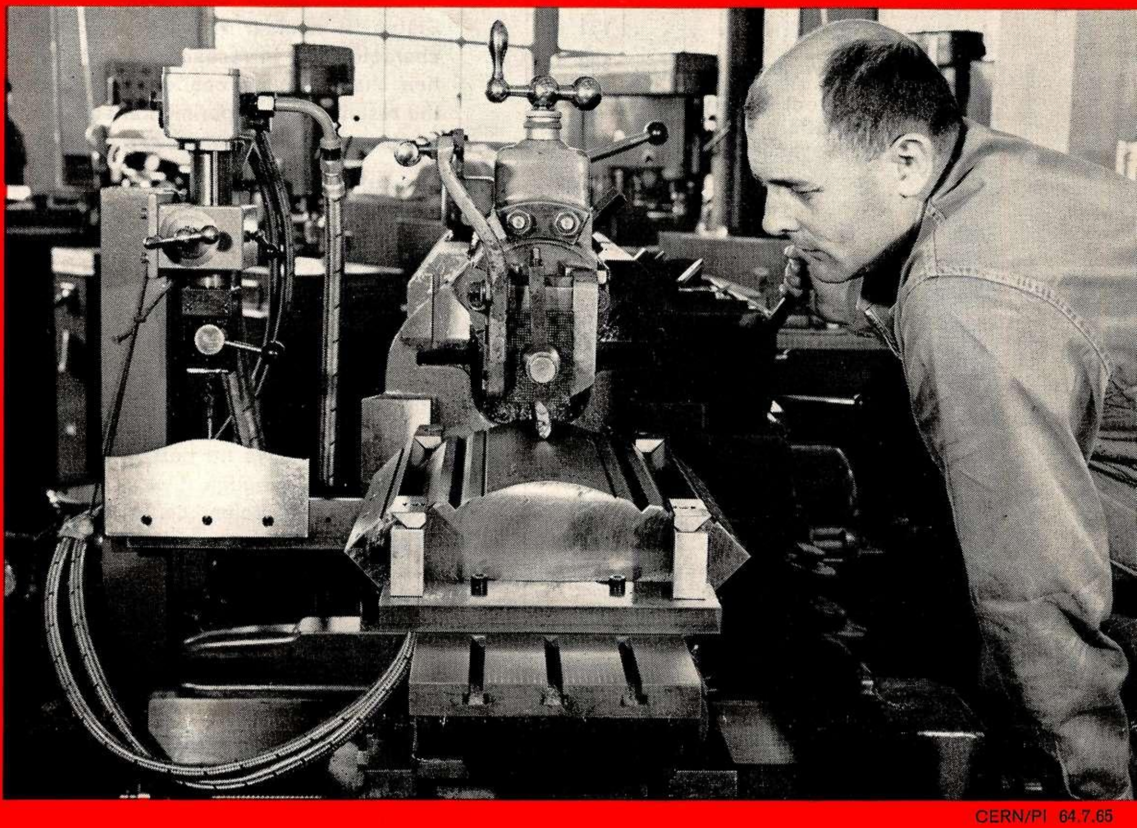
CERN COURIER



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The cover photograph, taken in the main workshop, shows Gubian Candido controlling the machining of the pole-face profile on part of a quadrupole-lens yoke for the MSC Division. The required shape is produced automatically by the machine, using as a guide the accurately shaped template seen on the left. The cut is rapid (over 30 cm/second) and fine (steps of 0.15 mm). Each quadrupole magnet is made up of four identical pieces like the one shown, fitted together to form a roughly cubic shape with the curved surfaces facing inwards ; the coils, moulded in Araldite, are also on the inside, fitting into the slots seen on either side of the curved surface. The result is a magnet with a large internal aperture (roughly 25 cm in diameter) and small overall cross-section (49 cm square), having a strong-focusing action (maximum field gradient 600 gauss/cm). Six of them are being made for use at the synchrocyclotron. They were specially designed to be put close to the accelerator, inside the machine room where space is limited, to provide a new high-intensity pion beam.

CERN COURIER

is published monthly in English and in French. It is distributed free of charge to CERN employees, and others interested in the construction and use of particle accelerators or in the progress of nuclear physics in general.

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The European Organization for Nuclear Research, more commonly known as **CERN** (from the initials of the French title or the original body, 'Le Conseil européen pour la Recherche nucléaire', formed by an Agreement dated 15 February 1952), was created when the Convention establishing the permanent Organization came into force on 29 September 1954.

In this Convention, the aims of the Organization are defined 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.'**

Conceived as a co-operative enterprise in order to regain for Europe a first-rank position in fundamental nuclear science, CERN is now one of the world's leading laboratories in this field. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of **high-energy physics,** often known as **sub-nuclear physics** or the **physics of fundamental particles.**

High-energy physics is that front of science which aims directly at the most fundamental questions of the basic laws governing the structure of matter and the universe. It is not directed towards specific applications — in particular, it plays no part in the development of the practical uses of nuclear energy — though it plays an important role in the education of the new generation of scientists. Only the future can show what use may be made of the knowledge now being gained.

The laboratory occupies an area of 41 hA (100 acres) at Meyrin, Canton of Geneva, Switzerland, next to the frontier with France. A similar area on adjacent French territory is expected to be taken over shortly.

Its main experimental equipment consists of two large particle accelerators:

- a 600-MeV synchro-cyclotron,
- a 28 000-MeV (or 28-GeV) proton synchrotron,

the latter being one of the two most powerful in the world.

The CERN staff totals some 2100 people.

In addition to the scientists on the staff, there are about 300 Fellows and Visiting Scientists, who stay at CERN, either individually or as members of visiting teams, for periods ranging from two months to two years. Although these Fellows and Visitors come mainly from universities and research institutes in the CERN Member States, they also include scientists from other countries.

Thirteen Member States contribute to the cost of the Organization, in proportion to their net national income:

Austria (1.95%)	Italy (10.78%)
Belgium (3.83%)	Netherlands (3.92%)
Denmark (2.07%)	Norway (1.47%)
Federal Republic of Germany (22.74%)	Spain (2.18%)
	Sweden (4.23%)
France (18.57%)	Switzerland (3.19%)
Greece (0.60%)	United Kingdom (24.47%)

Poland, Turkey and Yugoslavia have the status of Observer.

The budget for 1965 amounts to 128 760 000 Swiss francs (= $29 800 000), calling for contributions from Member States totalling 126 400 000 Swiss francs (= $29 300 000).

A supplementary programme, financed by twelve states, covers design work on two projects for the future of high-energy physics in Europe — intersecting storage rings for the 28-GeV accelerator at Meyrin and a possible 300-GeV accelerator that would be built elsewhere ●

Last month at CERN

New layout in experimental halls

Following the considerable changes of beam lines and apparatus for experiments, carried out during the previous three to four months, all three of the PS experimental halls presented a very different appearance at the end of August.

The beam lines then in position, most of which will stay at least until the end of the year, were as follows, listed from left to right as seen from their origin in the PS ring :

SOUTH HALL

From target no. 1 :

q_3 : unseparated pions, below 3 GeV/c momentum,

b_{10} : neutral beam at 23°,

m_4 : separated beam for counter experiments, giving pions, kaons, or antiprotons ; new end part known as m_{4a},

d_{18} : unseparated pions, kaons or antiprotons, 3 to 15 GeV/c ; different endings, known as d_{21} and d_{23}.

Ejected beam from straight-section 1 :

h_3 : ejected protons, 12 GeV/c (fast ejection).

NORTH HALL

From target no. 6 :

k_5 : separated kaons, 800-1200 MeV/c,

m_5 : separated kaons up to 3.5 GeV/c, pions or antiprotons up to 6 GeV/c.

EAST HALL

Ejected beam from straight-section 58:

e_2 : ejected protons (slow ejection),

u_1 : separated positive or negative kaons up to 10 GeV/c (fast ejection on to external target and radiofrequency separator).

From target no. 60 :

o_8 : separated kaons up to 5 or 6 GeV/c, pions up to 12 GeV/c.

From target no. 64 :

b_9 : neutral beam, 16.7°,

b_8 : neutral beam, 7.5°,

d_{22} : negative pions, 6 GeV/c (later 12 GeV/c), extended as d_{22a}.

New experimental period

In the first five weeks of the new experimental period that began after the shut-down, the CERN / E. T. H. Zürich group completed their data-collection runs with a hydrogen target and spark chamber / magnetic-field combination at the end of the d_{18} beam line. About 1000 events were photographed showing **charge exchange** of 12 GeV/c negative kaons or 9 GeV/c antiprotons in the target, and 2000 events were obtained indicating the production of a pair of K^0_1 mesons by 12 GeV/c negative pions. Later this year, two more groups will conduct experiments in basically the same beam, one studying the **scattering of pions** from polarized protons, the other conducting a systematic seach for negatively charged **pionic resonances,** using the missing-mass spectrometer.

Although the q_3 beam line existed before the shut-down, a new experiment is now being carried out at the end of it. This experiment, by a joint group of visitors from the Italian National Laboratory at Frascati, the University of Naples and the University of Trieste, is to measure the branching ratio for the **decay of the eta meson** into two gamma rays and into other neutral particles. Later in the year, another group will use the same pion beam for an experiment on the **decay of the lambda hyperon,** one of many experiments in progress or planned in different laboratories to investigate the problem of CP invariance.

The problem of CP invariance

Interest among theoretical and experimental physicists in this problem* is reflected in the presence already of four different groups around the synchrotron, engaged in related experiments. From an observational point of view, there appear to be two neutral kaons, one with a comparatively long lifetime (5×10^{-8} second), which is now called $K^0(L)$ the other with a shorter lifetime (10^{-10} second), known as $K^0(S)$**. Until last year, the latter was identified with a particular combination of kaon and antikaon known as K^0_1, whilst the former was taken to be an associated combination called K^0_2. In this way the experimental observations were explained within the current theoretical framework. This situation was rudely shattered by the discovery at Brookhaven that the longer-lived kaon sometimes decayed in a way

* roughly speaking, the problem of whether or not an antiparticle going backwards behaves according to the same rules as the corresponding particle going forwards.

** the L and the S are usually written as suffixes, in the same way as the 1 of K-nought-one.

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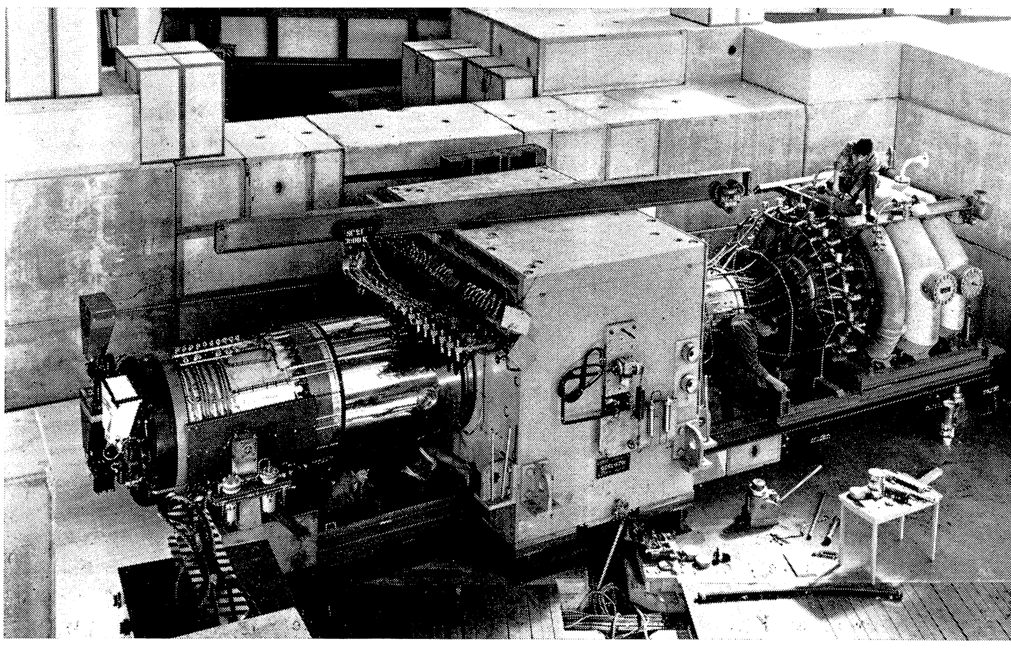
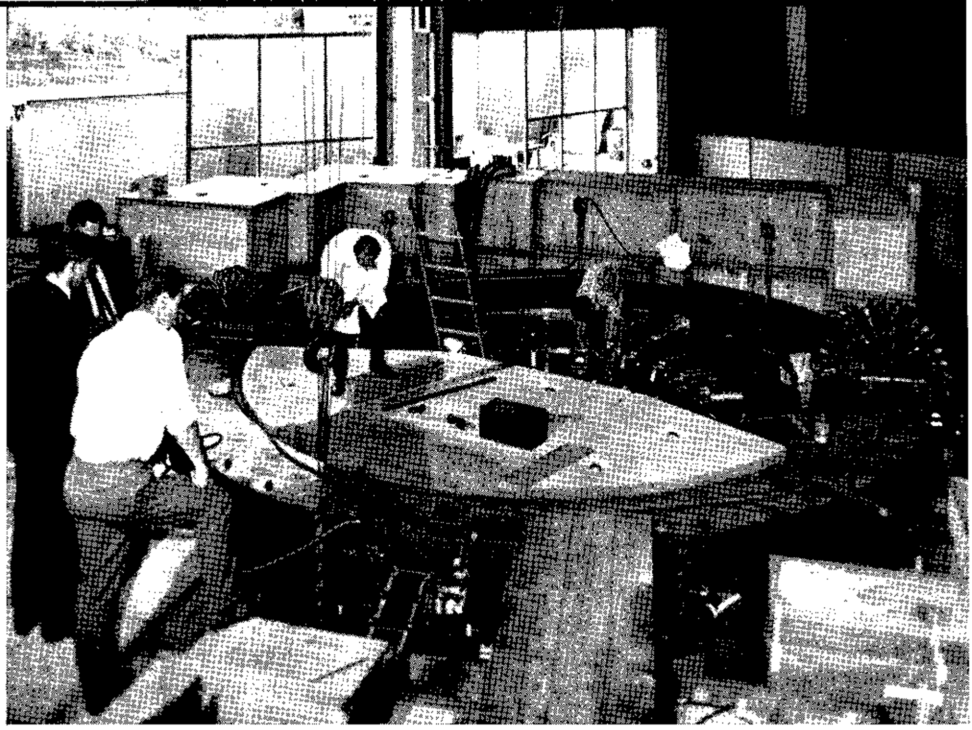


The CERN 1.1-m³ heavy-liquid bubble chamber spends most of its time hidden inside a massive concrete bunker and only seldom does it become possible to photograph it to good advantage. One such occasion, however, presented itself during the last PS shut-down, when the chamber was being re-assembled in the North experimental hall after being transferred from the 'neutrino' area in the South hall. The more highly polished of the two cylinders on the left is the outside of the chamber body itself, withdrawn from the electromagnet that surrounds it during operation. The other is the safety tank supporting the three cameras. To the right of the magnet is the complex of pipes and annular tanks making up the expansion system. The bubble chamber was moved to the North hall for two experiments on the decay of positive kaons brought to rest in the liquid of the chamber.

thought to be possible only for the $K^0(S)$ (see *CERN COURIER*, vol. 4, pp. 118-119 and 124, September 1964). After experiments at CERN and the Rutherford Laboratory (U.K.) had confirmed this fact and also ruled out the possibility that it could be caused by a particular kind of very weak but long-range cosmological force (*CERN COURIER*, vol. 5, pp. 20-21, February 1965), attention turned more strongly to the idea that the law of CP invariance is in fact violated in this decay. If such is the case, the long-lived state $K^0(L)$ no longer has to be the 'pure' state K^0_2 but can be a mixture of K^0_2 (CP = −1) and K^0_1 (CP = + 1). It follows that **interference** should be observed between this K^0_1 component (which decays into two pions) and the 'regenerated' K^0_1 mesons formed by passage of the K^0_2 component through matter. Evidence for such an effect was indeed obtained recently by the Princeton/Brookhaven group that made the original discovery.



The muon storage ring at the end of the South hall, photographed during installation of the electron counters (inside the ring on the far side) and before the shielding roof was put into place. The proton beam from the synchrotron enters the ring tangentially on the side nearest the camera, the entry point being hidden by the boards bridging the gap between the ring and the shielding.

Preliminary tests of a similar nature were tried by the CERN group early this year, with the apparatus of their previous experiment, but the neutron background was then too strong. In their new b_8 beam, the neutron intensity has been reduced by a factor of 100 and the first data were obtained during August. This experiment aims essentially at finding both the relative intensities and the phases of the wave functions describing the K^0_1 and K^0_2 combination that constitutes the 'physical' particle $K^0(L)$.

In the b_9 beam, a joint group from the Rutherford Laboratory and CERN is investigating the **decay of the $K^0(L)$ into two neutral pions** (instead of one positive and one negative, as hitherto studied). The relative frequency of this decay compared to the decay into charged pions is related to another 'rule', the $\Delta I = 1/2$ rule, which states that in weak interactions not involving leptons the total isospin quantum number can change only by the value 1/2. This rule has been under suspicion for some years and it is hoped that this experiment will not only decide how rigid it is but also throw some light on the cause of the CP-invariance violation.

In the other neutral beam, b_{10}, another CERN group is conducting some tests for a proposed experiment which would study the decay of kaons very close to their production point, where $K^0(S)$ is still present as well as $K^0(L)$. Measurement of the interference pattern in their K^0_1 components (given by study of the two-pion decays) should give a precision measurement of the **mass difference between the K^0_1 and K^0_2,** vital to a really accurate computation of the phase angle of the wave functions.

Although the evidence now points strongly to an actual violation of the CP-invariance law, the source of the violation is still not at all clear. For example, it seems that it could equally well be a direct result of a particular kind of weak interaction or an indirect result of the strong or electromagnetic interaction. Among the many ideas that have been put forward and discussed are some that link the problem with the work on various particle classification schemes (SU_6 and so on), the general idea being that the same 'force' that causes the particles of a given multiplet to have different masses, instead of one single mass, might give rise to small violations of the symmetry laws in some interactions. Careful examination of the evidence for the symmetry laws has also shown that it is mostly indirect and a number of crucial experiments have been suggested to clear up the uncertainties. One of these is the lambda experiment already mentioned, another concerns the **decay of the eta meson (neutral) into three pions** (one positive, negative and neutral). If the results of the $K^0(L)$ experiment are due indirectly to a violation of 'C invariance' in the strong interaction, that is to say if the constants in the equation describing an interaction between particles are, after all, not the same as those in the equation describing the interaction of the corresponding antiparticles, then this violation should show in an even more pronounced way in the eta decay.

An experiment is being prepared in the m_{4a} beam line, a new ending to the old m_4 beam, by members of the CERN/E.T.H. group, who will again be using their spark chamber operating in a magnetic field.

High-intensity beam

For the first time, an external proton beam has been brought into an experimental hall and the h_3 beam line stretches right across the South hall to the muon storage ring in the far west corner. Because this is a primary proton beam instead of a beam of secondary particles, the intensity is very much higher than in any other beam ever used outside the accelerator tunnel; even with only one bunch out of twenty being ejected at each synchrotron pulse, the number of particles in the burst is about 1000 times higher. The problem of confining the secondary radiation from the beam, particularly neutrons, has thus been of a completely different order to usual.

At the end of the line the protons strike a target inside the **muon storage ring,** producing pions which decay to

Continued on p. 136

The PS shut-down, and afterwards

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Installation of one of the 'bump coils' added to eight of the PS magnets during the shut-down, in preparation for the planned beam ejection from straight-section 74, intended for neutrino experiments. The coil fits round the yoke of the magnet and the bundle of conductors (here 16 pieces, each of 150 mm² cross-section, 11 metres long) had to be eased inside, between the yoke and the screw-jacks separating the main coils, without damaging the insulation of either the new or existing coils.

Although the installation of the ejected-beam system for the East hall and the major changes in beam layout have already been mentioned in these columns, much of the work carried out during the intensely busy period of the PS shut-down has not been discussed. Indeed, much of it, as usual, consisted of more or less routine checking, maintenance and repair work which, although vital to the efficient running of the accelerator, is difficult to describe effectively in a report such as this. All we can do here, in fact, is to pick out a few of the more typical jobs by way of example, whilst remarking that the schedule of work to be done contained 271 separate items under 24 different headings.

Because the new resonant ejection system for the proton beam in the East area is so closely integrated with the operation of the synchrotron as a whole, its installation required work on many different parts of the machine. For example, in order to accomodate the 'bump' in the proton orbit that causes some of the protons in each revolution of the beam to enter the septum magnet and be ejected, wider vacuum chambers had to be made and inserted not only for straight-section 58, which contains the ejection magnet, but also in the two preceding and the two following PS magnets. A wider pick-up station was also necessary in straight-section 57. Installation of these items meant dismantling the whole of that part of the vacuum system, together with its pumping units, magnet connexions and so on. Again, two pairs of magnets had to be interchanged (58 and 59 with 82 and 83) to enable the beam to be ejected from this point. Then special 'shims' had to be fixed to the new magnet 58, together with a shielding pipe on magnet 59, to reduce the effect of their field on the emerging proton beam.

In the North hall, two bubble-chamber beams now originate in the same target. Among the changes that had to be carried out in order to make this possible, the rapid beam deflector (RBD) (which produces a short burst of primary protons on the target) had to be moved from straight-section 51 to straight-section 41, the acceleration unit in the latter being moved to the former position. A new vacuum chamber was also necessary in section 6, from where the beams begin. Among other work carried out on target chambers and the vacuum system, the large tank in section no. 1 was taken out and given a thorough overhaul, and the old slow-ejection magnet, used for the initial tests on the resonant system two years ago, was removed.

The new chamber no. 6, tank no. 1 and chamber no. 64, as well as those for the new ejection system, were all equipped with quick-release vacuum joints, instead of the old joints with many nuts and bolts. With these new joints, units can be removed and replaced in a very much shorter time than previously. This has obvious operating advantages, but the most important result is to reduce the radiation dose during such changes. Until recently the dose to any one person from the residual radioactivity of the accelerator has been kept down by employing many people on the shut-down work, and by waiting a sufficiently long time before starting some jobs. With increases in the local radiation intensity, however, and the introduction of more complex systems, such as the new ejection equipment, which might need to be attended to during operating time as well as in the shut-down periods, this solution has become less and less practicable. In fact, the quick-release joints form part of a general programme of similar changes which also includes a new type of quick-release bellows unit (needing 3 minutes instead of 30 for its installation) for the vacuum system and the use of plugs and sockets instead of permanent wiring for the electrical connexions to pump units, vacuum valves, target installations and similar equipment.

In the experimental halls, the beam lines c_8, o_2, k_4, b_7 and d_{21} were all dismantled and the new ones e_2, u_1, o_8, d_{22}, b_8, b_9 (East hall), m_5, k_5 (North hall), h_3 and b_{10} (South hall) put into place*. As usual, for each beam line the necessary magnets (bending and quadrupole) had to be put accurately in position, electrical and water supplies connected, collimators installed, sometimes with remote controls for adjustment; in some lines, electrostatic or radiofrequency separators, with all their power supplies and controls, were included. Radiation and hydrogen security and alarm systems had to be installed and tested, a new blockhouse had to be constructed from concrete blocks, and beams for the heavy-liquid bubble chamber. Each beam line and experimental area needed appropriate concrete shielding walls, with electrically interlocked doors and television viewing systems. The experimental equipment, often heavy and usually needing very accurate alignment, had to be put in place, with electrical supplies, intercommunication systems, and racks of electronic apparatus. And so on... Although much of this work goes on continuously round the year, the unusually large number of changes made during this shut-down resulted in a particularly strenuous time for those concerned.

Another change worth mentioning is the demolition of the partition wall near the far end of the South hall, originally put up in 1960 to separate the bubble-chamber operations from other experiments. The muon storage ring occupies the space once used by the 81-cm bubble chamber in its first experiments at CERN and the hall is now open (above the parallel lines of concrete blocks marking the path of the h_3 beam line) right to the end. The 10-ton and 20-ton cranes formerly spanning the walled-off section have also gone and the main South hall cranes now operate over essentially the whole length.

To be continued.

* At the beginning of September the e_2 and u_1 lines had not been finally completed.

Bad Kreuznach, 1-15 April, 1965

1965 Easter School for Physicists using the CERN Proton Synchrotron and Synchro-cyclotron

reviewed by **D. M. HARMSEN,** Deutsches Elektronen-Synchrotron (DESY), Hamburg *

Looking back on the successful course of the latest CERN Easter School, held at Bad Kreuznach, Germany, during the first fortnight of April this year, one is prompted to present the history of this school as an example of a fruitful idea.

The first CERN Easter School was held at St. Cergue, in the Swiss Jura, under the auspices of the CERN Emulsion Experiments Committee in April 1962 (see *CERN COURIER* vol. 2, no. 5, p. 10, May 1962). The main aim was to instruct young physicists who used nuclear emulsions as an experimental tool in all the different aspects of emulsion work, particularly in that of emulsion experiments carried out in conjunction with the particle accelerators at CERN. The first school was so successful that another one was arranged, also at St. Cergue, in March the following year. In the second school, which was again organized for young emulsion physicists by the CERN Emulsion Experiments Committee, the main emphasis was laid on more general problems of high-energy physics (see *CERN COURIER* vol. 3, p. 67, May 1963).

The third Easter School took place in May 1964 at Herzeg Novi, a small town on the Montenegrin coast, by invitation of the Yugoslav Federal Nuclear Energy Commission (see *CERN COURIER* vol. 4, p. 156, Nov. 1964). It was organized under the joint auspices of CERN and the Yugoslav Federal Nuclear Energy Commission. Since the programme dealt again mainly with the wider problems of high-energy physics, there was no reason to limit the participation to emulsion physicists and an invitation was made also to those working with bubble-chamber films.

This year's school was organized by CERN in collaboration with high-energy physicists in Germany, and it was decided to allow attendance at the school to all postgraduate students doing research in high-energy physics, independent of the techniques they used, that is, nuclear emulsions, bubble chambers, spark chambers, or counters.

The only restrictions for acceptance were that the student should have done at least one year's postgraduate research work and that he should not be more than 30 years old. From 156 applicants, all fulfilling these conditions, 91 students were selected, and finally some 84 students, of 21 different nationalities, were present. They came from 49 laboratories in 17 countries. The largest contingent came from the Federal Republic of Germany, as the host country, followed by those from the United Kingdom and France. The number of participants was restricted to about 90 so that all the students and lecturers could be housed under the same roof, greatly facilitating discussions among the students themselves and between students and speakers.

At the School, two lectures were given each morning ; in general, the afternoons were left free until five o'clock, when the seminars, which continued until dinner time, began. On three days also, evening seminars were given by prominent physicists on subjects of their own choosing. The morning lectures were devoted to current theoretical ideas in high-energy physics, whilst in the late-afternoon seminars many of the experiments in progress at CERN and elsewhere were discussed by the physicists involved.

Morning lectures

Prof. L. Van Hove (CERN) gave a series of six lectures on symmetries in strong-interaction physics, related mainly to the symmetry groups SU_3 and non-relativistic SU_6. He presented the methods used in formulating and calculating the symmetry properties and illustrated them by their most significant predictions : mass formulae, magnetic moments of baryons and meson-baryon interactions.

The three lectures of Prof. P. Beckmann (Mainz) dealt with the electromagnetic form factors of nucleons — mathematical terms that describe the structure of the nucleon arising from its coupling to pions and other strongly interacting particles. The lectures were concentrated on those aspects that arise in the interpretation

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After-seminar discussion : (l. to r.) Prof. W. Jentschke, Prof. M. W. Teucher, Dr. K. Winter, and one whose name we cannot trace.

* Now at The Enrico Fermi Institute for Nuclear Studies, University of Chicago, U.S.A.

Group photograph, taken in the grounds of the Kurhaus Hotel, 11 April 1965.

of electron-proton scattering experiments at large momentum transfers.

Prof. H. Rollnik (Bonn) discussed photo-production processes in three lectures. The aim of these was to explain what the investigation of photo-production processes can teach us about the structure of strongly interacting particles.

An excellent guide to the understanding of weak-interaction theory was given by Dr. M. Veltman (CERN) in his course. The six lectures were mainly devoted to K-meson physics and contained a discussion of the problems raised by the discovery that the neutral K-meson known as K^0_2 can decay into two pions. Since this decay mode violates one of the symmetry laws, previously thought to be invariant in nature (the so-called symmetry law of CP invariance), many new hypotheses and ideas have been developed to explain the experimental fact.

Afternoon seminars

In the programme of afternoon seminars, Dr. R.D. Tripp (CERN) gave an informative review of the determination of the spin and parity of resonances (sub-nuclear structures with very short lifetime). Dr. H. Pilkuhn (CERN, now Lund) dealt with the peripheral model, which describes some of the production processes of resonances, and Dr. N. Schmitz (Max Planck Institute, Munich) discussed the experimental data on peripheral collisions. Prof. G. Höhler (Karlsruhe) lectured on photo-production processes and Dr. U. Meyer-Berkhout (Hamburg) reviewed the measurements of electromagnetic form factors. In relation to the latter, Dr. A. Zichichi (CERN) gave a very instructive seminar on the Papep and Paplep experiments (**P**roton + **a**nti**p**roton → **e**lectron **p**air and **P**roton + **a**nti**p**roton → **lep**ton **p**air) carried out at CERN.

Dr. D.H. Perkins (Bristol, now Oxford) reported on the status and the future programmes of neutrino experiments. Dr. K. Winter (CERN) discussed the problem of CP invariance and, in this connexion, new results on the decay modes of neutral kaons, Dr. A. Wetherell (CERN) covered high-energy elastic scattering, and Dr. C. Rubbia (CERN) reported on the determination of the parity of the xi particle, using a polarized-proton target in a strong magnetic field and spark chambers as particle detectors. Finally Prof. C. O'Ceallaigh (Dublin) dealt with the variation of ionization with the particle velocity, a question which is not yet fully answered in the very high-energy region.

Evening seminars

The first evening seminar was held by Prof. B.P. Gregory, Member of the CERN Directorate and now soon to be Director General. In his report he discussed the plans for new machines — the intersecting storage rings (ISR) at CERN and the 300-GeV proton accelerator somewhere else in Europe —, covering not only the technical and physical problems but also the financial problems that arise in such really big research programmes. It became once again apparent how important are close contact and exchange of ideas between scientists and politicians, for the decision in favour of or against building such new accelerators is a political one reaching far into the future.

In the second evening seminar, Prof. W. Heisenberg (Max Planck Institute, Munich) spoke on the application of Goldstone's theorem to electrodynamics and other problems concerning the spectrum of elementary particles. This remarkable report required a rather high level of theoretical knowledge but it gave a good impression of the new developments and thought concerning the so-called 'universal formula' for explaining elementary particles.

The last evening seminar was held by Prof. R.H. Dalitz (Oxford) who gave an excellent talk on the systematics of the fundamental interactions, covering the current theories of strong, electromagnetic, and weak interactions.

The high quality of the lectures found its counterpart in the enthusiasm and seriousness of the students, and even in the last lecture the same number of students could be seen as in the first. Informal seminars held

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Dr. U. Meyer-Berkhout (Hamburg),
Prof. L. Van Hove (CERN),
Miss E.W.D. Steel (CERN), Secretary.

by Prof. Van Hove or Dr. Veltman during free afternoons or evenings were also well attended. Until late in the night lecturers could be found discussing their subjects, surrounded by a crowd of those eager to learn, whether it was at the blackboard of the auditorium or in one of the jovial wine cellars.

Social events

However, the hard work of lectures was also interspersed with several excursions and visits to factories. There was warm sunshine on the first week-end, when an excursion was made along the river Rhine to St. Goar and the Lorelei rock and back to the lovely surroundings of Bad Kreuznach, to the famous Drosselgasse and very old wine cellars and inns. The second excursion led into other parts of the lovely surroundings of Bad Kreuznach, to the Soonwald and through the Nahe valley.

Some of the participants joined in the visit to the well-known Jenaer Glaswerke, Schott u. Gen., at Mainz, one of the few works manufacturing optical glass. from the raw material for lenses up to big windows for bubble chambers (including those for the 2-m chamber at CERN). Not less interesting was the visit to the optical works of Jos. Schneider & Co., in Bad Kreuznach itself, which manufactures camera lenses in particular.

One of the outstanding social events of the School was the wine-tasting evening, to which the Director and Management of Schneider kindly invited all the participants. Finally, the end of the School was marked by a festive dinner, attended also by Prof. Jentschke, Director of DESY, Hamburg, who brought the proceedings to a close with a humorous after-dinner talk.

This series of CERN Easter Schools will be continued next year, and it has already been agreed that the 1966 School will be held from 5 to 18 June in Noordwijk aan Zee, Netherlands. Apart from the fact that CERN is relieved of a good part of the organizational work, the holding of an Easter School in one of the Member States serves to provide special inspiration and encourages an interest there in the physics of elementary particles ●

Last month at CERN (cont.)

give muons which then perform many revolutions of the ring before they in turn decay. By detecting the decay electrons a measure can be obtained of the precession of the muon spin in the magnetic field of the ring and in this way it is hoped to obtain a new value for the anomalous magnetic moment (g-2) of the muon, an order of magnitude more accurate than the existing one, obtained at CERN in 1962*. This will test still further the region of validity of quantum electrodynamics and perhaps give some clue to the solution of the muon-electron puzzle : why are these two particles apparently identical except for their mass ?

Improved electrostatic separator

In the North hall the **81-cm Saclay/Ecole Polytechnique hydrogen bubble chamber** and the **CERN enlarged heavy-liquid bubble chamber** were occupied until the middle of August with 'technical' runs, during which the new beam lines were also tuned.

The 81-cm chamber is scheduled to take over a million photographs of antiproton, kaon or pion interactions in deuterium, for three different collaborations ; the heavy-liquid chamber will be used for studies of the decay properties of positive kaons in a liquid known as 'genatron'. Two weeks will be devoted to a run for the Rutherford Laboratory, arranged after the breakdown of their synchrotron 'Nimrod'.

* CERN COURIER, vol. 2, no. 4 (April 1962), pp. 3-6.

Included in the m_5 beam feeding the 81-cm chamber is a new 6-m-long **electrostatic separator,** developed in the NPA Division. Instead of having both electrodes of stainless steel, as in previous types, this separator has a negative electrode of aluminium, treated (anodized) to give it a thin surface coating of aluminium oxide*. Initial operating experience has confirmed the earlier laboratory tests and the new separator produces electric fields nearly twice as strong as before: for example, 100-110 kV/cm over a gap of 5 cm has already been held for long periods, and even higher fields have been achieved under favourable conditions.

Technical run of British bubble chamber

In the East hall, apart from the K^0 experiments, only the d_{22} and o_8 beam lines had been finished and tested up to the middle of August. In the former, two experiments are to be carried out : one on the **charge exchange** of pions, using the **polarized-proton target,** the other on the **decays of resonances by electromagnetic interaction.** The o_8 beam line is for the **CERN 2-m bubble chamber.**

Soon after the PS began operation again, the d_{22} beam line (extended as d_{22b}) was used to give particles for a 'technical' run of the **152-cm British National Hydrogen Bubble Chamber.** This was mainly to test the feasibility of converting to a 'Scotchlite' retro-directive illumination system, which would enable the fiducial volume to be almost doubled.

* Report CERN 64-50.

Initially the tests were rather disappointing. The vapour-phase expansion system of this chamber results in liquid conditions under which very small bubbles are produced and it was found that a high-contrast (and therefore slow) film was required to photograph the tracks. With the small lens aperture required to give adequate depth of focus there was then insufficient light available, from the point source used, to give acceptable picture quality. However, better results were obtained later by changing the operating conditions of the chamber, and with different light sources it would seem feasible to adopt an illumination system of this kind in some circumstances.

This was the final run of the bubble chamber at CERN. The magnet, in fact, had already left for England and dismantling and shipment of the rest was begun soon afterwards. The last item to leave will be the vacuum chamber itself, expected to travel by road to the Rutherford Laboratory about the end of September. By then most of the physicists, engineers and technicians who have been with the chamber at CERN for the past 2 ½ years will also have returned. After re-assembly next year, the bubble chamber will be used in experiments at the 7-GeV accelerator 'Nimrod' of the Rutherford Laboratory ●

BOOKS

Gravity, by George Gamow (London, Heinemann Educational Books Ltd.*, 1962 ; 5 s.), is number 17 in the *Science Study Series* originated by the Physical Science Study Committee in the U.S.A. and published under the auspices of Educational Services Incorporated. The series aims to give students and the general public 'the writing of distinguished authors on the most stirring and fundamental topics of science, from the smallest known particles to the whole universe'. The primary purpose is to provide a survey of each particular topic within the grasp of this class of reader, although it is also hoped that the books will serve as an encouragement for their further investigation of natural phenomena.

This volume is written (and illustrated !) by a theoretical physicist who is one of the foremost interpreters of science to the layman, creater of the famous Mr. Tomkins a quarter of a century ago. As might be expected, it is clearly written, interesting, and instructive. Dealing with a subject that is more 'fundamental' than 'stirring', at least at the present time, it should nonetheless encourage many readers to search for further information, whether it be of a historical or a scientific nature.

The story in fact follows historical progress in explaining the current theoretical ideas on the nature of gravity, dealing, as Gamow says, with the three great names in the history of man's understanding of gravity : Galileo Galilei, Isaac Newton, and Albert Einstein. Six of the book's ten chapters deal with the Newtonian theory of universal gravitation, since this must remain the basis of any modern refinement.

In discussing Galileo's experiments on falling bodies and his formulation of the mathematical relations describing free fall, the ideas of vectors and vector addition are easily introduced, and this leads naturally to Newton's reasoning that a body moving fast enough above the earth would never fall to the ground but continuously circle around our spherical planet like the moon (or a modern satellite). The logical development from these first thoughts to the theory of universal gravitation — that there is an attractive force between any two bodies proportional to the product of their masses and inversely proportional to the square of their distance apart — is then followed through, after which there is a pause of one chapter whilst the basic principles of the infinitesimal calculus are explained.

One of the interesting things about Newton's theory is that its publication was held back for some twenty years whilst its author developed the mathematical methods necessary for its proper formulation. The differential and integral calculus that resulted is now an essential part of physics, and Gamow makes no excuses for including a discussion of it in this book. 'Those who are frightened by mathematical formulas can skip that chapter', he says, 'but if you want to learn physics, *please do try* to understand Chapter 3.'

Succeeding chapters deal expertly with Newton's proof of Kepler's laws, the phenomenon of precession, and the cause of the tides. In the latter case, one is reminded that tidal friction gradually slows down the earth's rotation (so that a day is now 0.0007 second longer than it was century ago and the century 14 seconds longer than it would otherwise have been) and that the conservation of angular momentum in consequence pushes the moon into orbits of steadily increasing radius.

Some of the triumphs of celestial mechanics are then recounted — the prediction of the planet Uranus and later of Pluto, the calculation of the dates of eclipses (as a result of which it appears that this year is in fact AD 1969 !), and the perturbations of the earth's orbit responsible for the ice ages and other changes of climate over the millenia. A chapter on rockets and space ships concludes this section on the classical theory.

The advance made by Einstein, which even after half a century still seems to have many conceptual difficulties for the layman, is well explained in this book. The equivalence principle, that there is no essential difference between the gravitational field and any other accelerated system, here seems almost obvious ; the bending of light rays in a gravitational field follows naturally and a brief mention of non-Euclidian geometry serves to introduce the notion of the curvature of space-time produced by material bodies. Gravity is still far from being explained, but we are one step further from 'the action at a distance' of Newton's day.

The concluding chapter deals with some unsolved problems of gravity, including the fundamental one of the relationship between gravity and the forces of electromagnetism and the fundamental particles. An interesting speculation, which seems to have disappeared from the discussions surrounding the neutrino experiments of the last few years, is that there may be some connexion between the neutrino and the graviton (the 'particle' of the quantized gravitational field).

Finally, lovers of science-fiction will be disappointed to learn that gravitational shielding would depend on the existence of 'antigravity', of particles with gravitational repulsion instead of attraction, which would be contrary to the equivalence principle. It is perhaps worth recalling here that Gamow's speculation on the possible (if improbable) possession of antigravity by antiparticles has since been disproved experimentally and the equivalence principle itself has been confirmed to an extremely high order of accuracy by the recent CERN experiment on K^0_2 decay.

A.G.H.

Plasma kinetic theory, by D. C. Montgomery and D. A. Tidman (New York, McGraw-Hill Book Co., 1964; $11.50).

The authors of this book have set out to describe the present state of the theory of plasmas and especially of the kinetic theory. Their intention was to present and discuss the latter on the basis of the phenomena known when the book was published (1964), without, however, hazarding too many explanations. It can be said at once that the book clearly describes the principles of plasma kinetic theory, but it is not for the reader who wants to gain a grasp of the subject in a short time: the reader is expected to have considerable mathematical knowledge concerning the

* By arrangement with Doubleday and Co. Inc., New York, who distribute this book on the continent of Europe as well as in the U.S.A.

mechanics of fluids, electromagnetic theory and statistical mechanics.

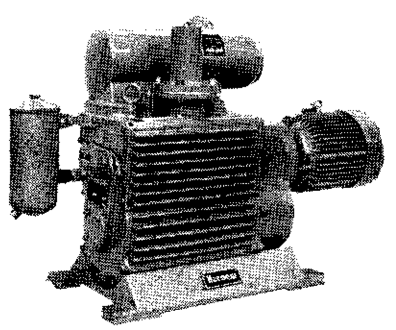
In the first part, the authors recall the fundamentals of classical kinetic theory for a system of particles interacting through short-range forces. This is the case for molecular gases, to which the Boltzmann transport equation applies. However, this theory is incapable of describing the behaviour of charged particles interacting through long-range forces, such as Coulomb forces. More specifically, although it is possible to envisage a model of a molecular gas in which two particles interact for an infinitely short period of time, because molecular forces vary as $1/r^6$, such a model is no longer possible in a plasma, where the Coulomb forces vary as $1/r^2$.

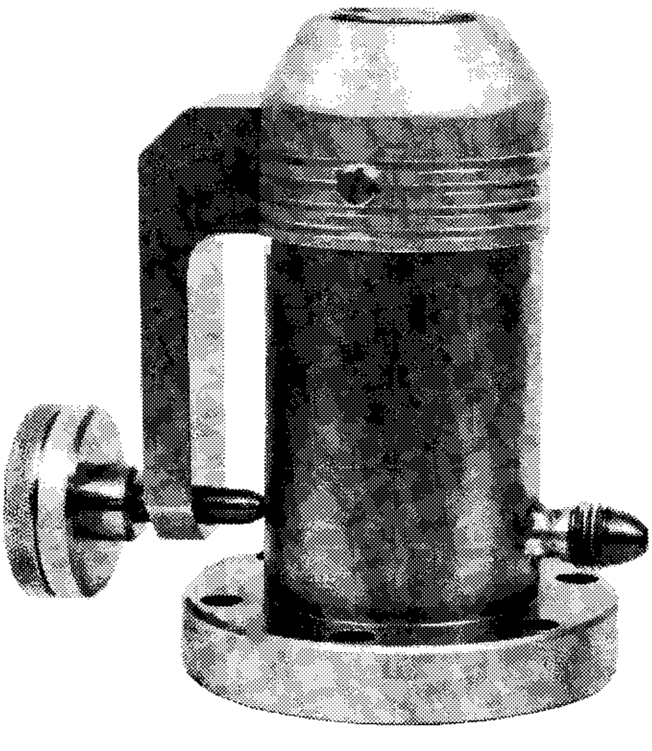
In the second part of the book the authors describe the so-called BBGKY theory, which is the most systematic and the most powerful of the theories of statistical mechanics. It is applied to a single-component plasma, to provide a description, among other things, of its fluctuations and of the adiabatic hypothesis.

The third part of the book deals with more specific problems involving a larger variety of physical phenomena and plasmas more complex than the single-component one: plasmas in magnetic fields, 'hot' plasmas, electromagnetic radiation, etc. However, this third part, which is written from a different point of view, cannot be read on its own.

In conclusion, this book can be said to give a clear account of plasma kinetic theory, but it is not an introduction to plasmas and should not be the first book to be read on this subject.

D. Leroy





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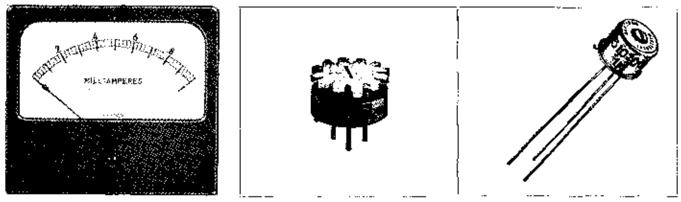

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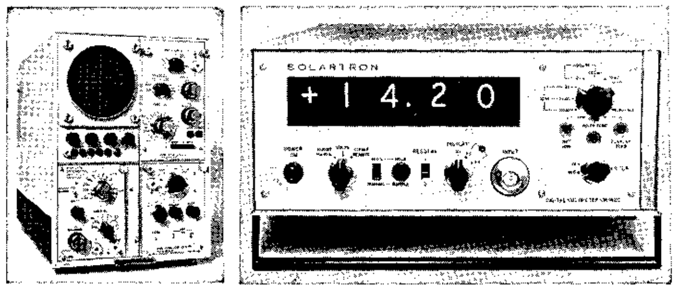

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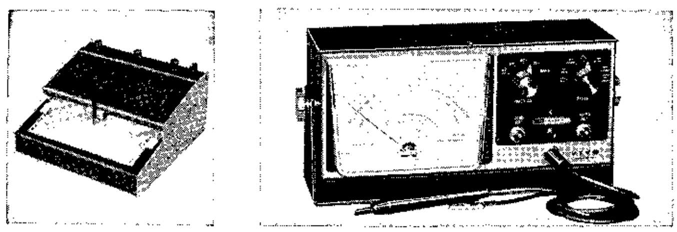

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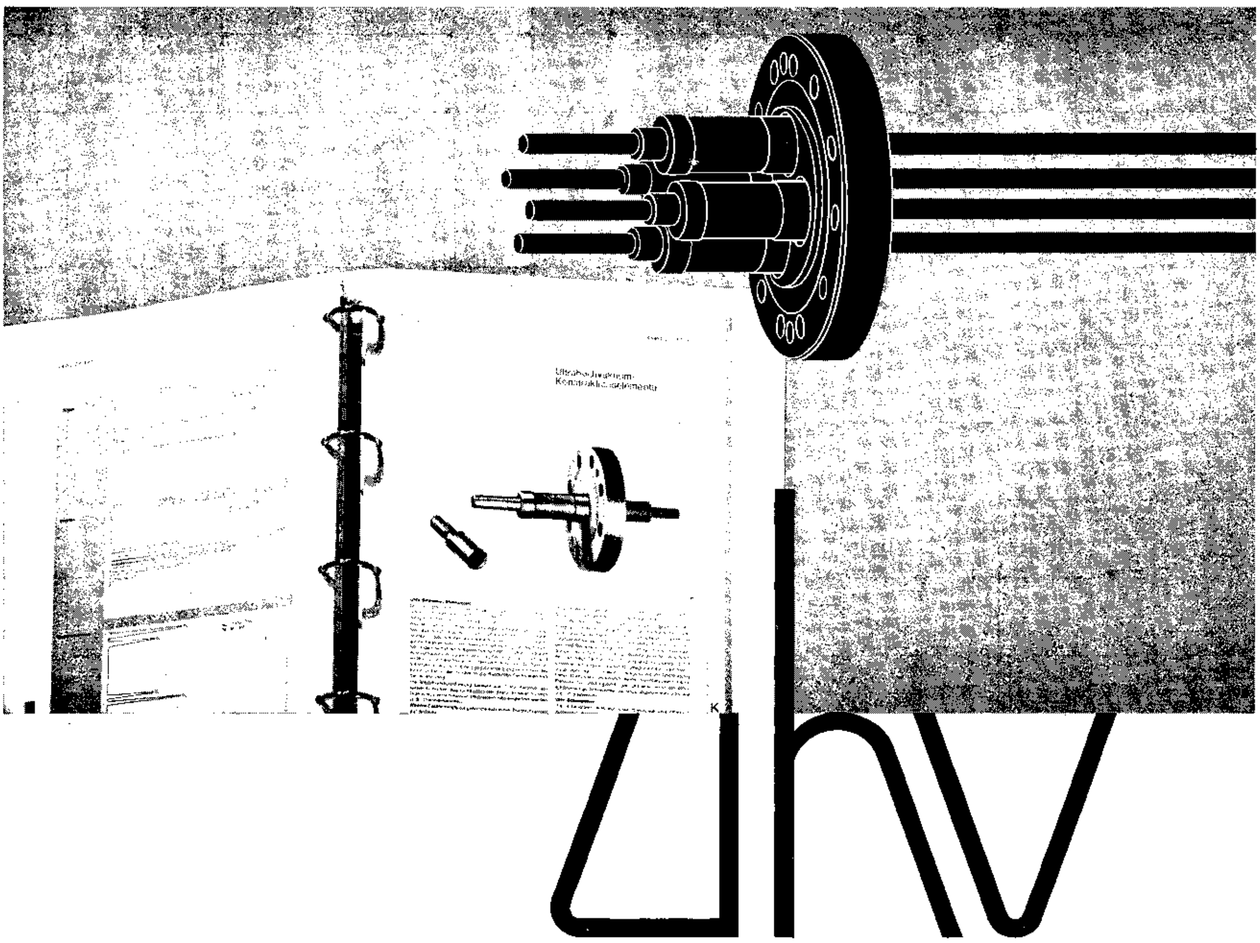

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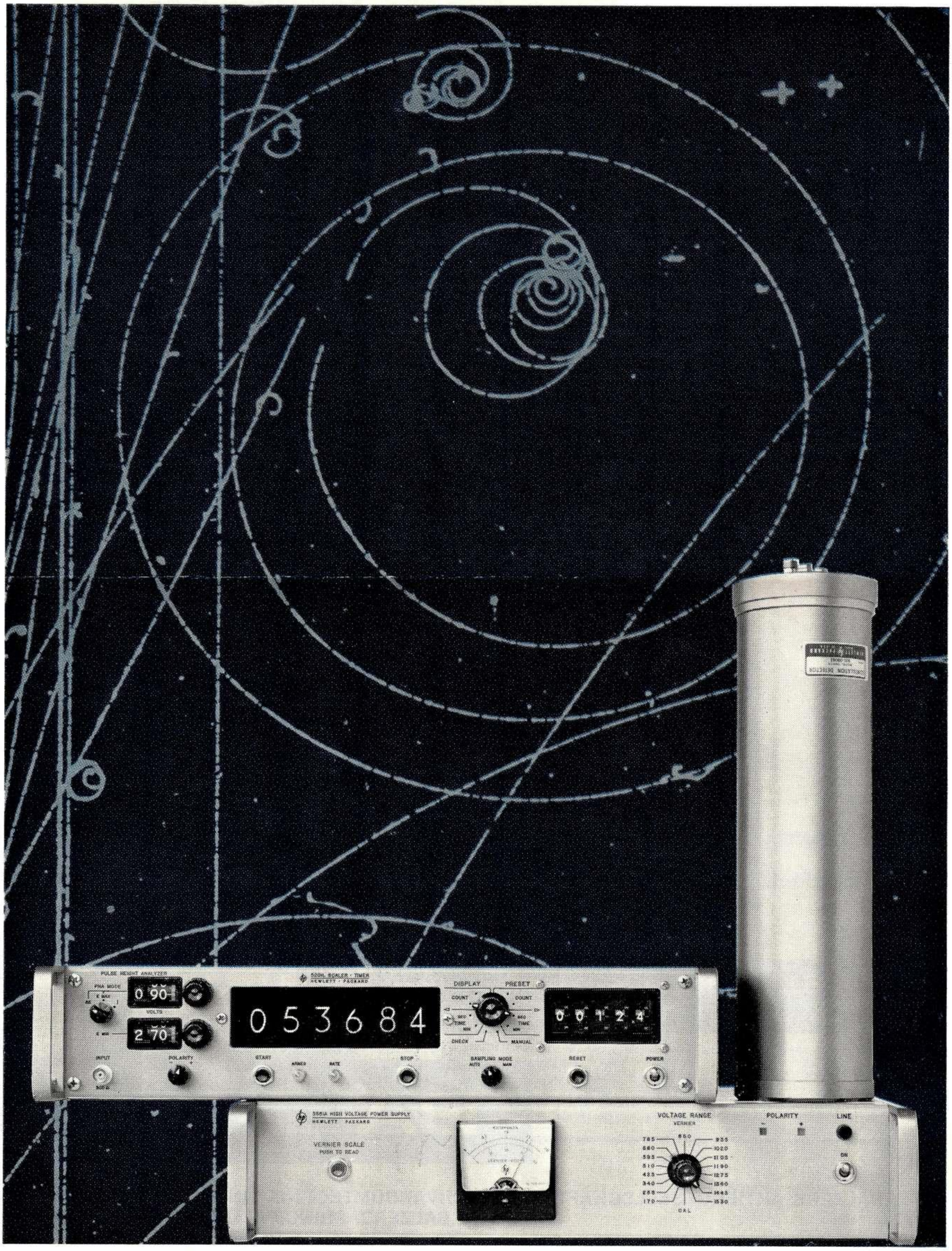

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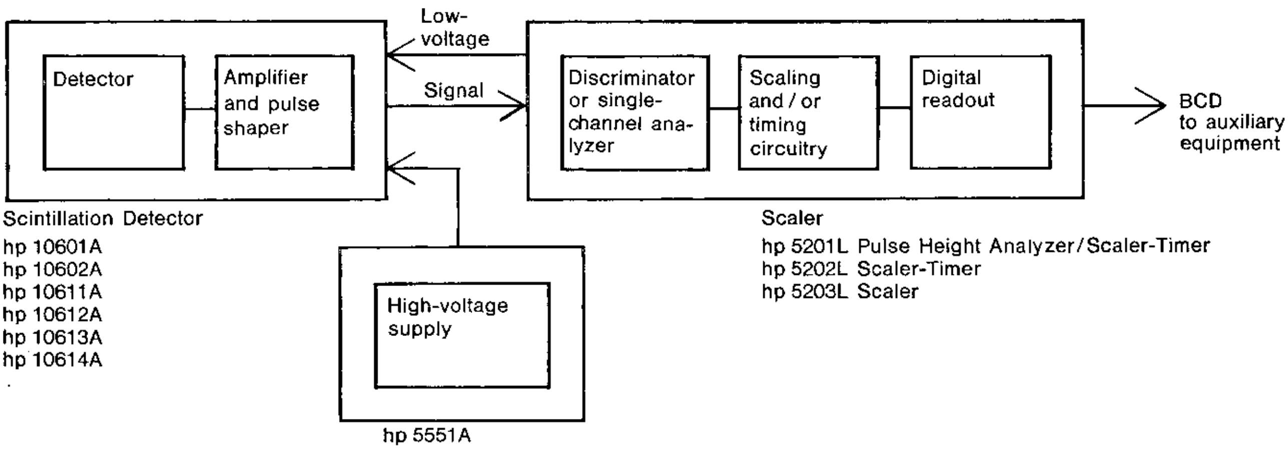

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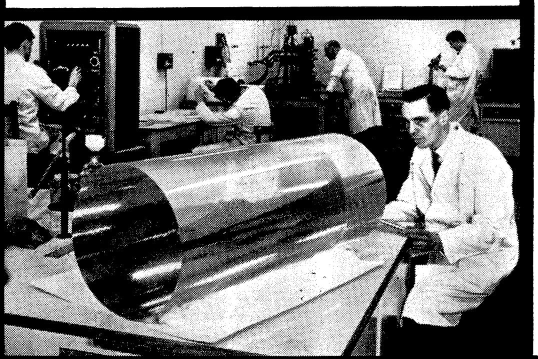

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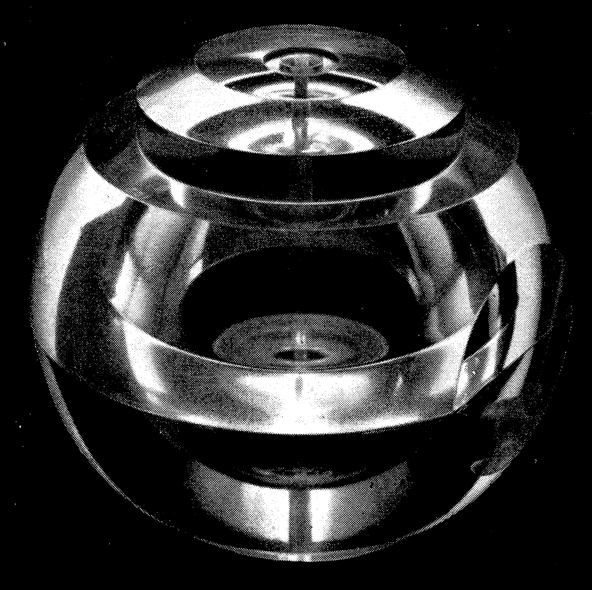

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