CERN COURIER

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5

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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 (1.96%), Belgium (3.85), Denmark (2.09), Federal Republic of Germany (22.86), France (18.66), Greece (0.60), Italy (10.83), Netherlands (3.94), Norway (1.48), Spain (1.68), Sweden (4.25), Switzerland (3.20), United Kingdom (24.60).
Contributions for 1964 total 107.2 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.'

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The cover photograph gives some idea of how the use of beams in the East experimental hall of the proton synchrotron has developed since the first targets were put in just over a year ago. Taken from a viewpoint just inside the junction of the East hall with the ring tunnel, the picture shows work in progress during the April shut-down of the machine. Nearest the camera, the vacuum tube for the o_2 beam is seen passing through various magnets and collimators. Further back, to the left, is the c_8 beam, and behind that the d_{16} beam. The ring magnets of the synchrotron itself follow the line of the far wall of the tunnel. Experiments at the PS, using the beams seen here as well as those in the North and South halls of the accelerator, are discussed in an article beginning on p. 57 of this issue.

CERN COURIER

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Last month at CERN

During April it was announced that an order has been signed by CERN for the **purchase of an electronic computer** of the type CDC 6600, manufactured by the Control Data Corporation, Minneapolis, U.S.A. The CDC 6600 is one of the largest computers now available and is capable of carrying out more than a million arithmetical operations every second.

Preceding the decision to place this important order, there had been a year-long study carried out by a committee of European specialists in the field of computers and data processing for high-energy physics. This committee examined the future computation needs of the Laboratory and the possibilities offered by the various manufacturers in Europe and the United States. Its conclusion was that the use of computers for high-energy research would continue to develop rapidly in the future and that CERN should acquire a machine of modern design, at least ten times as powerful as its present one.

The capacity of the two computers now at CERN has become insufficient to satisfy the demand resulting both from the Organization's own work and from its collaboration with other laboratories in the Member states. In the past year, the utilization of these computers has increased by a factor of four, and they are now saturated. Rapid growth in the use of computers is, in fact, commonplace in high-energy physics, as in other branches of modern science, and many laboratories find that their computing needs double every year if they are not to be unduly restricted.

The new computer that CERN is acquiring is designed to be used on a ' time-sharing ' basis, that is, it will handle several problems at the same time. This characteristic has become indispensable, particularly because of the development of experimental techniques involving fully automatic operation ' on line ', or ' in real time ', in which the experimental apparatus is connected directly to the electronic computer to give immediate results. In certain cases, the apparatus itself will include small computers to convert the experimental data into a form suitable for use in the large computer. Part of the capacity of the big new computer will be absorbed by another aspect of this ' automation ' of experiments in fundamental nuclear physics — the use of automatic devices (such as the HPD and ' Luciole ') for examining and measuring hundreds of thousands of track-chamber photographs.

The 6600 has a fast 'memory' store of 131 000 ' words ', each of 60 binary units (bits), with an access time of one microsecond, a disc store of 16 million words, and a magnetic-tape memory of 16 units in which 240 000 characters per second can be recorded or found. The potential output will be about 15 times greater than that of the IBM 7090 at present used by CERN and, as a result of its modern design, the cost per unit of calculation of the 6600 is three times lower than that of any other computer now in service. The initial price of the machine, which has been met by a generous loan from the Swiss Federal Government, is 23 million Swiss francs.

The new computer will be installed at CERN at the end of this year and will then be the most powerful in Europe, with an identical installation in use at the Livermore nuclear laboratory in California. CERN, in this respect, will thus regain the status it had in 1960, with the most powerful computer on the continent.

Moreover, the possession of the machine will enable the European scientists participating in CERN's research programme to gain early practical experience of the operation of the next generation of computers.

One of the contributions to the issue of *Physics Letters* dated 1 April (vol. 9, no. 2, p. 207) announced the discovery of another new fragment of nuclear matter, as a result of an experiment at the CERN proton synchrotron. This **new 'particle'** (for want of a better name), or 'resonance', is called C — or C^0 (C-nought) since it has no electric charge. As mentioned briefly in last month's *CERN COURIER*, it is highly unstable, with a lifetime of only about 10^{-20} second, has a mass of 1230 MeV/c^2 *, probably a spin of 1 and positive parity, and decays to a neutral kaon and a pair of pions, one positively charged, one negative.

If the present observations are confirmed by a more detailed analysis of the experiment, the C^0 will be the first in a new group of nuclear fragments, occupying one of the positions in a new 'multiplet', as given by the theory of unitary symmetry for the classification of these 'fundamental particles'.

CERN/PI 67.4.64

Breaking through the wall of the synchrotron tunnel was no easy task, as can be seen from this photograph. Formerly a fairly narrow horizontal slit to let through beams of particles, the aperture has now been enlarged to full height in one place to allow room for beam-transport magnets. Full shielding is ensured by movable concrete blocks, as in the other beam areas.

The experiment that led to its discovery was carried out over the period 1962-1964. Six physicists from CERN and eight from the Nuclear Physics Laboratory of the Collège de France, Paris, took part, with the 81-cm Saclay/École Polytechnique liquid-hydrogen bubble chamber, operated at CERN since May 1961.

At CERN, the **proton synchrotron** was shut down for practically the whole of April, from 26 March until 29 April. During this time, many changes were made to the beam layouts, especially in the North and South experimental halls, to prepare for the next series of experiments (as described in the article by W. O. Lock in this issue). To allow for the new m_4 beam in the South hall, an extra opening has been cut in the reinforced-concrete wall of the machine tunnel, and this was completed during the shut-down. Various additions and modifications were made to the accelerator and its associated equipment and the usual maintenance was carried out. The first experiment when the synchrotron started operation again was another emulsion exposure for the proton-proton scattering experiment of the University of Rome.

Under the auspices of the CERN Emulsion Experiments Committee, a small working meeting was held on 9 and 10 April in the Zeeman Laboratorium, University of Amsterdam (by invitation of Prof. J. C. Kluyver), to discuss **'Automation in nuclear emulsion physics'**. About 35 people took part in the meeting, from 15 laboratories in Europe, those from CERN being W. A. Cooper, D. Evans, W. O. Lock, M. A. Roberts and D. Wiskott. Topics discussed included multiple scattering and ionization measurements, automatic track-following and scanning devices, and data-handling problems.

At a meeting on high-energy physics **(Journées nationales des hautes énergies)** organized in Brussels on 16 and 17 April by the 'Institut interuniversitaire des sciences nucléaires' and the 'Société belge de physique', the Director-general of CERN, Prof. V.F. Weisskopf gave three talks, entitled: 'The place of elementary-particle research in modern physics', 'Plans for the development of high-energy physics in Europe', and 'Why pure science?'. Prof. Weisskopf and two Belgian senior members of the CERN staff, P. Germain and Prof. L. Van Hove, were received by H.M. the King of the Belgians, Baudouin 1er, at a luncheon given during the meeting.

Among the **visitors** to CERN in recent weeks have been Mr. Mattarella, Italian Minister for Trade, with Mr. F. P. Vanni d'Archirafi, Italian Ambassador to Switzerland, on 27 March, Mr. E. Che Guevara, Cuban Minister of Trade, on 11 April, and Mr. J. Burckhardt, Minister Plenipotentiary and Head of the International Organizations Division of the Swiss Federal Administration, on 21 April ●

EQUIPMENT AVAILABLE

From time to time CERN has various items of surplus electronic and other equipment for sale. Though used, these are generally in good condition and may be of particular interest to schools, universities, and other educational or scientific institutions. Potential buyers should write to the Purchasing Office, CERN, Geneva 23, Switzerland, stating the types of material in which they would be interested; lists of equipment and details of the conditions of sale will then be sent to them as items become available.

Enquiries cannot, unfortunately, be entertained from private individuals or commercial organizations ●

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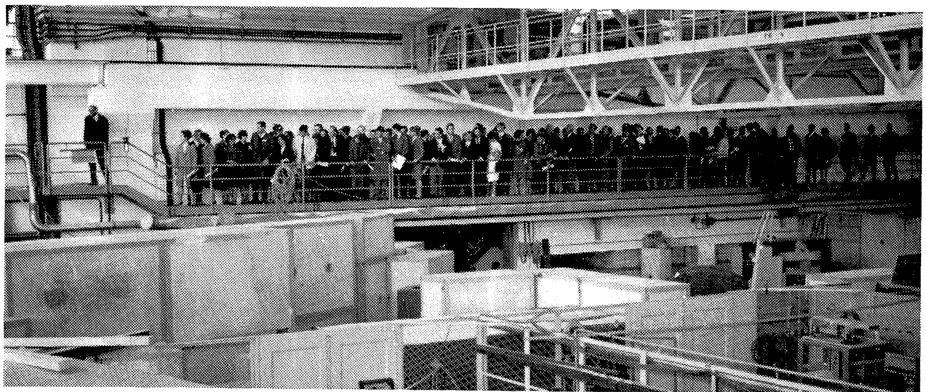
* MeV/c^2 is a convenient unit of mass that arises from the equivalence of matter and energy (related by the formula $E = mc^2$ or $m = E/c^2$) and the use of the electronvolt (eV) and its multiples (M = million) as units of energy. The electron, for example, has a 'rest energy' (or what might be called an intrinsic energy) of 0.51 MeV. Although this is often called its 'mass', strictly speaking the latter is 0.51 MeV/c^2 (c is the velocity of light in vacuum).

Open Day



Not the queue at the bar ! Visitors on the gallery in the South experimental hall of the proton synchrotron.

CERN/PI 197.4.64

Saturday 25 April was the occasion of another CERN ' open day ', when, between 2 p.m. and 6 p.m., all those who work here had been invited to come, with their families and friends, to look around.

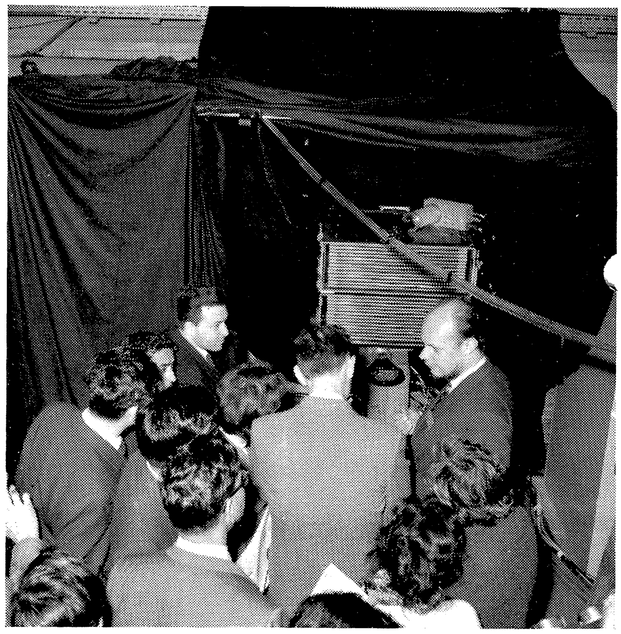
Most areas of the site were accessible, and neither of the two particle accelerators was in operation during the visit. Special arrangements were made to allow people to see part of the tunnel housing the proton synchrotron and the machine room of the synchro-cyclotron.

Among the special attractions were the animated model of the PS, health-physics displays, a spark chamber set up to show the tracks of cosmic-ray particles, and demonstrations of glass blowing. Scanning tables for track-chamber films, instruments for the evaluation of photographs (IEPs), the 7090 computer, and machines in the workshops, could be seen in use.

The colour film of CERN, 'Matter in question', was shown throughout the afternoon in English, French, German and Italian versions, and publications were available from an information desk near the auditorium. The restaurant bar was open for refreshments.

In spite of the counter-attraction of the France-Hungary football match, some 1100 visitors took advantage of the fine weather to come to CERN and discover more about the work that goes on here.

The open day was arranged by the Public Information Office, but thanks are due to very many people who helped to make it a success – the ' guides ' who posted themselves at strategic points to provide information and explain the exhibits, other members of the staff who exhibited and explained their own equipment, the security guards, health physics and safety staff, members of the cleaning staff who became guards for the afternoon, those who looked after the children, and all those in every Division who helped with the preparations and organization ●



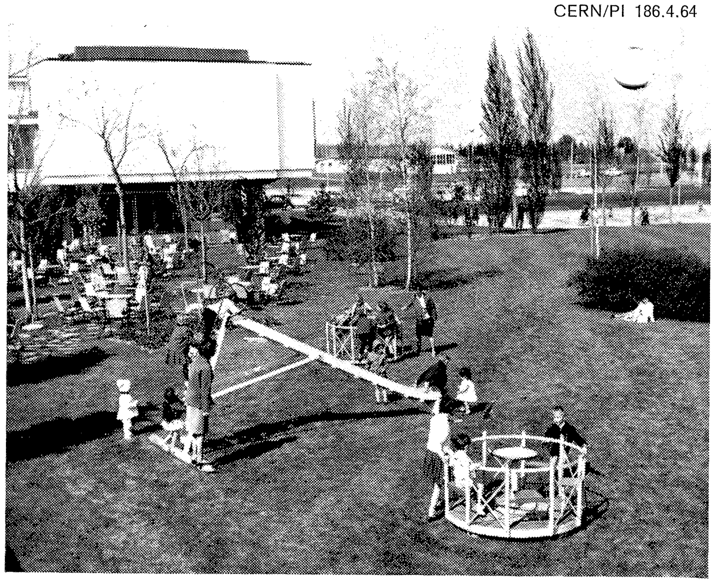
K. Unser explains the operation of the spark chamber demonstrated in the PS South hall.

CERN/PI 205.4.64

Demonstrating the model of the 28-GeV proton synchrotron is B. Agoritsas, while to the left R. Raffnsøe explains some of the exhibits in the health physics display in the PS North hall.

CERN/PI 204.4.64

CERN/PI 186.4.64



As well as firemen, cleaners and transport staff, teachers from the CERN nursery school and girl guides from the international troupe at Ferney-Voltaire helped to look after the children. The Geneva authorities kindly lent the playground equipment.

The PS Research Programme

by W.O. LOCK, Nuclear Physics Division, PS Co-ordinator

Because CERN is the centre for high-energy physics for laboratories all over Europe, the demand for use of its accelerators is very heavy. In this article, the introductory section describes briefly how all the various proposals for experiments are channelled through the committee system to decide which should be accepted. Details are then given of experiments that are expected to be carried out at the CERN proton synchrotron during the months following the shut-down in April 1964. A concluding section indicates how the different experiments approved are fitted into a workable schedule for the accelerator.

In this short article an attempt will be made to outline the experimental programme at CERN's 28-GeV proton synchrotron for the next few months. This programme is built up from the proposals put forward by the Track Chamber Committee, the Electronics Experiments Committee and the Emulsion Experiments Committee. These three committees meet about every month and have the difficult task of choosing between the large number of experiments proposed to them by groups of physicists both inside and outside CERN. The Chairmen of these committees (Prof. C. C. Butler, Prof. G. Puppi and Prof. A. G. Ekspong respectively) put forward their programme to the Nuclear Physics Research Committee, which assigns priorities and judges whether the proposals are of sufficient merit to be allocated time at the accelerator. Then the Experimental Planning Committee (R. Gouiran, G. L. Munday, P. H. Standley and the author) has to fit the experimental proposals together into a logical and practicable programme and thus to derive a possible schedule, that is, an order and a time-scale for the execution of the experiments. In cases of conflict, the Nuclear Physics Research Committee (or, in the last analysis, the Directorate) has to take a decision. Table I illustrates this committee system.

The experimental proposals are frequently discussed in terms of the techniques employed. On the other hand, from the point of view of the Experimental Planning Committee, the important fact is the occupancy or otherwise of a particle beam. We shall therefore make our survey of the experiments that are to be scheduled by considering the beams in each of the three experimental areas. For convenience, we summarize in table II all the experiments that will be mentioned, together with some information on the different particle beams.

PS South Hall

In the South experimental hall, we come first to the fast ejected proton beam. The main user here is the neutrino experiment, employing as detectors both the CERN heavy-liquid bubble chamber and a complex array of spark chambers, some of them containing magnetized iron plates. A run of four weeks took place in February and March ; further runs will be made during the summer. The fast ejected beam was also used in February by the emulsion group from DESY, Hamburg, to test their experiment to study proton-proton scattering at small angles, using a hydrogen gas target. The proton beam passed near the centre of the target and the recoil protons were detected in nuclear emulsions placed inside the hydrogen gas, which was at a pressure of about 0.25 atmosphere. The test was successful and runs at different energies will be made in the near future.

Next is the d_{15} beam, which yields negative pions of around 10 GeV/c, and which originates from target number 1 (each target is numbered after the number of the magnet unit immediately next to it in an anticlockwise direction). The experiment in this beam at the time of writing is that of the Hyams group and has the code number S5. The S indicates that it is an electronic experiment of some kind, though the origin of this nomenclature seems to be obscure ! The purpose of experiment S5 is to observe γ-rays from pion-proton collisions in the extreme forward direction (at angles of less than 2° to the proton direction), in order to test the hypothesis put forward by Drell in 1961 that the one-pion-exchange model (or peripheral model) plays an important role in such collisions. The equipment consists of a hydrogen target and a large number of scintillation counters and spark chambers, together with a complex array of mirrors. Hardly any of this is visible in the South hall, as it is surrounded by black curtains to allow the photographs of the spark chambers to be taken.

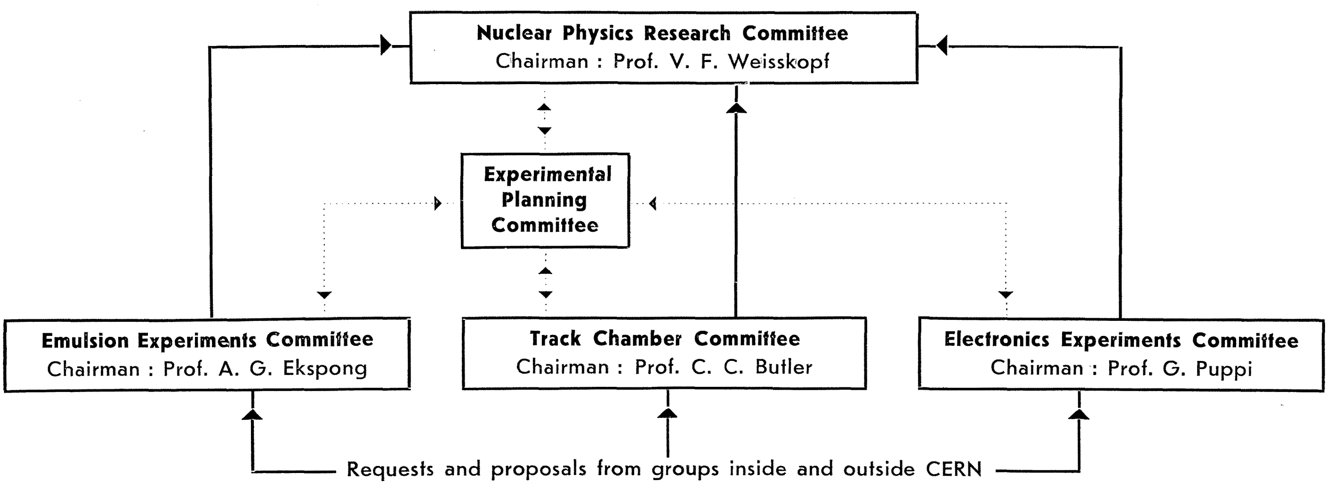


TABLE I : The Committee System

Beam	Particles	Experiment	Group(s)	Purpose
			SOUTH HALL	
Internal	Protons	E47	Rome	Small-angle p-p scattering
Fast ejected	Protons 24 GeV/c	Neutrino	CERN HLBC, CERN Sp. Ch. UCL-CERN Sp. Ch. + emulsions	Neutrino interactions
Fast ejected		E46	Hamburg	Small-angle p-p scattering
d_{15}	Pions $\sim$ 10 GeV/c	S5	Hyams	Peripheral production of gamma rays
d_{17}	Pions $\sim$ 6 GeV/c (?)	S31	Maglic	Missing-mass spectrometry
m_{4a}	Antiprotons $\sim$ 2.5 GeV/c	S11	Paplep	Proton-antiproton annihilation to lepton pair
m_{4b}	K-mesons $\sim$ 1.5 GeV/c	S29	Ξ^- parity	Ξ^- parity
q_3	1-2 GeV/c particles	S30	Fidecaro	ϱ decay ratio π-γ to π-π^0
			NORTH HALL	
k_4	0.6-1.2 GeV/c K^+,K^- and $\bar{p}$	Many	Many	Experiments in H and D (81-cm chamber) with both K-mesons and antiprotons
a_8	$\pi^+ \sim$ 1 GeV/c	E11a	Bristol, CERN, Lausanne, Munich, Rome	Magnetic moment of Σ^+ hyperon
a_7	π^+, $\pi^- \sim$ 3.5 GeV/c	S28	CERN-Ivry	π-p large-angle scattering
			EAST HALL	
o_2	Various	Many	Many	Interactions of π^-, π^+, K^-, K^+, p, $\bar{p}$ in 150-cm HBC
o_2	5 GeV/c K^-	E42	Oxford, Strasburg	Hyperfragment studies
o_2	10 GeV/c π^-	E43	Munich	Small-angle π^--p scattering
o_3	20 GeV/c protons	N6	Neutrino	Neutrino calibration using Lagarrigue HLBC
c_8	Protons	S24	p-p scattering	Small-angle p-p scattering
d_{16}	Pions 5-17 GeV/c	S26	Falk-Vairant	Charge-exchange of pions

TABLE II : Experiments to be scheduled at the PS in the period May - September, 1964 (not necessarily complete)

The work of the Hyams group should be finished in June, when the beam will be modified for S31, which is an experiment of the Maglic group designed to search for new heavy mesons in the mass range between 1 and 3 GeV. In particular, a search will be made for particles which we can designate by X^-, produced in the two-body reaction

$$\pi^- + p \rightarrow p + X^-.$$

Since the heavy meson X^- probably decays into two or more pions, what will be observed is

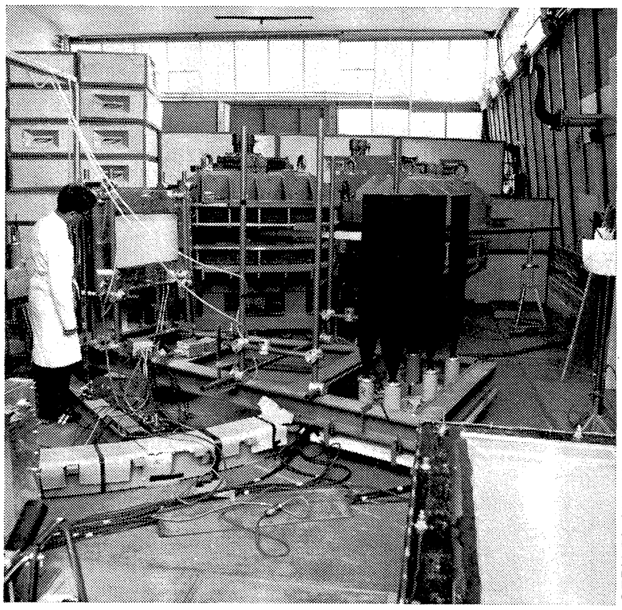
$$\pi^- + p \rightarrow p + n\pi \qquad \text{(where } n \text{ is 2, 3, etc.).}$$

For a fixed incident pion momentum one measures the angle and momentum of the outgoing proton and from these data one can calculate the effective mass of the pions, M. If the pions are uncorrelated, the distribution of the values of M will show no special features. However, if the pions 'resonate', that is, if the production reaction really is $\pi^- + p \rightarrow p + X^-$, then a peak will occur in the distribution of M corresponding to the mass of X. The interesting feature of the experiment, which again is a combination of spark chambers, scintillation counters and a liquid-hydrogen target, is that the information from the detectors is directly fed to a computer, which carries out all the necessary calculations, so that one can plan the next step of the work almost at once. The apparatus is extremely complex but it has been tested in a pilot experiment at the synchro-cyclotron and behaves as expected.

Two more beams originate from target 1. That at 6° is called the m_4 and has only been constructed during the recent shut-down in April. It is intended to provide high-intensity beams of both K^--particles, of about 1.5 GeV/c momentum, and of antiprotons, of around 2.5 GeV/c momentum. Just after entering the South hall through the shielding wall, the beam is in fact divided into two parts, one to provide the antiprotons for experiment S11 and one to provide K-particles for S29.

The aim of S11 (Zichichi group) is to detect muon pairs from antiproton-proton annihilation, and it is a continuation of the earlier work on the production of electron pairs from this annihilation process. This first experiment was called 'Papep', that is, the initial letters of the process under study : the present experiment is known as 'Paplep', where 'lep' is short for lepton pair, in this case a pair of muons. These weakly interacting particles are being detected in large multiplate spark chambers similar to those being used in the neutrino experiment to detect and identify muons.

S29 is a complex experiment, in an attempt to measure the parity of the Ξ^- (xi-minus), the cascade-minus particle. A polarized-proton target will be used, consisting of a hydrogen compound kept at a temperature of 1°K (-272° C) in a magnetic field of about 20 kilogauss inside a microwave cavity. The size of



CERN/PI 16.5.64

Part of the 'missing-mass spectrometer for heavy mesons', photographed during dismantling after calibration tests in the proton room of the synchro-cyclotron. The proton path is defined by two large-area sonic spark chambers, one of 80 cm x 40 cm sensitive area (seen in position to the left of the picture) and the other 100 cm x 150 cm (removed but partly visible in the bottom right-hand corner). The tall black objects are plastic scintillation counters for measuring the time of flight of the protons through the system. To vary the angle made with the direction of the incoming pion beam, the spectrometer arm moves on the circular platform (here protected by cardboard coverings).

the target (developed by a group at C.E.N., Saclay, under Abragam) is about 5 cm × 2 cm × 2 cm. The first tests of this experiment will take place during the summer.

The last beam in the South hall consists of low-energy pions emitted at 23.5° to the circulating proton beam ; it is called q_3. The Fidecaro group has just commenced work in the area on experiment S30, using a liquid-hydrogen target and an array of spark chambers. Their aim is to investigate the decay modes of the charged ϱ-particle, which is a resonant state of two pions. In particular, two decay modes will be studied : that in which the ϱ-particle decays to one pion and a gamma ray and that in which it decays to a charged pion and a neutral pion. In fact the decay $\varrho^+ \rightarrow \pi^- + \varrho$ or $\varrho \rightarrow \pi^- + \gamma$ has not yet been observed experimentally, but there are good reasons to believe in its existence. A measurement of the branching ratio — how often it occurs relative to the usual decay mode $\varrho^+ \rightarrow \pi^+ + \pi^0$ or $\varrho^- \rightarrow \pi^- + \pi^0$ — would give another piece of information about the ϱ-particle, which in some respects is still rather a mysterious object from the point of view of the role it plays in high-energy interactions.

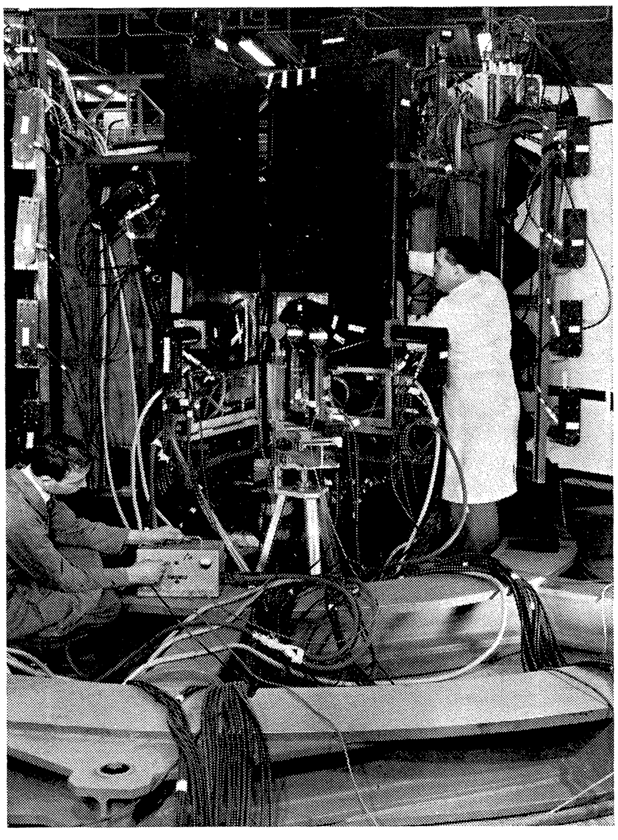
PS North Hall

In the North experimental hall the Saclay/École Polytechnique 81-cm bubble chamber has recently been installed in a new beam, the k_4, which starts from target 10. This beam is designed to yield K^--particles and antiprotons of momenta between 600 and 1200 MeV/c. The first runs will be with slow and stopping antiprotons in deuterium to study resonances and low-energy antiproton-neutron interactions. The code numbers for these runs are T14 and T21, where the T indicates that it is a track-chamber experiment. Then the beam will be run to give K^--mesons and antiprotons of about 1 GeV/c momentum for experiment T47 (K^- in H_2) *or* T67 (K^- *in* D_2) and for T69 ($\bar{p}$ in H_2).

The purpose of experiment T47, for example, is to study the various pion-hyperon resonant states formed when K^--mesons collide with protons. These are usually called Y* states and at least five are well established. The first one found (in 1960) was the Y_1^* state, produced in the reaction

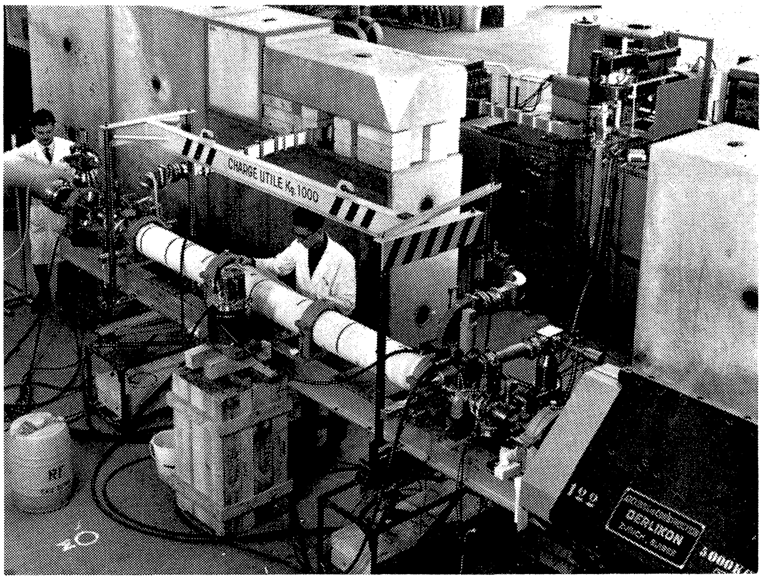
$$K^- + p \rightarrow \left\{ \begin{array}{c} Y_1^*(1385)^+ + \pi^- \\ \\ Y_1^*(1385)^- + \pi^+ \end{array} \right\} \rightarrow \Lambda^0 + \pi^+ + \pi^-,$$

where the 1385 denotes its mass measured in MeV. The masses of the known Y* states range between 1385 and 1815 MeV so that incident K^--mesons of between 700 and 1100 MeV/c momentum are required to produce them in collisions with protons. Excited states, K*, of the K-meson itself can also be produced in K^--p collisions and in antiproton-proton collisions. Runs with incident K^--mesons of different momenta are required to yield useful data on the many different states and to search for new resonances.



CERN/PI 187.1.64

Some of the detection equipment for the 'Paplep' experiment. The target is the circular grey disc in the centre of the picture and the two black rectangular structures are large spark chambers for determining the kinematics of emitted particles. Behind each of these spark chambers are specially shaped lead absorbers (grey), and behind them (out of the picture) even larger spark chambers for identifying muons. Various scintillation counters, for defining the incoming beam and providing other trigger signals, can be seen. The turntable visible in the foreground enables each of the two similar sets of counters to be rotated around the target, as required by the momentum of the incoming beam, for calibration measurements.



CERN/PI 4.5.64

One of the deflecting stations of CERN's radiofrequency particle separator (the first of its kind in the world) being installed in the o_2 beam for preliminary deflexion tests. The waveguide structure in the beam, and the vacuum system, can be clearly seen, while behind the shielding wall is the 20-MW microwave power source with the modulator and control racks.

Another experiment on the list is T35, for which K^+-particles will be stopped in hydrogen. The interest here is in the electron decay modes of the K^+-meson.

The second beam in the North hall is the a_8, which is a new version of the a_6 existing there previously. It starts from target 6 and will yield pions and K-particles up to momenta between 1 and 3.5 GeV/c. The experiment now being set up is an attempt to measure the magnetic moment of the Σ^+ hyperon, and it has the code number E11a The E indicates that it is a nuclear-emulsion experiment ; E11 was an experiment carried out in 1963 to measure the magnetic moment of the Λ^0 hyperon. For E11a a collimated beam of positive pions of momentum 1.15 GeV/c will be sent along the axis of a liquid-hydrogen target placed in a pulsed magnetic field of 200 kilogauss. Inside the hydrogen target, conical nuclear emulsions will be placed to detect the Σ^+ particles produced in the reaction

$$\pi^+ + p \rightarrow \Sigma^+ + K^+.$$

As the lifetime of the Σ^+ particle is only 0.8×10^{-10} second, the emulsions must be placed very close to the axis of the incoming pion beam. A study of the angular distribution of the protons from the decay of the Σ^+ ($\Sigma^+ \rightarrow p + \pi^0$) should enable one to deduce its magnetic moment.

PS East Hall

The East experimental hall now has nearly as many beams as the South hall. The most complex one is the o_2, built to provide high-energy pions, protons, K-particles and antiprotons. In its version with three electrostatic separators it yields K-mesons of momentum up to 6 GeV/c and antiprotons up to 10 GeV/c. The addition of radiofrequency separators should enable one to go to 15 GeV/c K-particles. The main customers for these particles are the British 150-cm hydrogen bubble chamber and, it is hoped later in the year, the CERN 200-cm hydrogen bubble chamber.

One of the major fields of interest is that of K-meson interactions with protons at energies between 5 and 15 GeV/c. In the further runs planned for 5 - 6 GeV/c one might reasonably expect to find a number of Ω^- events, in order to begin to study the properties of this recently discovered particle. Apart from this, little is yet known about the K^+-p and K^--p interactions at high energies, while much work remains to be done on the different strange-particle resonant states, for example the system of two K-mesons and a hyperon designated as KKY. In addition to the work with strange particles there is a considerable programme to study pion and proton interactions in hydrogen up to the highest possible energy. Our knowledge of these fundamental interactions is still very meagre, particularly our knowledge of the importance of the excitation of the different pion resonant states and of excited states of the nucleon.

The large number of laboratories interested in pictures to be taken in the 150-cm chamber is illustrated by the numerous code numbers, which represent experimental proposals from individual or, more usually, groups of laboratories. For antiproton studies there are T36 and T80, for K^+-particles or K^--particles T41, T49, T55, T62, T63, T64, T77, T81, and for pions and

	30 APRIL to 10 MAY	14 MAY to 24 MAY	28 MAY to 7 JUNE	11 JUNE to 21 JUNE	25 JUNE to 5 JULY	9 JULY to 19 JULY	23 JULY to 2 AUGUST	6 AUGUST to 16 AUGUST	20 AUGUST to 30 AUGUST
MAIN USER	Setting up new beams	Neutrino experiment	Neutrino experiment	Counter experiments and 81-cm bubble chamber	Bubble-chamber runs	Bubble-chamber runs	Counter experiments	Neutrino experiment	Counter experiments
OTHERS	—	Lagarrigue bubble chamber	—	—	—	Counter and emulsion experiments	—	—	150-cm bubble chamber

Note : in each calendar fortnight the PS is operated for 10 days for physics use.

TABLE III : Outline PS schedule, May - August 1964

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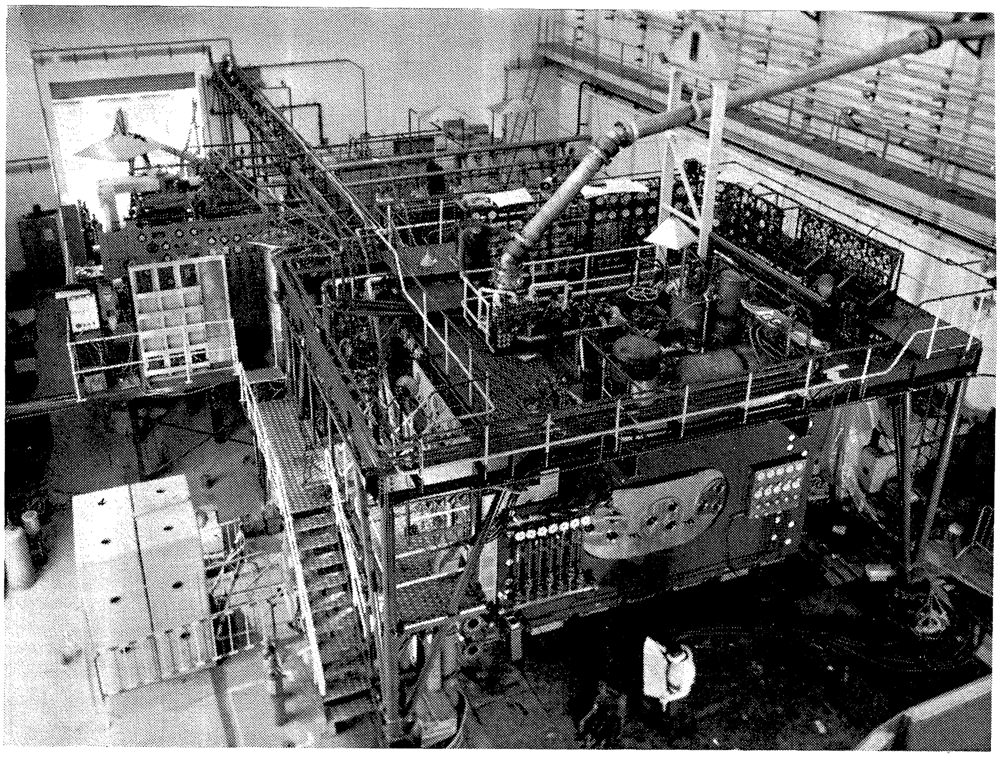

The 150-cm British liquid-hydrogen bubble chamber, more or less complete, in the East bubble-chamber building of the PS. Clearly visible is the bridge, on which are mounted the fast-acting valves, together with instrumentation and control panels, for the gas-expansion system. In the left back ground is the refrigerator control panel. Part of the magnet can be seen under the bridge, with one face of the vacuum tank containing nine ports ready to receive the lamp housings. Pyramid-shaped ' hats ' hanging from the ceiling are part of the hydrogen alarm system, and the long pipe enables the hydrogen in the chamber to be transferred to the safety sphere outside in case of emergency. The concrete blocks on the left absorb the beam after it has passed through the chamber.

protons T39, T40, T56, T59, T60, T65, T82, T83 and T85 ! To give three examples of the number of groups covered by a code number, T49 represents the 5 - 6 GeV/c K^--meson runs in hydrogen requested by Birmingham, Cambridge, Glasgow, Imperial College (London), NIRNS and Oxford in the United Kingdom and Munich in Germany ; T39 (15 - 20 GeV/c protons in hydrogen) is requested by Aachen, Cambridge, CERN, Stockholm and Vienna ; T40 (15 GeV/c π^- in hydrogen) is requested by the collaboration linking, CERN, Hamburg, Vienna, Berlin, Krakow, Prague and Warsaw.

The o_2 beam will also be used as a source of high-energy pions for a scattering-camera experiment using nuclear emulsions to study pion-proton small-angle scattering (experiment E43). As in the case of the proton-proton scattering experiment mentioned earlier (E46), the target will be hydrogen gas at a low pressure and the emulsions will be inside the gas in order to detect the very slow recoil protons. Several emulsion groups are also interested in the o_2 beam as a source of fast K^--particles to produce hyperfragments, a field of study which is almost exclusively the domain of the emulsion technique. Many litres of emulsion will be irradiated during the course of the year (E42).

The scattered-out proton beam which used to exist in the South hall has been rebuilt in the East hall, where it originates from target 61 and is known as c_8. Here the p-p- scattering group is just beginning a new series of measurements of small-angle proton-proton scattering at 10, 19 and 26 GeV/c (experiment S24). They are using sonic spark chambers in conjunction with magnetic-tape data storage, the tape reels being subsequently transferred to the 7090 computer. This obviates the need to take and scan many thousands of photographs.

The third beam in the East hall originates from target 64 and yields pions of energy between 5 and 17 GeV/c. Since the prefix 'd' has become associated with high-energy pion beams, it is known as d_{16}. A new experiment (S26) and a new group, that of Falk-Vairant from Saclay, has just started here. Its purpose is to measure the charge exchange of negative pions, that is, $\pi^- + p \rightarrow \pi^0 + n$, at 5, 12 and 17 GeV/c. Again this is an arrangement of spark chambers in association with a liquid-hydrogen target.

The Schedule

At this stage the reader is probably wondering how it is possible to fit all these experiments into a schedule of reasonable length ! Luckily, the technique of dividing the accelerated protons in the machine among several targets has now been brought to a fine art by the members of the MPS Division and, moreover, there are enough protons accelerated (normally around 7 x 10^{11} every pulse) to make such target sharing useful. For example, for most of the track-chamber runs the k_4 and o_2 beams can be operated at the same time, that is, both the 81-cm chamber and the 150-cm chamber would be taking pictures containing a reasonable flux of the wanted particles. Again, it is often possible to run five beams for counter experiments all at the same time by distributing the accelerated protons between target 1 (beams d_{15}, m_4, q_3), target 6 (beam a_8) and target 61 (beam c_8). When the neutrino experiment is running it is possible to use the so-called rapid beam deflector to put about 5 % of the internal beam on to target 60 to provide a beam for the 150-cm bubble chamber. With these many possibilities the construction of a schedule is rather like doing a complex jigsaw puzzle.

The usual procedure is first to make a programme containing only the major experiments, that is, major in terms of time on the machine. For example, for the months of May to August it means deciding where to place the main track-chamber runs, which in turn depends on the state of the beams (the o_2 and the k_4) and on the state of the chambers. Similarly the placing of the time for the counter experiments depends on the readiness of the new beams that have been constructed. Time for the neutrino experiment is the third major piece of the jigsaw to be positioned. Once the framework for these three ' main users ' has been fixed (see table III), the smaller pieces of the jigsaw, that is, the short experiments, emulsion and radiochemistry irradiations, tests for new experiments, etc. have to be fitted in at the most convenient times. This is usually done at the weekly schedule meetings, where the detailed programme of the PS is firmly established week by week ●

BOOKS

Chemistry in nuclear technology, by S. Peterson and R. G. Wymer (Oxford, Pergamon Press Ltd., 1963 ; 94 s.).

Anyone who has attempted to instruct postgraduate students possessing little knowledge of chemistry in the essential role played by that scientific discipline in the development of nuclear energy will be grateful for this book. It has its shortcomings : for example the early chapters, covering such topics as the fundamentals of chemistry, radiochemistry, nuclear reactions and the detection of radiation, are rather over-compressed. There are a few small inconsistencies : many elementary concepts, both in chemistry and radioactivity, are introduced in italics, with a few explanatory words, whereas the important phenomenon of pile poisoning is allowed to slip in unobtrusively as if the reader can be expected to know all about it already. The authors confess to a difficulty in defining 'radiochemistry' and seem to come down in favour of the chemistry of very dilute systems studied with the aid of radioactive tracers. This definition does not harmonize with the rest of the book and I think most people would take a broader view, even if they would not go all the way with Edward Bruninx in saying that radiochemistry is 'nuclear physics for plumbers'.

But these are minor criticisms. The remainder of the book deals authoritatively with the basic chemistry of nuclear fuels and the technology of fuel production and processing, the disposal of radioactive wastes, and the principles of isotope separation, ending with a brief chapter on the chemistry of some important non-radioactive reactor components. Here the authors write with admirable style and present a wealth of facts and figures which justifies their hope that the book will become a useful addition to the bookshelf of the practising nuclear technologist.

Each of the seventeen chapters is followed by a few useful illustrative problems and a good selection of references, and there is an adequate index. The number of misprints is very close to zero. There have been far too many recent books in the nuclear-energy field which would have been better compressed into half their size, but all 374 pages of the one under review are good ones and the whole is at least equal to the sum of its parts.

K. F. Chackett

Nuclear reactor control engineering, by Joseph M. Harrer (London, D. Van Nostrand Company Ltd, 1963 ; 128 s.).

The physical theory of neutron chain reactors has been described by many authors and an excellent literature exists on the subject. Important aspects of reactor technology, such as reactor control, reactor shielding, and nuclear radiation detection, have also been treated in numerous books.

In the case of the book under review, the author set out on a new path, with the intention of transmitting to engineers the experience obtained so far in reactor control ; to stress the state of the art rather than the basic theory.

To avoid possible confusion, it may be useful to point out that the inclusion in this section of reviews of books dealing with nuclear power engineering and other aspects of the uses of nuclear energy does not mean that CERN, as an organization, is concerned with such activities. It is just that these books are made available to us for review, the subjects are sometimes of interest to members of the CERN staff, and we assume that many readers of CERN COURIER **have interests other than in fundamental research.**

Besides reactor control, a number of related subjects are dealt with. There is a comprehensive introduction, covering reactor physics, instrumentation, feedback control systems, and computer techniques, which is advantageous to the engineer just entering the reactor field, although in consequence some aspects of the main subject of the book are not covered in as much detail as they could have been. For example, control-rod calibration techniques could have been described more fully, perhaps enclosing loose calibration charts ; the information on the effects of irradiation on lubricants, cables and connectors is limited ; more could have been said on pre-operational and operational check on the control rods.

The following résumé of the contents of the fourteen chapters will, however, give a better idea of the scope of the book :

- compilation of elementary reactor concepts ; description of different types of reactors ;
- reactor physics ; the thermal-neutron diffusion equation, buckling, reactivity effects ;
- reactor kinetics, theory of control-rod calibration ;
- control-rod design considerations, discussion of the properties of control-rod materials ;
- neutron detectors, neutron-flux measuring channels ;
- control-rod drive mechanisms, descriptions of the various types employed on reactors ;
- feedback control systems; stability and feedback analysis, the meaning and use of transfer functions ;
- the specific transfer functions of reactors, techniques for measuring reactor transfer functions ;
- rod-control systems, discussion on rod speeds, start-up and steady-state requirements ; the effects of xenon and samarium (3 chapters in all) ;
- reactor safety ; discussion of the SL-1 reactor accident ; ultimate reactor shut-down devices ; fail-safe and reliability concepts ;
- miscellaneous topics, such as spectral-shift control and solid-state fission counters ;
- elementary explanation of analogue and digital computors ; reactor simulators.

Each chapter is followed by an extensive list of references, although these date generally from before 1961. It should also be noted that the reactors and commercial firms mentioned in the book are practically all situated in the U.S.A.

To sum up, the transmission of 'know-how' on paper is difficult, but here the author has succeeded, at least in part. The frequent reference to experience and the clear definitions of basic concepts make the book a valuable addition to the literature on nuclear reactors.

J.H.B. Madsen

The theory of superconductivity, edited by N. N. Bogoliubov, (New York, Gordon and Breach Science Publishers Inc., 1963 ; $ 4.95).

This book is the fourth volume of the *International Science Review Series,* devoted to collecting the pioneering papers in rapidly developing fields of the physical sciences — established classical material as well as articles representing more recent progress — selected from the world literature. Since the selection of papers in each anthology is made by an investigator actively engaged in the field, it is only natural to expect a bias in the direction in which the editor's interests lie.

The present volume is no exception. As Prof. Bogoliubov mentions in his preface, the purpose of this collection of papers is to acquaint the reader with the basic works on the microscopic theory of superconductivity *published in the foreign literature* (reviewer's italics), mainly during the period of 1957-1958. This means that the reader will look in vain for the extensive contributions of the Russian School to the theory of superconductivity ; Prof. Bogoliubov's very important own work forms the subject matter of the last article in the book, albeit in a rather shortened translation. By way of compensation, some of the more important of Fröhlich's papers, dating from the period 1950-1954, as well as Kuper's review article are included in the collection.

It is fortunate that this latter paper has found its way into the book, as it will help the reader to orientate himself in the mathematical maze that is the theory of superconductivity. In fact it is suggested that the reader tackles this book by studying Kuper's review, turning to the other articles only when a reference so requires it. He will then find that he has all the basic material neatly parcelled up under one cover, and that only the more esoteric publications will have to be looked for in the library.

Since an incidental by-product of an anthology of this type is a formidable bibliography, the reviewer will permit himself the perennial tirade against the editor and publisher. When will these misguided gentlemen realise that a book even remotely connected with science needs an index, and a good index at that, and at least some form of bibliographical summary!

This much said, the reviewer has nothing but praise for the splendid idea behind this series, for the choice, and for the presentation. A veritable boon for the busy physicist who must have his information from the horse's mouth, yet who prefers to keep his search of the literature down to a minimum.

St. L.

Also received

The rare-earth elements, by D. N. Trifonov (Oxford, Pergamon Press Ltd., 1963 ; 25 s.) — describes the properties of the rare earths, methods of separating them and obtaining the pure metals, and the history of their discovery ; translated from the Russian edition of 1960.

Enriched uranium processing, by F. S. Patton, J. M. Googin and W. L. Griffith (Oxford, Pergamon Press Ltd., 1963 ; 70 s.) — covers basic data, chemical, metallurgical and ceramics operations, radiation safety, uranium control, plant design, economics and management.

Analytical chemistry : volume 3, parts 1-3 of series IX of *Progress in nuclear energy,* edited by C. E. Crouthamel (Oxford, Pergamon Press Ltd., 1962 ; 30 s.) — articles on radiochemical separations of low-level radioactivity, the determination of atom per cent fission in uranium fuel, and radiation problems associated with the handling of the actinide elements.

Scientific words, their structure and meaning, by W. E. Flood (London, Oldbourne Book Co. Ltd., 1960 ; 18 s.) — introduction describing the structure of scientific words, followed by some 1150 word ' elements ' (roots, prefixes and suffixes) most likely to be encountered in scientific vocabulary, with many examples of their combination and meaning ; a useful reference book taking much of the mystery out of the specialized language of scientists.

Out of my later years, by A. Einstein (New York, Philosophical Library Inc., 1950) — a collection of essays written during the years 1934 to 1950, on philosophical, political and social, as well as scientific topics.

Treasury of world science, edited by D. D. Runes (New York, Philosophical Library Inc., 1962 ; $ 15.00) — a collection of so-called ' classic ' scientific papers published over the last 2400 years, from Agricola to Volta — in alphabetical order ; interesting, but superficial editorial introductions and lack of proper references to the original sources make this a highly misleading example of scientific writing ●

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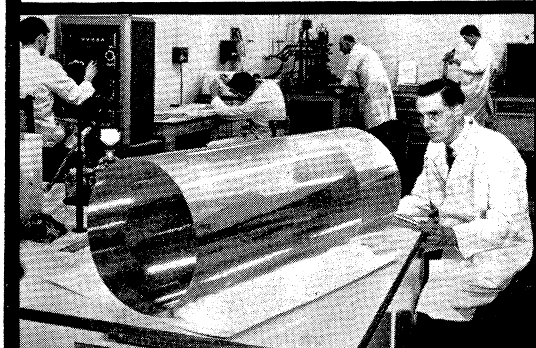

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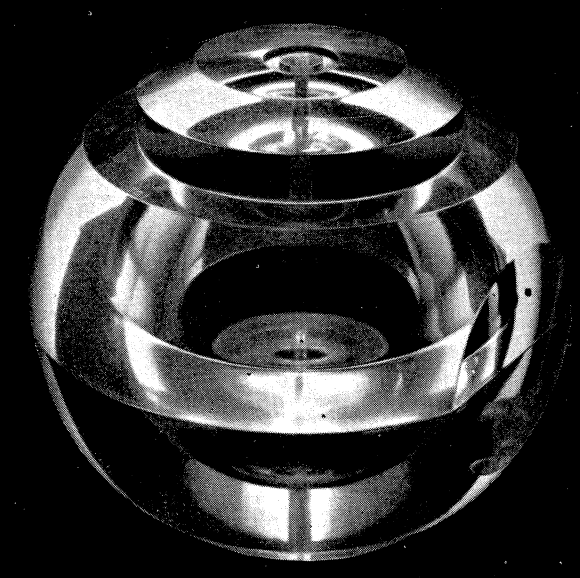

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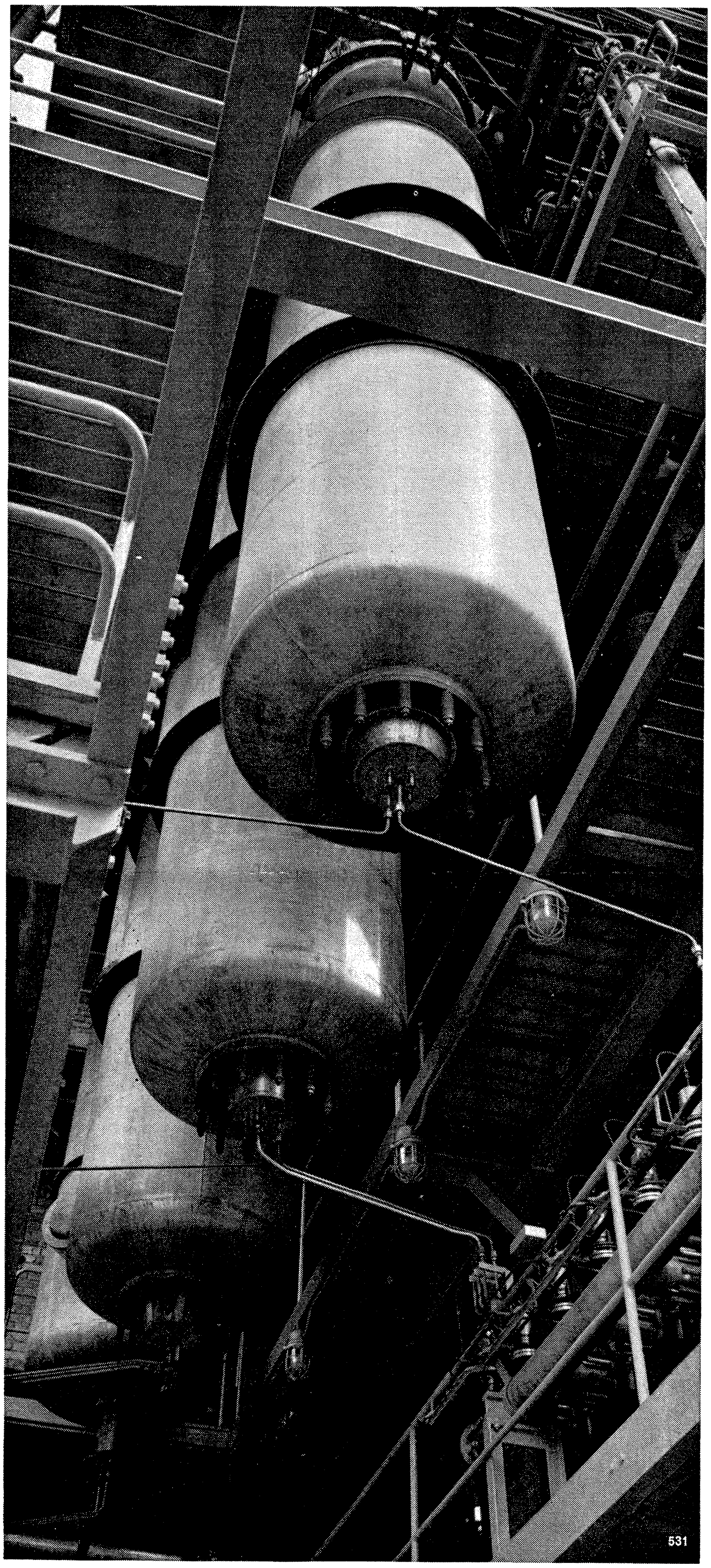

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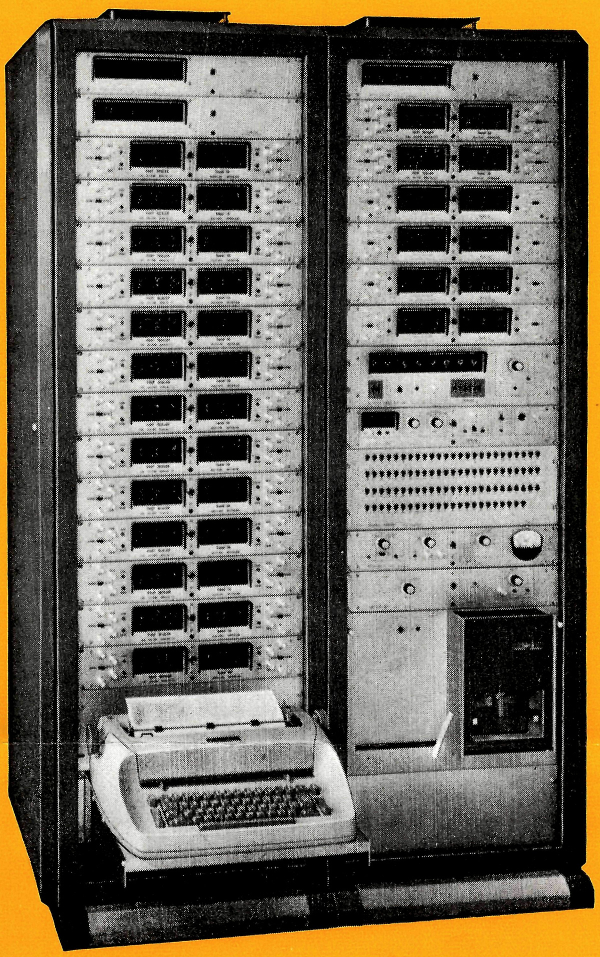

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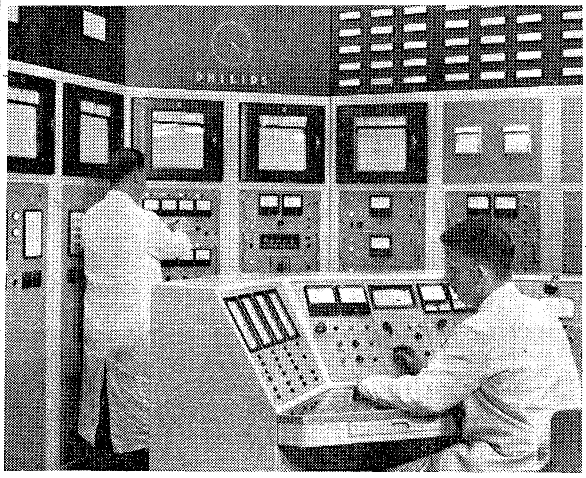

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