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The cover photograph shows two members of the Survey Group of CERN's AR Division, D. Bois (left) and A. Gressot, checking the position of one of the proton-synchrotron magnets. They are using an instrument invented by the Group and perfected over the last few years to the extent that the 100 magnets of the accelerator can now be surveyed, with a precision of better than a tenth of a millimetre, by three men in only two days. The conventional method previously used occupied four men for eight days.

Named 'Distinvar', the new apparatus, like the old, employs calibrated wires made of invar, an alloy of iron and nickel with a negligible coefficient of thermal expansion. The wires are of various lengths, corresponding to the nominal distances to be measured; one end is fixed in a 'balance', which serves to define the position of the end and to apply a fixed tension to the wire, the other is fixed to a micrometer screw which is used to measure the precise difference between the length of the wire and the distance being measured. The two end pieces are accurately mounted in special sockets, in the case of the PS one in the concrete survey pillar and the other on the magnet. Calibration of the wires is carried out on a comparator – constructed by the Société Genevoise d'Instruments de Physique and installed in one of the PS radial tunnels – which is regarded as the most up-to-date in the world.

The Distinvar, which has many possible applications outside the field of accelerator technology, has been described by the Leader of the Survey Group, J. Gervaise, in CERN reports 64-16 (French) and 64-39 (English).

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The European Organization for Nuclear Research, more commonly known as **CERN** (from the initials of the French title of 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 th 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 2000 people.

In addition to the scientists on the staff, there are nearly 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 fro other countries.

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

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

Poland, Turkey and Yugoslavia have the status of Observers.

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 eleven states, covers design work on two possible future European projects in high-energy physics – intersecting storage rings for the 28-GeV accelerator at Meyrin and a 300-GeV accelerator to be built elsewhere ●

Last month at CERN

29th Session of Council

Delegates from the thirteen Member States of CERN met on 25 March for the 29th Session of Council, with Mr. J. H. Bannier (Netherlands) presiding.

This was a special meeting originally arranged in the hope that a decision could be made on the project for intersecting storage rings. In the event, this decision was not possible, but the meeting provided the occasion for a review of progress on the whole European future programme and of how it fitted in with similar ideas in other parts of the world, particularly with the comprehensive programme presented to Congress in the U.S.A.

Further details of this meeting are given on pp. 69-71 of this issue.

PS experiments in March

During the first period of March, the proton synchrotron was used mainly for counter experiments, although in the second week the 81-cm bubble chamber was also in use in the k_4 beam of the North hall. The accelerator was operated to give protons with a momentum of 19.2 GeV/c, with a target programme including a 300-millisecond 'long burst' on target no. 1 and a repetition rate of one pulse every 2.3 seconds.

Among the counter experiments, the **missing-mass spectrometer,** radically redesigned and incorporating many new components (including scintillation counters such as that illustrated in last month's issue) was used in an investigation of mesons with isotopic spin 1 and mass between 600 and 1100 MeV/c^2. The **CERN/Ivry group** took another 100 000 spark-chamber photographs, and in the **proton scattering experiment,** with sonic spark chambers and an on-line computer, 90 000 events were registered of scattering from lead and 68 000 of scattering from copper.

Continuing their investigation of antiproton-proton annihilation, the **Paplep group** obtained another 35 000 spark-chamber photographs. After news had been received of the observation in America of the antideuteron, they also spent a few hours investigating the occurrence of this 'antinucleus' in their m_4 beam. About 100 were detected, indicating a proportion of 1 antideuteron for every six thousand million negative pions.

As mentioned in last month's *CERN COURIER*, the **CERN 2-metre hydrogen bubble chamber** was brought into use during the second half of March, after testing and 'tuning' of the new **o_6 beam line.** Its operation was very satisfactory.

At the same time the **81-cm Saclay/Ecole Polytechnique bubble chamber** took 174 000 photographs of antiprotons stopped in deuterium, after taking 90 000 photographs of antiprotons in hydrogen the week previously. In fact it should be noted, as was announced during the March Council Session, that this chamber has now taken more than **5 million photographs** since it was put into operation at CERN in May 1961. The length of film involved is about 1500 km!

Another new bubble chamber

Effectively a new instrument, the enlarged **CERN heavy-liquid bubble chamber** had its first test runs during February. Studies of its operating characteristics were carried out during March and will be continued until the proposed antineutrino run in May. This chamber, which is normally filled with 1180 litres of freon, is at present the largest in the world, in terms of visible volume of liquid.

Also in preparation for the antineutrino run, the PS operators have been gaining experience in handling the fast-ejection system, which they are taking over from the designers in the NPA Division who have been operating it since its installation.

TV beam watching

External proton beams are, in fact, much in evidence in the work of the PS Division and a great deal is being done in preparation for the installation of the first ejection system and proton beam line in the East area.

Particularly in the early stages of testing and operation, it will be necessary to observe the path of the external beam in order to facilitate correct adjustment. Both for ease of operation and because of radiation hazards, this observation will be made with the aid of a number of remotely controlled television cameras. This, of course, is not a new technique at CERN, but a completely new viewing system, of commercial manufacture apart from some of the switching systems, is being installed for the purpose. In the first half of March this system was subjected to a life test, to see how it would operate during the whole eleven days' running period of the accelerator.

Although the proton beam itself is quite invisible, its path will be shown by placing fluorescent screens in suitable positions, each screen lighting up where the particles pass through it, to give an indication of the position and 'shape' of the beam. This technique, the oldest known method of particle detection, has been allied to one of the newest 'industrial' TV systems to enable all the fluorescent screens to be viewed in the PS main control room.

One camera will look at the septum magnet that ejects the protons from the accelerator, two more will look at screens in the path of the beam, and a fourth will observe the external target at the end of the beam line. At present, arrangements are being made to view the beam ejected from section no. 58 of the synchrotron, but a similar system will be used for the later beam starting from section 62.

The television cameras are of particular interest, because of their small size and remote-control facilities. They are of a type that was developed for use inside nuclear reactors and other inaccessible places and have the advantage for CERN use that even the pre-amplifiers, as well as the other electronic components, can be placed away from the areas of high radiation intensity. The camera tube itself is shielded to some extent against radiation and the unit looks something like a small telescope, 7.6 cm in diameter, 32 cm long and weighing 3.2 kg.

In the PS East area, only the cameras will be inside the synchrotron tunnel, the pre-amplifiers and camera-control units being outside in the so-called East-ejection building. Two television monitors with 20-cm screens will be installed in the main control room, with means for selecting the view shown by any one of the cameras. The sensitivity of the cameras is such that pictures of normal contrast can be obtained with an illumination of only 10 lux — about the same as that of a reasonably well-lit street at night.

Again intended primarily for the new ejection system, though it also has more general uses, an instrument has been designed by the PS Radio-frequency Group to enable electronic measurements to be made at precisely determined times in the PS cycle. Called a **cascade counter,** it has two inputs, the first of which is connected to the standard timing pulses of the PS and the second to pulses controlled by the signal to be measured. Counting begins automatically after a certain number of pulses have entered the first input, the number being preset to give the required time delay between the start of the whole operation and the taking of any particular measurement.

Nuclear-structure experiment at the SC

As described in last month's issue, the installation of the new slow-ejection equipment in the synchro-cyclotron created some difficulties, but the first week of tests after putting the accelerator back into operation showed that it had been worth while. Overall beam intensities up to 60% of that of the fast-ejected beam were obtained, with a duty cycle of 30%; that is protons were available in the external beam for a third of each machine cycle. The new inflector magnet for the muon channel was also tested during this time and shown to provide many possibilities for new beams.

One of the experiments resumed during March was that in which 'muonic x-rays' are studied in order to gain information on the structure of various nuclei. In this experiment, negative muons (produced by the SC muon channel) are slowed down in a target consisting of the materiel to be investigated, say tungsten. When the muon is nearly at rest it comes under the influence of a tungsten nucleus and orbits around it in much the same way as an ordinary atomic electron. From the outer orbit it drops down into successively lower orbits until finally it either decays or is captured into the nucleus. As the muon changes from one orbit to another it emits radiation, in exactly the same way as an electron dropping from orbit to orbit in an excited atom. The energy of each quantum of radiation is equal to the energy difference between the two orbits, and in the case of the muon these energies are in the range of about 1 to 6 MeV. The various energies of these x-rays are characteristic of the atoms in the target (analogous to the optical line spectra in the case of electrons), and since the muon orbits lie much closer to the nucleus, or sometimes even in the nucleus, the energies of the x-rays are very sensitive to the distribution of the nuclear electric charge. Study of the x-ray spectra thus gives information firstly on the charge distribution of spherical nuclei, which is expressed as a nuclear radius and a 'skin thickness' (the way in which the charge decreases at the edge of the nucleus), and secondly on any quadrupole (that is, non-spherical) structure of the nucleus.

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The spreading of the laboratory atmosphere into more traditional fields is exemplified by this photograph, which shows part of the computer installation in CERN's Finance Division. This computer is used primarily for all accounting concerned with salaries, but can also deal with stock records and the compilation of statistics and general accounting work. Information is fed into the computer by means of punched paper tape and the results of the calculations are printed automatically on each person's account sheet, which appears in the central console. Mrs. L. Oldrati is at the console in the photograph. The account sheets also have magnetic tracks and the information they hold can be extracted by the account reader, seen in the cabinet behind E. Luchmann.

Precise measurement of the x-ray energies is very difficult, requiring a sensitive, energy-dependent, stable detector together with extreme stability in the associated electronic equipment. In the experiment at CERN, carried out by a group comprising CERN physicists and those of a Dutch visiting team, a new technique, only recently developed, is being used, in which the detector is a lithium-drifted germanium crystal. This kind of crystal, in the same 'family' as crystal diodes and transistors, consists of germanium in which a precisely controlled amount of lithium has been introduced in a particular manner. It is an extremely sensitive x-ray detector, giving much higher energy resolution than previously possible (only about 3 eV is needed to produce an electron/hole pair in the crystal, compared to about 300 eV for each photoelectron in a sodiumiodide/photomultiplier combination), but requires great skill in its production.

The results of measurements obtained between October 1964 and January 1965, on nuclei of gold, lead, bismuth, tungsten and uranium, were published last February*. The run now in progress is being carried out with a new, larger detector (2.5 cm square and 6 mm thick), produced especially for this purpose in the

Continued on p. 74

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* H.L. Acker, G. Backenstoss, C. Daum, J.C. Sens, S.A. de Wit : Measurements and analysis of muonic x-ray spectra in the spherical nuclei Au, Pb and Bi and the deformed nuclei W and U, Physics Letters, vol. 14, pp. 317-320, 15 February 1965.

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29th Session of CERN Council

The CERN Council held its 29th Session on Thursday 25 March, under its President, Mr. J. H. Bannier, of the Netherlands.

This was a special meeting, between the normal Sessions in December and June, arranged to review progress on the future plans for high-energy physics in Europe and with the particular hope that a decision could be made on the construction of the PS storage rings at CERN[*]. Unfortunately, the decision once again had to be postponed, but nevertheless the meeting afforded a useful occasion for a further exchange of views on the wider problem, especially related to the recently published American proposals (outlined on pp. 72-74 of this issue).

January-March at CERN

Conforming to the usual practice, the Session opened (after formal business) with a report to the Council Members, by the Director General, of the most important developments at CERN since they had last met.

Foremost among these was the completion of the first experiment at CERN on the decay of the K^0_2 meson, which had shown that the proposed 'fifth force' could not be invoked to explain the violation in this decay of the hitherto fundamental principle of CP invariance[**]. CERN had found itself in the unique position of having the only high-energy neutral kaon beam in the world and was thus able to be the first to confirm the occurrence of the decay into two pions and to rule out what might have been a simple explanation. Another interesting experimental result showed the existence of a new meson, with a strangeness number of 2, which decays into two kaons. Then, early in March, confirmation had been obtained at CERN of an interesting discovery at Brookhaven, when antideuterons had been detected in the m_4 beam. Although this was not surprising, it was at least satisfactory to know that they existed. So far, only 'antiparticles', corresponding to the normal 'fundamental particles', had been found; now there was experimental proof of the existence of 'antinuclei', in this case the combination of antiproton and antineutron, confirming that the forces between antiparticles were certainly not much different from those between particles.

Among the activities of the theoretical physicists, many new and original contributions had been made at CERN to the various symmetry theories that were being talked and written about, although it was still much too early to come to any conclusions on the final outcome of all this thought.

In December, Prof. Weisskopf said, he had been able to announce the first tests on the CERN 2-metre bubble chamber. Now he could say that it was successfully carrying out physics research, and already it had taken its first 100 000 photographs. The new computer had arrived and was in operation 24-hours a day, though still more for tests than for actual use on physics experiments.

Lastly, the Director General mentioned the neutrino conference held last January[*], from which it had emerged that the CERN experiments, done with the best existing neutrino beam, had more or less exhausted the present possibilities. Even though some of the results had been negative they had helped to establish a definite situation, and it was clear that any major advances would require improved instrumentation.

Expansion of high-energy physics in the U.S.A.

As a prelude to re-opening the discussion on the programme for future high-energy physics research in Europe, Prof. Weisskopf reported to the Council on his participation in the public hearings on the American programme, held by a sub-committee of the Joint Committee on Atomic Energy. Although he had been asked to appear in his capacity as an American citizen

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[*] CERN COURIER, vol. 5, p. 26, February 1965.

[**] See CERN COURIER, vol. 5, pp. 20-21, February 1965.

[*] CERN COURIER, vol. 5, pp. 38-41, March 1965.

and Professor at Massachusetts Institute of Technology, ti was in fact his experience as Director General of a European organization with international contacts that was of interest to the committee, and he had spoken on two topics: 'High-energy physics at CERN and in other non-U.S. Western countries', and 'International co-operation in high-energy physics; possibilities of co-operation in the construction of a multi-hundred BeV (GeV) accelerator'.

Dealing with the American programme, Prof. Weisskopf remarked that the present level of expenditure on high-energy (sub-nuclear) physics in the U.S.A. is about twice that in Europe, and it is proposed to double the annual expenditure there over the next five years. It seems likely that a decision to build the 200-GeV accelerator will be taken before the end of this year, and that it will certainly be a national machine, although a larger one, of some 800 GeV, might be constructed on an international basis.

International co-ordination

At the moment, the possibility of creating organizations on a larger scale than CERN for the construction of new accelerators was still in the future, but this did not mean that there was no co-operation, continued Prof. Weisskopf. In fact, there was already a sort of 'world programme' of accelerators: 70 GeV at Serpukhov (say 1967), 200 GeV in the U.S.A. (1972?), 300 GeV in Europe (1975?) and 800 GeV in the U.S.A. (1980s). This programme had not been worked out in committee but was simply the result of give and take arising from the mutual consideration of other people's programmes.

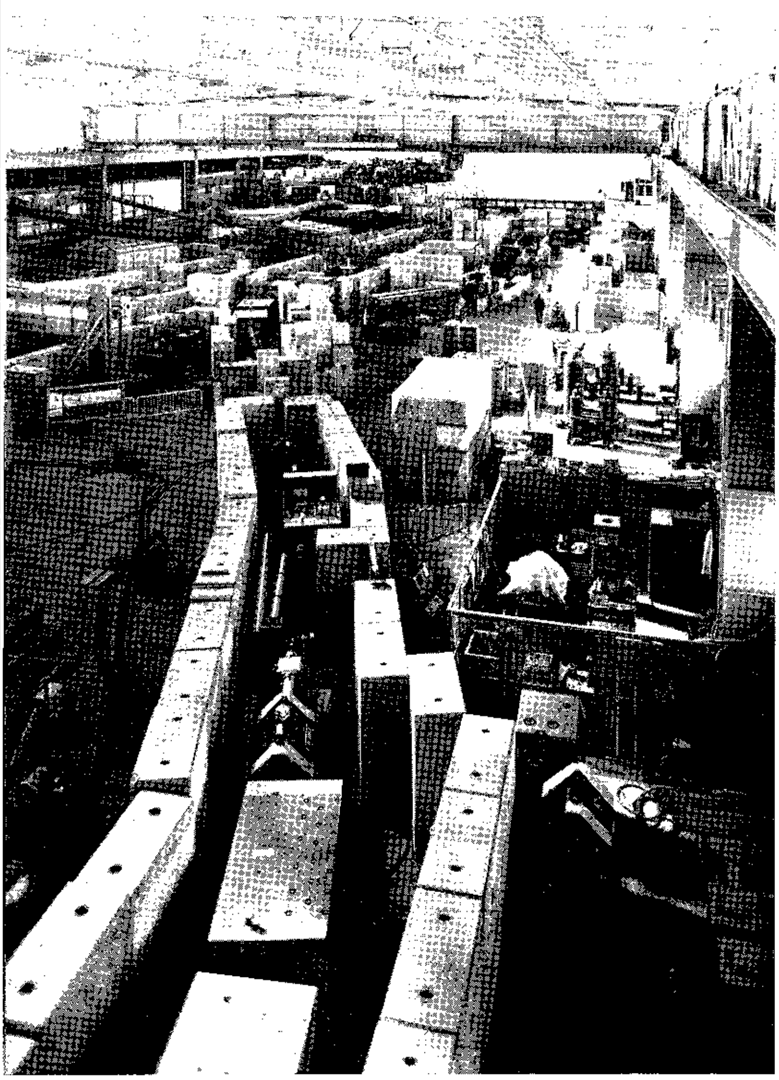
A good example of this kind of procedure was the American decision not to build storage rings at the Brookhaven AGS. This was certainly not because of lack of interest in the type of physics that could be investigated with such apparatus, and in consequence the proposed storage rings (ISR) at CERN acquired added significance. There was also no question that experiments with colliding beams would stimulate the development of new detection techniques, placing Europe in a strong position in a field that was of equal interest for experiments with the larger accelerators.

Already, physicists in the United States had shown themselves interested in participating in some way in the research carried out at the ISR, and CERN was anxious to foster this kind of collaboration. In a similar way, the Russian 70-GeV proton synchrotron at Serpukhov could provide experience for the 200-GeV accelerator in the U.S.A., and both could be of use to the 300-GeV machine in Europe. This idea had, in fact been taken up with the Russians and they were quite enthusiastic about the possibility that instruments from CERN could be taken to Serpukhov when their accelerator is in operation.

S.P.C. confirms its position

Speaking for the Scientific Policy Committee, its chairman, Prof. L. Leprince-Ringuet, reiterated its views on the three-point programme put forward last year. It firmly believed that these plans should be supported and that it was important to come to conclusions about the whole programme as soon as possible, even though construction of the different items would be phased over a relatively long period.

The three main parts of the programme consist of the appropriate development of the present CERN facilities, the construction of intersecting storage rings for the PS, and the building of a 300-GeV synchrotron somewhere in Europe. Basic details of the CERN improvement programme have now been worked out


CERN/PI 87.4.65

As mentioned in Prof. Weisskopf's report to the Council, the CERN 2-m liquid-hydrogen bubble chamber was in operation during March. To bring antiprotons or kaons to the bubble chamber from the target inside the proton synchrotron, the o_2 beam in the East experimental hall was deviated after the electrostatic separators and brought across the hall by means of a new series of bending and focusing magnets. The complete beam line (o_6), enclosed on each side by concrete blocks, can be seen in this photograph.

for the first four years, to include the first phase of the PS improvements aimed at increased intensity, better experimental facilities, some large instrumentation for counter techniques, and the installation of a new heavy-liquid bubble chamber, to be constructed in France. The cost of these developments would be 1, 6, 18 and 30 million Swiss francs, respectively, in the years 1965, 1966, 1967 and 1968. The Scientific Policy Committee, in its statement to the Council, remarked that this expenditure was modest compared with that on similar developments proposed in the U.S.A. However, it represented capital expenditure, which was in addition to the normal running costs of the laboratory and should be taken into account appropriately in considering the budgets for 1967 and 1968, still to be determined.

On the question of the storage rings, Prof. Leprince-Ringuet underlined the fact that, apart from their intrinsic value, they provided an important element for wider co-operation among the world's high-energy physicists. The site was already chosen and in order to secure maximum benefits from the machine it should be built as soon as possible. The decision to undertake construction should thus be taken in 1965.

During discussion on the storage-ring project it was announced that Italy was after all able to participate in the supplementary programme (design studies for the storage rings and the 300-GeV accelerator) this year and was also in favour of the ISR project as such. A number of other Delegates also indicated that their countries were in favour of constructing the storage rings, adding to those who had announced this at the December Session. Of the major financial contributors to CERN, only the United Kingdom had still to come to a positive decision. As Sir Harry Melville explained, the new Government had called for a complete review of all research expenditure and no decision could be taken out of this context.

'Gargamelle'

Detailed discussion of the improvement programme for CERN-Meyrin concentrated on proposals for two new bubble chambers.

Prof. Leprince-Ringuet reported the Scientific Policy Committee's recommendations that two new large chambers should be built, the more important one being a liquid-hydrogen chamber and the other, which could be built more rapidly, a heavy-liquid chamber.

The Committee proposed that a working party should be set up to study in detail all the questions concerning the hydrogen chamber, so that a detailed design could be ready in about a year's time.

For the heavy-liquid chamber, a design has already been brought to an advanced stage by a joint group from the 'Ecole Polytechnique', Paris, the University of Paris, and the 'Centre d'Etudes Nucléaires' at Saclay. The chamber even has a name: 'Gargamelle', after the giant, mother of Gargantua, created by the French author Rabelais in the sixteenth century. Professor F. Perrin, speaking for France, stated that his Government was willing to finance the construction of this apparatus as a contribution to European physics. There would be profit to France in the experience gained in developing techniques for its construction and operation, but once built it would be used at CERN in the same way as any other bubble chamber; French physicists would demand no special privileges.

The chamber would have a diameter of 1.9 metres and a length of 4.5 metres, with a visible volume of more than 10 m^3, ten times larger than the present CERN heavy-liquid chamber. It would cost rather more than 12 million Swiss francs and could be built in $3^{1}/_{2}$ years. CERN would have to provide the power supply (6 MW) and other facilities for its installation, at a cost of 7 to 8 million Swiss francs spread over four years.

The possibility of building such a bubble chamber, which would be of particular use in the study of neutrino interactions, was greeted with great interest by the Delegates to the Council, and it is probable that a decision to proceed with its construction will not be long delayed ●

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News from abroad

U.S.A.

HIGH-ENERGY PHYSICS PROGRAMME

As reported briefly in last month's issue, the U.S. Atomic Energy Commission early this year prepared a report on *Policy for national action in the field of high-energy physics.* This report was submitted to President Johnson, who in turn transmitted it for consideration to the Joint Committee on Atomic Energy of the U.S. Congress. From 2–4 March, the Joint Committee's Sub-committee on Research, Development and Radiation held a succession of public hearings on high-energy physics, during which many of the leading scientists in this field in the United States put forward their views on the subject. Among these scientists, as described on p. 69 of this issue of *CERN COURIER*, was Prof. V. F. Weisskopf, Director General of CERN.

The Atomic Energy Commission's report, together with a number of other reports and background data, was published in February as a 'Joint Committee Print', under the heading *High-energy physics program: report on national policy and background information**.

$500 million per year in 1975

In view of the current debate in Europe on the provision of facilities for the next stage of sub-nuclear research, the American plans are particularly interesting. At present, according to the report, the total annual expenditure in the U.S.A. in this field of study is about $166 million; if the subject is allowed to develop naturally, it seems likely that by 1975 the Federal Government, which contributes the major part of the necessary funds, will be meeting costs of about $500 million per year.

Long-term plans are necessary because new, higher-energy accelerators needed to advance substantially the high-energy physics frontier take at least 8 years to plan, design and build and because the continuing advance in this field implies growing expense.

Policy guide lines

The main elements that the Commission believe should guide the long-range planning of the high-energy physics programme are given in ten points which can be summarized as follows:

It is in the national interest to support vigorous advancement of high-energy physics as a fundamental field of science. The programme should be truly national and its support should be related to the overall national science programme (and not to the applied research and development programmes of the Atomic Energy Commission). Progress should be in two steps, to an energy of about 1000 GeV, the second accelerator being available in 1979-84. Existing accelerators and their associated research should be supported so that they play a part in the national high-energy-physics programme; new ones should be built only when they provide a significant advance and unproductive ones should be closed down or reduced in level of operation. University users should play a major part in the research done with the big accelerators, and careful planning is required for the organization and location of the major new facilities of the future. Finally, opportunities for international co-operation in accelerator construction and use should be actively explored.

Specific proposals

The specific plans presented in the report are:

1. Construction of a high-energy proton accelerator of approximately 200 GeV, to be begun in 1968.
2. Conversion of the Brookhaven AGS to a high-intensity facility, work on the first phase to begin in 1968.
3. Upgrading of the Argonne ZGS by an improvement programme including a new experimental area (1966) a large bubble chamber (1966) and a higher-energy injector (1967).
4. Construction of a high-energy electron-positron storage ring at the Stanford linear accelerator (SLAC), to be authorized in 1967.
5. Support of the study of new accelerator principles and techniques, in particular for a 600-GeV to 1000-GeV accelerator which could be available for experiments in 1980. The later addition of high-energy storage rings should be included in the design considerations.
6. Support for the development of new and improved techniques.
7. Continued and increased support for productive accelerators in operation or under construction.
8. Construction of large bubble chambers and similar apparatus. Two or three hydrogen bubble chambers should be started within 1 to 3 years.
9. Increased support of university 'high-energy user groups'.
10. Closing down or reducing of the level of operation of relatively unproductive accelerators.
11. Provision for an overall review of the programme at suitable intervals.

Among the projects not included in the present plans, because they are of lower priority or insufficiently developed and would add too much to the cost, are SLAC II (doubling of the energy and intensity of SLAC I, under construction), further improvements (phase II) to the AGS, proton storage rings, additional electron-positron storage rings, and superconducting linear accelerators.

As in Europe, one of the questions raised in considering the expansion of research on sub-nuclear physics has been that of the supply of staff. After looking into this, the Commission concludes not only that there will be no shortage of advanced (Ph.D.) physicists to carry out the proposed programme but that this research will train more new physicists than it can use.

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* Superintendent of Documents, U.S. Government Printing Office, Washington D.C., 20402, 55 cents.

REMARKS ON HIGH-ENERGY PHYSICS[*]

High-energy physics is unique and concerns itself with the most fundamental laws governing the constitution of matter and the elementary particles of which matter is constructed. Although the consequences of the discovery and understanding of fundamental physical laws cannot be foreseen at the time they are made, it has been historically true that in the long run these understandings have had a very great impact on science and technology and on all mankind.

Glenn T. Seaborg
Chairman, U. S. Atomic Energy Commission

The field of high-energy physics is one of the most exciting and vigorous fields of basic research in the world today. It is also a field requiring the construction and operation of very complicated and expensive accelerators and auxiliary equipment.

Chet Hollifeld, Melvin Price
Joint Committee on Atomic Energy

In attempting to develop long-range plans for high-energy physics, it should be recognized that it is extremely difficult, and perhaps impossible, to blueprint in advance the detailed course of a basic research programme. Progress in basic research as opposed to progress in applied research does not evolve in accordance with an orderly long-range master plan but follows a course which is continually being modified by the impact of the most recent scientific developments.

Introduction to the A.E.C. report

Science knows no national boundaries; this has been especially true of high energy physics. It seems to me that this is a particularly fruitful field for international collaboration. Large accelerators are available in the United States, in Western Europe, and in the Soviet Union; and the scientific results are made available everywhere. Effective international co-operation and collaboration can advance not only science but can show the way to greater international understanding.

Lyndon B. Johnson
President, U.S.A.

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[*] From the publication referred to on the previous page.

Organization of new laboratories

It is proposed that the new 200-GeV and 600-GeV to 1000-GeV accelerators should be national facilities, not reserved for any particular groups of universities. Each laboratory would probably be set up and operated by a corporation formed from among the leading universities in the field, although the members of the board of trustees (or equivalent) would represent the interests of the entire national programme rather than specific universities or research groups. This board would thus be somewhat different to the CERN Council, which has more of a dual responsibility — to the governments of the Member States as well as to CERN itself —, but otherwise the organization of the American laboratories would be similar to that of CERN. Thus, the director would be responsible for management of the laboratory and its operation, within the guide lines laid down by the trustees, and the resident staff would include resident research staff forming a relatively small proportion of the total number of people doing research around the accelerator. A scientific advisory committee (similar to the Scientific Policy Committee at CERN) would advise the board on matters affecting scientific and technical operation.

Sites for the new accelerators have yet to be found, but these again will be decided on a national basis, from the point of view of greatest advantage to the overall programme, and will not be determined by the location of the design study groups (at present the Lawrence Radiation Laboratory, Berkeley, for the 200-GeV machine and Brookhaven National Laboratory for the larger machine).

No proton storage rings

In its presentation, general approach and many of its recommendations, the latest report can be closely compared with the report of the panel headed by Prof. N. F. Ramsey, in 1963, to which it is a logical successor. Two of the biggest differences are that a specific date is now given for starting the 200-GeV accelerator and that proton storage rings at the AGS are not now proposed. The decision not to build the storage rings has been made solely on the assumption that they will be built at CERN. As in Europe, there is considerable interest in the experiments that could be done with such equipment and the report puts forward the idea that U.S. physicists should try to participate in some way in these experiments. The report also points out that the position would have to be reconsidered if the CERN rings were not built and that storage rings for the larger synchrotrons should always be kept in mind.

Electron-positron colliding-beam storage rings are in any case proposed for the SLAC at Stanford. An energy of 4 GeV is considered to give an appropriate compromise between higher energy and higher costs. Among other things, these rings would allow the electromagnetic structure of all the strongly interacting particles to be investigated, giving a test of the current theoretical schemes of particle symmetries, and might even produce samples of the intermediate boson — if this particle exists with a mass less than 4 GeV.

International collaboration

On the question of international collaboration (or 'intercontinental' from the point of view of CERN), the report states that it is clear that a large accelerator constructed and effectively managed jointly by the United States, the U.S.S.R. and Western Europe would be a significant achievement in many ways. However, it is recognized that many complex problems, technical and non-technical, would need to be solved before such an idea could become reality. In the 200-GeV to 300-GeV class, too, it is considered that all three areas are capable of constructing their own machines and that a joint undertaking, apart from its obvious administrative difficulties, would not even be scientifically advantageous because the research needs of the numerous scientific groups could not be met by a single accelerator. For the 600-GeV to 1000-GeV machine the outlook is rather different. The greater expense provides a stronger need for wider collaboration and the longer time scale provides more opportunity for it to come about. Nevertheless, the report concludes that vigorous design and engineering effort should be exerted independently by U.S. scientists so that such an accelerator could become reality in 15-20 years, wether as an international project or as a national one.

The question of collaboration in the *use* of accelerators, rather than in their construction and operation, is of a different order and very much easier. Considerable encouragement is given in the report to the interchange of scientists between the various laboratories existing or expected to come into operation in the next year or two.

U. K. — RUTHERFORD LAB.

End of N.I.R.N.S.

Among the changes brought about by the new British Government, in office since last October, have been the setting up of a 'Science Research Council' and the consequent dissolution of the National Institute for Research in Nuclear Science (N.I.R.N.S.). The National Institute was set up in 1957 to provide facilities on a national scale, financed by the Government, for the use of universities and other bodies interested in nuclear science. Its first laboratory was the Rutherford High Energy Laboratory at Chilton, Berkshire, equipped with a 50-MeV proton linear accelerator and the 7-GeV proton synchrotron 'Nimrod'. A second, the Daresbury Nuclear Physics Laboratory, in Cheshire, is being built round a 4-GeV electron synchrotron 'Nina' and has a former physicist of CERN's SC Division, Dr. A. W. Merrison, as its Director. The Atlas Computer Laboratory also belonged to N.I.R.N.S., but since 1st April, when the changeover took place, all three laboratories come under the control of the Science Research Council, which has a much broader responsibility than N.I.R.N.S., embracing such fields as space research and astronomy as well as nuclear and sub-nuclear physics. The Science Research Council will also be the main U.K. agency for supporting CERN. Like the older Agricultural Research Council and Medical Research Council and a new Natural Environment Research Council, it comes under the Ministry of Education and Science. Its chairman is Sir Harry Melville who, as secretary of the Department of Scientific and Industrial Research, has been a British Delegate to the CERN Council for the last few years; one of the eleven other members is Prof. C. F. Powell, member and past chairman of CERN's Scientific Policy Committee.

Honour for Director of Rutherford Laboratory

The Director of the Rutherford Laboratory Dr. T. G. Pickavance, has been made a Commander of the British Empire and received the insignia of this Order from H.M. the Queen at Buckingham Palace on 18 March.

The Nimrod power supply

Further news about the damaged power supply for 'Nimrod'[*] became available on 2 April. Investigation has confirmed that the failure was due to metal fatigue, and it appears that certain stress-concentration effects had not been sufficiently appreciated in the design. As a result both alternators will have to be modified before satisfactory long-term operation can be resumed, but it is still hoped to operate the accelerator with the remaining motor-alternator set for a limited time. At the beginning of April, this alternator had been fitted with stress-recording instruments and was being run to check the conclusion about the fracture in the damaged one[**].

If the experimental programme is resumed on a limited scale, some experiments already planned will collect less data than originally foreseen and others will take longer to complete. Offers of assistance with accelerator time have also been received by the Rutherford Laboratory from a number of other high-energy physics laboratories, including CERN ●

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[*] As reported in CERN COURIER, vol. 5, pp. 58-59, April 1965.

[**] Early in May it was learned that similar fatigue cracks had been discovered in the rotor of the second alternator, so that this rotor also has to be returned to the manufacturer for rebuilding. As a result, even half-speed operation of the accelerator is not expected to be possible before September.

Last month at CERN (cont.)

University of Basle, and better electronic apparatus. Already, more detail has been revealed in the uranium and tungsten spectra and new data have been obtained on the quadrupole structure of the plutonium nucleus.

German Parliamentary Committee visits CERN

A visit lasting part of one afternoon and most of the next day was paid to CERN on 16 and 17 March, 1965, by members of the 'Bundestagsausschuss für Atomkernenergie und Wasserwirtschaft' (Parliamentary Committee for Nuclear Energy and Water Supplies) of the Federal Republic of Germany. The guests were welcomed on the first afternoon by the Director General, Prof. V. F. Weisskopf, who spoke to them on the part played by CERN in the field of sub-nuclear research. During their tour of the Laboratory the following day, the members of the Committee saw various aspects of the proton synchrotron and its experimental areas, the 2-metre bubble chamber, methods of measuring bubble-chamber photographs and the computers. Before leaving, they were given an idea of the future projects proposed for high-energy physics research in Europe and had an opportunity to discuss them with some of the people concerned ●

BOOKS

Plasma spectroscopy

The physics of plasma (a mixture of neutral and ionized gas) is a relative new-comer as a subject of advanced studies. It presents a fascinating field of research, worthy of an attention comparable to that lent to high-energy physics and solid-state physics. Among the interesting questions posed by plasma physicists one may quote the following:

— It seems that plasma mechanics may be partly responsible for many phenomena in the evolution of the cosmos, notably the formation of planetary systems. What is the connexion with other better-known forces, such as static and dynamic gravitation?

— The most promising experiments aiming at controlled fusion in the laboratory have so far been performed with plasma. However, all attempts to maintain the fusion for any considerable time, let alone gain energy from it, have failed. Is it perhaps theoretically (or practically) impossible to 'tame the H force'?

— What are the mechanics of the many instabilities shown by plasma?

Only further studies can answer these questions. Direct studies on the cosmic scale have so far been possible solely by using the emitted electromagnetic waves, mainly light*. In laboratories, also, one is limited to optical observation if one wants a fool-proof means of communication with the plasma.

Probes have been widely used but experience shows that the plasma is always disturbed**, often in an unexpected manner; it bends and twists away from the probe as if it resented the intrusion. The main parameters one wants to determine are temperature (when such can be considered), degree of ionization, and density, all as functions of time; they are hence preferably deduced from optical information.

Plasma spectroscopy, by Hans R. Griem (New York, McGraw Hill Book Company, 1964; $18.50) deals in a very thorough way with everything embraced by the title and is (so the cover tells us) the first book entirely devoted to the subject. It is to be read at the graduate level and is a very up-to-date work.

The first eight chapters of the book are theoretical and start with a revision of classical and quantum electrodynamics. They further contain an extensive theoretical and numerical discussion of all germane sources of information inherent in the emitted light, such as line strength, Stark broadening, Doppler shift and radiation from recombination. A whole chapter is devoted to equilibrium relations, especially the validity of the important concept of 'local thermal equilibrium' (LTE). The seventh and eighth chapters deal with radiation from extended sources and radiation energy losses. In the following chapters, plasma spectroscopy is discussed in practice, featuring different types of plasma and important optical instruments and detectors. Three chapters describe temperature and density measurements (especially the use of the famous Saha equation in LTE) and measurements of atomic parameters. A long series of tables (150 pages), including data related to our best-known spectral lines, ends the book.

The work is clearly intended to be a very complete text-book as well as a reference book on all matters related to its topic. The text is straight to the point, clear and unambiguous, mostly avoiding introductory remarks whenever a new subject is opened, which makes the book extremely useful for the second purpose. It may be more difficult to read as a text-book, in particular as there are very few (if any) indications as to which constitute the more important sections. Most commendable is the author's choice of the rationalized MKSA system of units throughout a book which unites parts of classical, quantum and statistical mechanics, electromagnetism, aerodynamics, hydrodynamics and optics. Also one appreciates the extensive list of references at the end of each chapter as well the aesthetic typography throughout. For the student a few problems are added to each chapter, with solutions at the end of the book. The index, however, is rather meagre.

K. Soop

The nuclear reactor, by Alan Salmon (London, Methuen & Co. Ltd., 1964; 16s.), is intended for 'the Honours Physics student, and as an introduction and guide to the research worker from another field', but is unfortunately not up to the usual standard of the *Methuen Monograph* series. Although the title suggests a general account of reactors, the book in fact concerns the physics of thermal reactors, and most of the development of the subject is related to the graphite-moderated, gas-cooled, natural-uranium power reactors of the British and French nuclear-power programmes. Very little attention is paid to the physics of fast reactors, and there is comparatively little discussion of the relative merits or characteristics of other types of thermal reactors.

Within this more limited scope, the theory of the neutron cycle in a reactor is developed up to an elementary level, principally using diffusion theory. There are also chapters concerning optimum fuel cycles and flux flattening, heat transfer, shielding, reactor control, the design and applications of research reactors, and some discussion of the economics of nuclear power. In a small book such as this there must be omissions, but one would have thought that physicists should be given some idea of the methods of calculation of neutron flux, fine structure, and hence thermal utilization, and also some account of the cross-section of the plutonium isotopes and their effects on the long-term behaviour of power reactors.

For the reader who already has some ideas on the principles of operation of reactors, this book may be useful to broaden his knowledge of the subject, but for the reader completely new to the field the often confused presentation will only slow his progress. For example, there is the sentence beginning: 'Due to the general decrease of neutron cross-sections with energy . . .', and also the curious sentence (especially in a book concerning thermal reactors): 'Some nuclei exhibit resonance behaviour in their scattering, depending on the nucleus involved the neutron energy may be low ($\sim$ 1 keV) or high ($\sim$ 1 MeV)'. In a very early paragraph, designed to give a broad outline of the design of a typical power reactor, we are given the thickness of

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* One hopes in the next few years to be able to use information inherent in emitted neutrinos.

** Use of laser light as a probe has recently been proposed.

the pressure vessel, and a '20 T crane' is referred to, whilst no mention is made of the geometry of the core, the nature of the fuel or the operating temperatures. There is also the somewhat alarming assertion that: 'The carbon dioxide coolant, at a pressure of 283 lbf/in^2, transports the energy produced by fission to the heat exchangers from whence it is carried in the steam to the turbine'.

It seems to me that there are many dangers in teaching reactor physics to undergraduates as an isolated subject, for the basic principles of reactor design result from a complex interweaving of various disciplines. For example, one of the most important components in a reactor from the point of view of expense and design complexity is the fuel element, and here the design must take into account chemistry, metallurgy, and basic engineering principles as well as physics. Dr. Salmon's book makes no mention of the subject.

C. R. Symons

Also received

Theory of crystal dislocations, by A. H. Cottrell (New York, Gordon and Breach Science Publishers Inc., 1964; paper $2.50, cloth $4.50) — first in a new series entitled *Documents on modern physics*, intended to make available selected reviews, lecture notes, conference proceedings and important collections of papers in branches of physics of special current interest; this text is basically that of lectures given at Les Houches in 1956, revised to July 1962.

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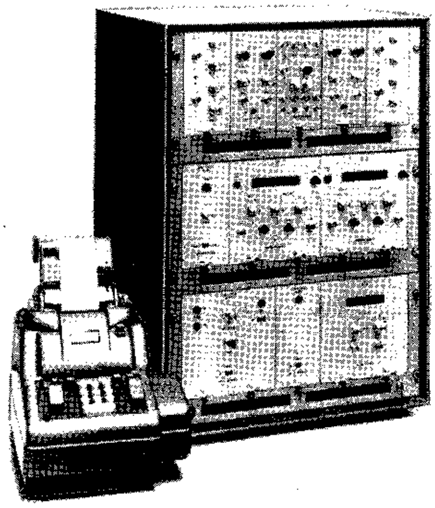

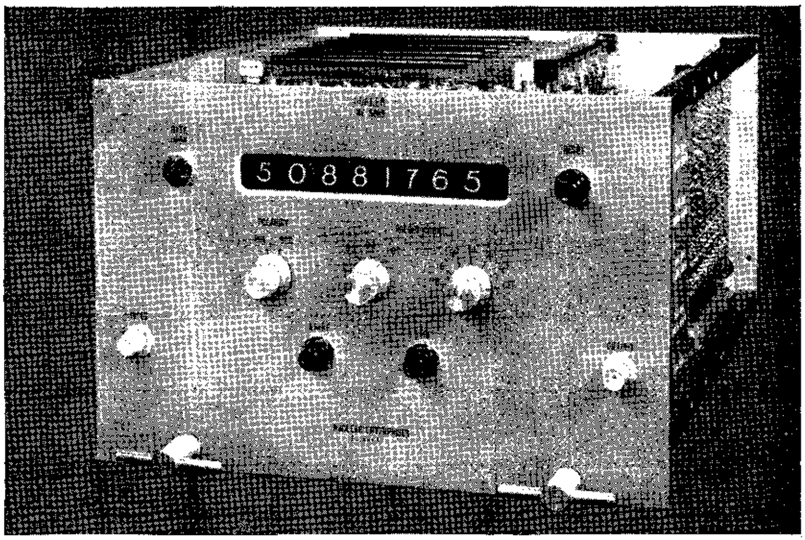

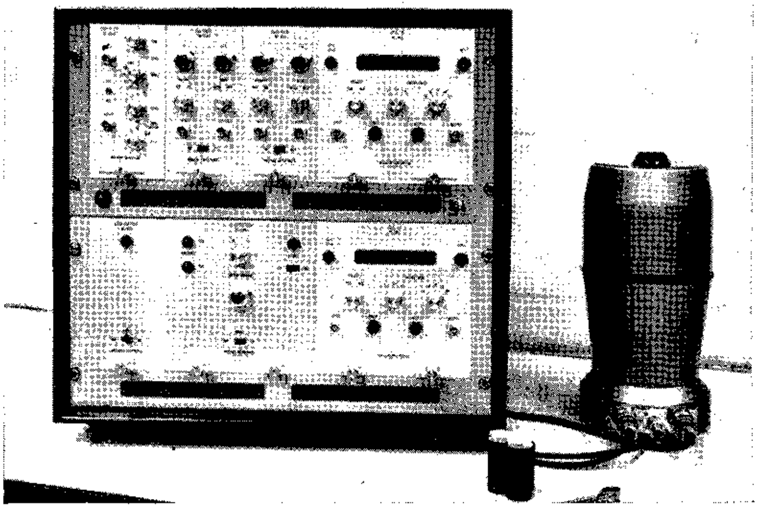

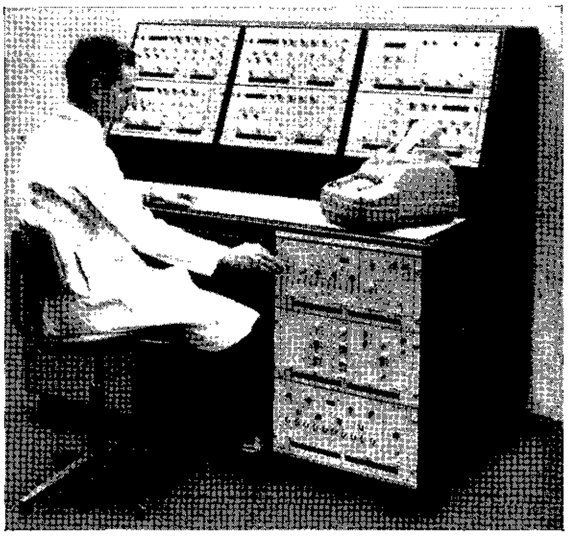

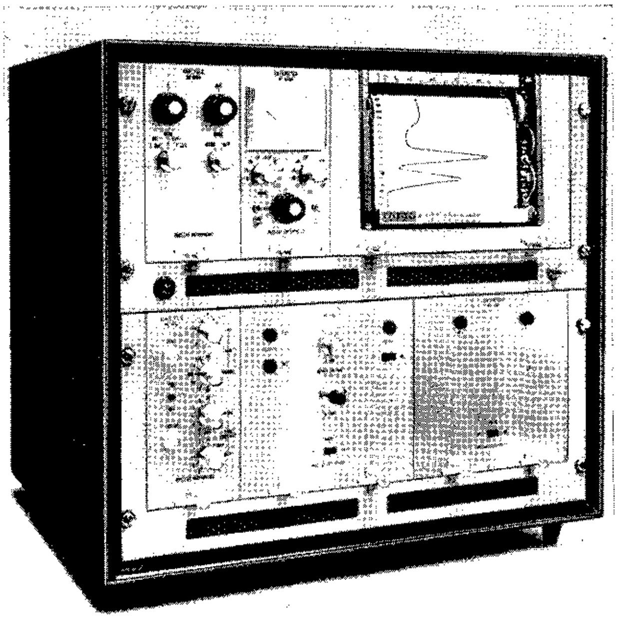

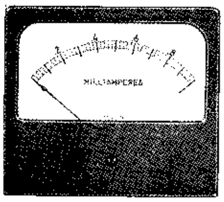

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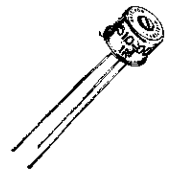

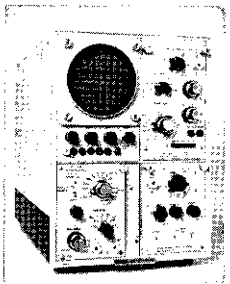

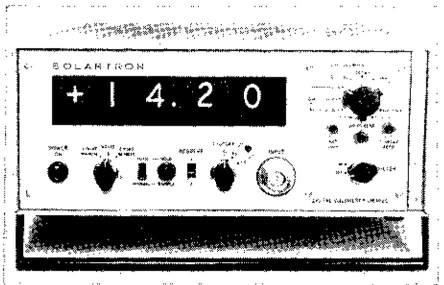

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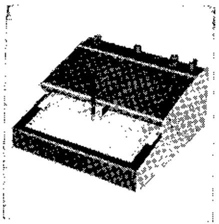

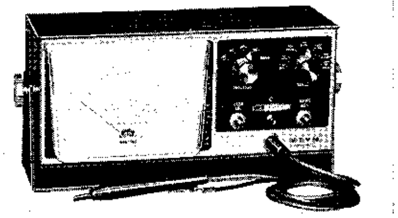

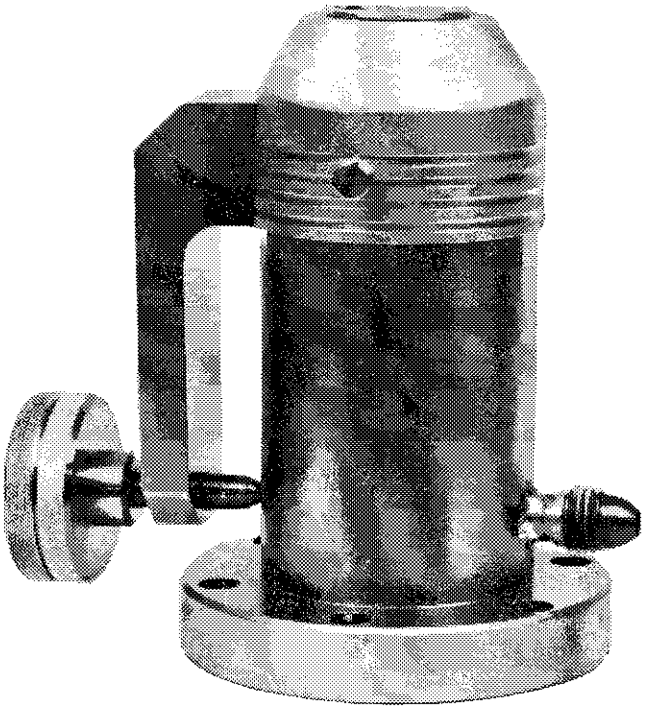

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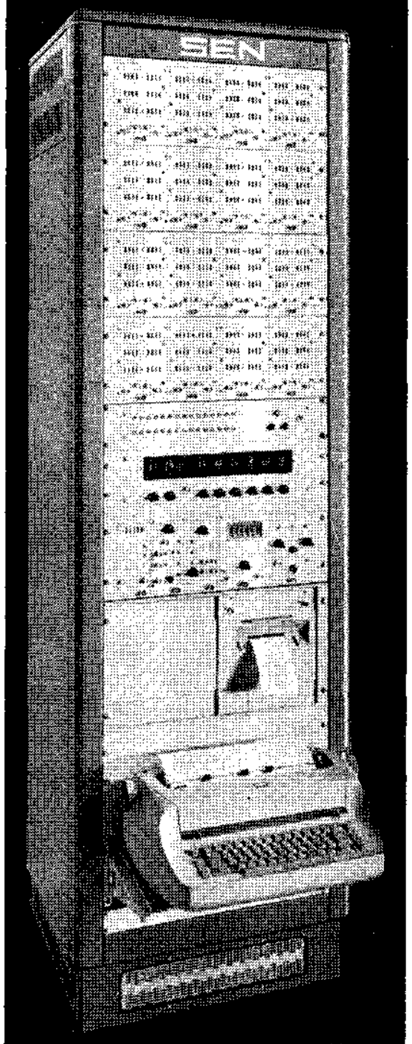

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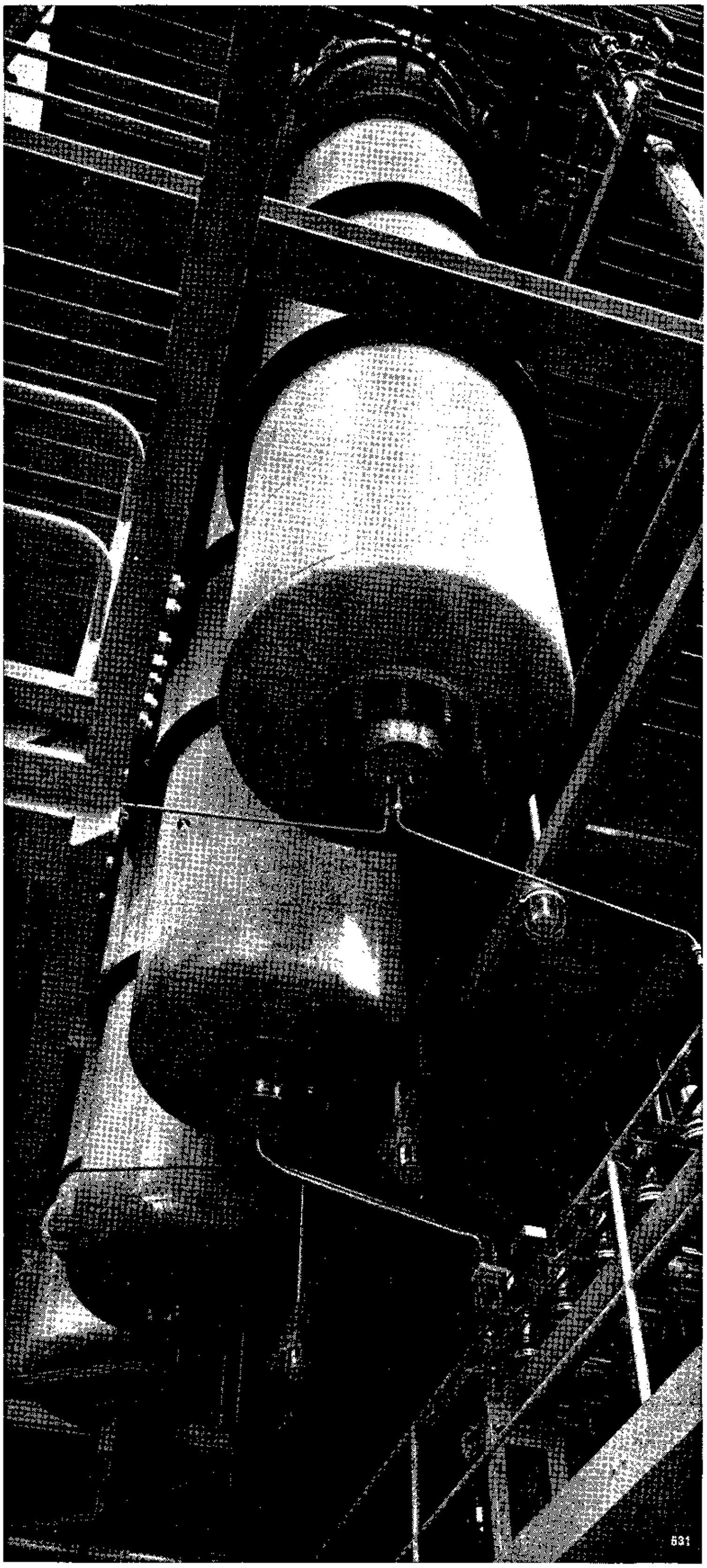
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