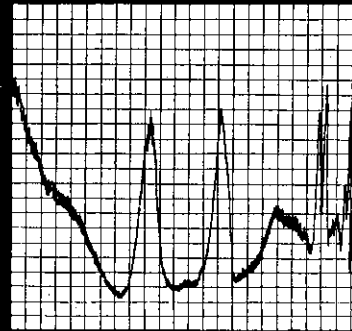
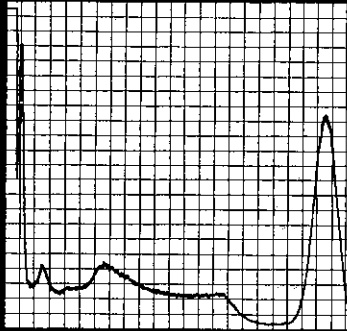
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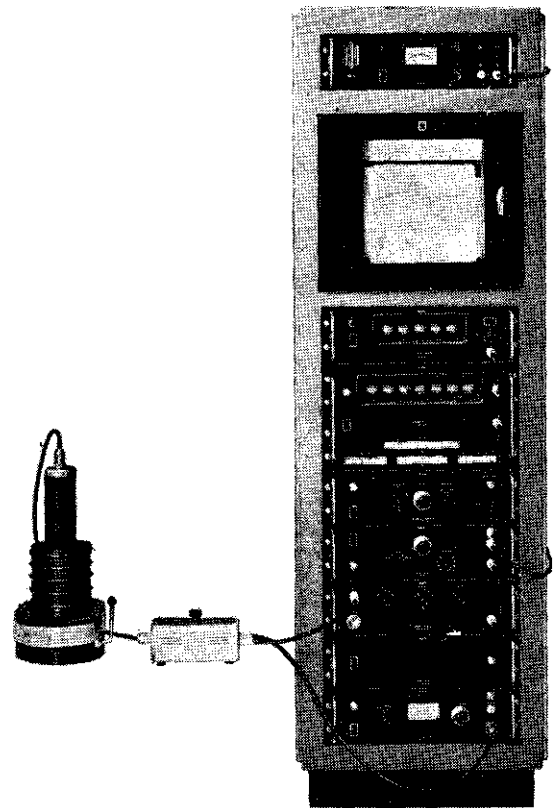
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