COURIER

CERN

CERN/PI 13.12.66

No. 12 Vol. 6

December 1966

CERN COURIER

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A seasonal **cover photograph** taken at a Christmas party held on 4 December for the children of CERN staff. Father Christmas met the children in the Main Auditorium. Note that he is obviously aware of the scientific nature of the Organization he is visiting, since he has furnished himself with an r.f. microphone.

We send our very best wishes for Christmas and the New Year to all readers of CERN COURIER.

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 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 comprises an area of about 80 ha (200 acres), straddling an international frontier; 41 ha is on Swiss territory in Meyrin, Canton of Geneva (the seat of the Organization), and 39.5 ha on French territory, in the Communes of Prévessin and St.-Genis-Pouilly, Department of the Ain.

Two large particle accelerators form the basis of the experimental equipment:
         — a 600 MeV synchro-cyclotron,
         — a 28 GeV proton synchrotron,
the latter being one of the two most powerful in the world.

The CERN staff totals about 2300 people.

In addition to the scientists on the staff, there are over 360 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. Furthermore, much of the experimental data obtained with the accelerators is distributed among participating laboratories for evaluation.

Thirteen Member States contribute to the cost of the basic programme of CERN in proportion to their net national income:

Austria (1.90 %)	Italy (11.24 %)
Belgium (3.56 %)	Netherlands (3.88 %)
Denmark (2.05 %)	Norway (1.41 %)
Federal Republic	Spain (3.43 %)
of Germany (23.30 %)	Sweden (4.02 %)
France (19.34 %)	Switzerland (3.11 %)
Greece (0.60 %)	United Kingdom (22.16 %)

Poland, Turkey and Yugoslavia have the status of Observer.

The 1966 budget for the basic programme amounts to 149 670 000 Swiss francs, calling for contributions from Member States totalling 145 860 000 Swiss francs.

Supplementary programmes, financed by twelve states, cover construction of intersecting storage rings for the 28 GeV accelerator at Meyrin and studies for a proposed 300 GeV accelerator that would be built elsewhere.

300 GeV

A report on the 'Status of the project for a European 300 GeV proton synchrotron' was presented to the CERN Council at its December meeting. We reproduce here the first three sections of the report which cover the scientific background to the European proposal.

I. The Significance and Development of High-Energy Physics

The last hundred years have seen immense progress in our understanding and control of the world of physical phenomena. In particular, the basic properties of matter have been revealed in successive steps, each of which uncovered laws and structures of the most profound significance both for natural philosophy and for advanced technology. Thus, in the first quarter of the twentieth century, experimental physics unravelled the structure of atoms and molecules, showing how they are constituted by electrons moving around very small but heavy nuclei. These remarkable findings led around 1925 to the discovery of quantum theory, which explains how the electrons move around the nuclei and how they bind the nuclei to each other to form molecules or solid bodies. The foundation was thereby laid for our modern understanding and utilization of chemistry, solid-state physics and electronics, while on the philosophical side our whole thinking on causality and determinism was revolutionized.

After atomic physics came the experimental study of the atomic nucleus. This was the first field of physics where particle accelerators became the basic instruments, because it soon appeared that the natural radioactive sources originally used were neither intense nor flexible enough for detailed work. One found out that nuclei are composed of protons and neutrons moving around each other in very compact and dense configurations. One understood how nuclear energy can be liberated through fusion of light nuclei, and how this phenomenon explains the burning of the sun and of the stars. One predicted that nuclear energy can also be liberated through fission of heavy nuclei and one succeeded in doing this on earth. One learnt how to make large numbers of new nuclear species, which are now in daily use in medicine, biology, metallurgy, and many other fields of science and technology.

While it was possible to describe the motion of protons and neutrons inside atomic nuclei in terms of quantum theory, nuclear physics revealed two entirely new types of force which we are still unable to understand. They are the 'strong' force which keeps the protons and neutrons tightly bound in the nuclei and is responsible for nuclear energy, and the 'weak' force which produces beta radioactivity and is intimately connected with the most elusive particle in nature, the neutrino. It is now entirely clear that the study of these two forces leads us beyond the framework of ordinary nuclear physics. One must probe into the inner parts of the proton and neutron themselves, or in other words, matter must be investigated at the sub-nuclear level. But there is a very general law of nature which says that the smaller the object one wants to investigate, the higher are the energies needed to penetrate it. Thus, sub-nuclear physics is also high-energy physics, and its progress requires accelerators of increasing energies.

Discovery of the Elementary Particles

The figure shows the date of the discovery of the elementary particles identified since 1945 (not including 1966). The Greek or Latin letters are, in many cases, the conventional symbols for families of particles whose members have different masses and for each mass there may be several particles with different electrical charges. Altogether about 100 different particles are known, not counting their corresponding antiparticles.

Most of the discoveries shown for 1945-1955 were made in cosmic-ray experiments, but the particles were studied in detail with the help of the first post-war accelerators. The large number found after 1960 were produced and investigated mainly with the proton synchrotrons at Berkeley, Brookhaven and CERN.
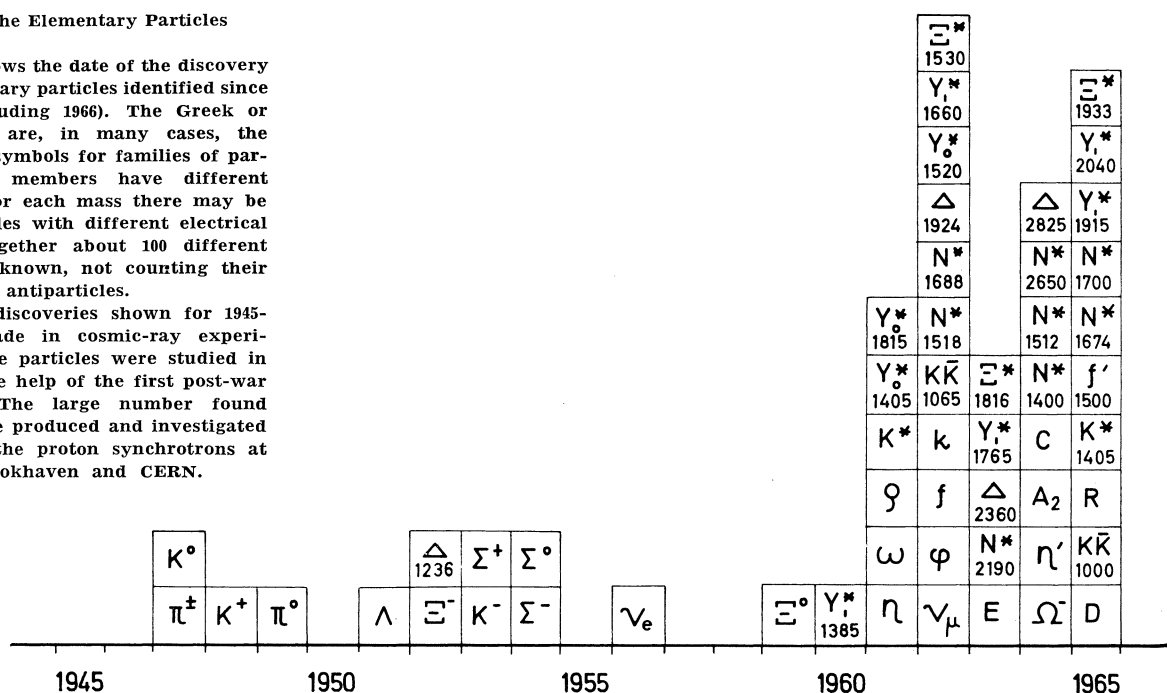
Up to now, the most significant discovery in high-energy physics is that the proton, the neutron and the electron are not the only basic particles of nature. There are many more such particles. They are more difficult to observe because, when produced, they disintegrate almost immediately. But they are as important as the proton, neutron or electron when one tries to understand the nature of the strong and weak forces. The first of these new, highly unstable particles were discovered in cosmic rays. Their accurate study and the discovery of many more are the main achievements reached with the high-energy accelerators constructed in the last fifteen years (see the Figure below). Indeed, as was the case with natural radioactivity in nuclear physics, cosmic rays as a natural source of high energies turned out to be neither intense nor controllable enough for the needs of experimentation.

The existing accelerators have revealed the existence of close to one hundred particles (these have often been called elementary particles, a name which is getting more and more questionable as their properties are better known). For some of them, the accelerators made possible the study, to some extent, of their modes of disintegration and their mutual interactions, thereby giving new, vital information on the nature of the strong and weak forces. As the list of the known particles grew, their astounding variety at first created bewilderment and discouraged systematic interpretations. Quite remarkably, however, the last five years have brought us to the stage where the very multiplicity of particles has revealed a novel order, characterized by well defined mathematical principles of symmetry (they are usually denoted by the symbols SU_3 and SU_6). Particles which at first sight are completely different from each other have now been recognized as belonging to the same family and as having deep-lying similarities. The proton and the neutron cannot be understood separately, they are only two members of a larger family containing perhaps eighteen particles, some of which are extremely unstable. Also the interpretation of the strong and weak forces is profoundly affected by these new principles of symmetry, which allow us to group into single interpretations experimental facts which would have been wholly unrelated a few years ago. Finally, most physicists tend now to believe that the new symmetries may be the manifestation of a remarkable internal structure of the proton, the neutron and many other particles which were earlier regarded as elementary. If this is true, the proton may contain even more fundamental objects (for which the name of 'quark' has been proposed), a fact which would open up once more completely new viewpoints in physics.

While the development of atomic and nuclear physics in the first forty years of our century was mainly concentrated in Europe, the USA took the lead in high-energy physics in the early 1950s thanks to the construction and rapid exploitation of the first high-energy accelerators. Fortunately, the European decision, taken in 1953, to pool without delay the human, technical and financial resources of the continent for the construction and operation of CERN, especially of the 28 GeV proton synchrotron, allowed Europe to take part at the highest level, on a par with the USA, in the present-day development of high-energy physics. The best European physicists were able to remain productive in high-energy and particle research,

'... I should point out one difference between high-energy physics and many other branches of science: the unavoidably large size of the equipment forces us to make plans for fifteen years ahead, involving the physicists of a whole continent. Delays in decision can therefore have a catastrophic effect on the whole future of fundamental physics in Europe, and for this reason Governments have been requested to decide on this new Laboratory as soon as possible. Five years of study will have gone into preparing the decisions, and ten more years will pass before the new Laboratory can start to operate. By then CERN will have been running for nearly twenty years. The time to take the next step forward is now.'

Prof. Bernard Gregory,
Director General of CERN,
in his Foreword to the Report

national laboratories and university institutes were founded and attracted highly competent staff, high-energy physics became one of the strongest components in European science. This is all the more gratifying and important since, as all advanced countries have come to realize, a balanced and resolute effort on the whole front of research is required for large nations or groups of nations to assure their long-range technical and economic development. The importance of a balanced research programme, ranging from the most advanced problems of pure science all the way to applied and technical research, cannot be underestimated. The point is not only that some parts of this programme can always, and often do, lead to unexpected applications at unexpected times. It is also that a balanced programme, with sufficient emphasis on basic problems, is the prerequisite for creating the right spirit and the right standards of value for the whole of the scientific and technological effort. As was said so aptly by Professor C. F. Powell: 'The scientific age is the product of a complex interplay of all science and technology. The problem is to ensure their balanced development, for a deficiency in one branch weakens the whole front of advance'.*

It is in the light of this general development that the significance of the 300 GeV project can best be evaluated. High-energy physics has revealed a world of many particles. A few of them, like the proton, neutron and electron, are quite familiar; all others are extremely ephemeral, difficult to produce and even more difficult to study. Still, all are equally important if we are to unravel the fundamental forces and laws which regulate matter at the nuclear and sub-nuclear levels. The CERN and Brookhaven proton synchrotrons, and other, lower energy accelerators in Europe, the USA and the USSR have revealed this new world of particle physics. Within the limits imposed by their energy and intensity, these machines are engaged in studying some of the multiple questions which we have to answer in order to reach a true understanding of what has been uncovered in sub-nuclear physics. Large-scale improvement and extension programmes have been undertaken to increase the potentialities of the CERN and Brookhaven machines. These programmes will ensure that the advanced positions reached by our continent and by the USA can be maintained for some ten years. But the next step must be prepared now, since projects on this scale take ten years to construct and bring into use. The community of particle physicists agrees that this step consists in building much

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* Professor C. F. Powell: 'The Role of Pure Science in European Civilization', speech delivered at CERN on 10 October, 1964.

'A great society is ultimately known for the monuments it leaves for later generations. We cannot foretell what detailed results may come from a very high energy machine, which should in fact aim for energies 20 to 30 times as high as the present ones to bring a sufficient new range within reach in the reasonably near future. We can foretell, however, that such a machine, which is on the scale of a national effort, will without question be a source of inspiration for new science and a monument to our days.'

Prof. Abraham Pais
'Nature of Matter'
January 1965

larger proton synchrotrons, because such machines have the remarkable advantage of offering simultaneously the two facilities most needed for further progress in particle physics, namely higher energies and higher beam intensities. Thus, the USSR is approaching completion of a 70 GeV proton synchrotron. The USA, while completing construction of an electron accelerator of 20 GeV which will be extended later to 40 GeV, are preparing the final decision on building a 200 GeV proton synchrotron. In Europe, both ECFA (the European Committee for Future Accelerators) and the Scientific Policy Committee of CERN have agreed that the 300 GeV proton synchrotron, with its higher energy compensating its longer construction time, would provide our continent with a suitable instrument to take over in the second half of the next decade.

A few examples may show the improvements in experiments which will be reached with the proposed 300 GeV accelerator. The typical energies in beams of special particles such as K mesons and antiprotons, which have been the principal producers of the new unstable particles, now range between 2 and 10 GeV. There is a need already to go higher, but this is limited by the low intensity of particle production from accelerators in the 30 GeV proton energy range. The 300 GeV machine should produce 10-20 GeV beams up to 1000 times more intense. It will also, of course, produce beams of much greater energy, and even in the 50 GeV region these will be of very high intensity by present-day standards. ·

For another class of experiments, using neutrino beams, which are of major importance in investigating the weak force, it now takes weeks of use of the CERN synchrotron at full intensity to observe 100 neutrino events. With the 300 GeV machine, not only will the energy range of neutrinos be greatly increased, but the observation times will be cut from weeks to hours, so that even rare events, which are often the most instructive, can be observed in useful numbers.

These examples show that the new machine will make a truly qualitative difference in the power of European physics resources, and that it is of the scale to become a worthy successor to the present CERN synchrotron. Anything more modest would carry a great risk of being too little and too late.

II. The Role of the 300 GeV Accelerator for European Research and Education

The proper exploitation of high-energy accelerators for the general benefit of scientific research and training poses difficult organizational problems in view of the fact that research must remain closely integrated with advanced teaching and hence with university life. Indeed, it is in the integrated research and teaching activities of the universities that lie the basic foundation of the scientific development. The universities detect and train the young scientists, who are the key to the future development. They also have been and remain the best places for original thinking and for the conception of novel lines of work. They require, however, access to the most up-to-date instruments of research, in particular to high-energy accelerators of such a large size and complexity that they are too expensive to be built for each university, and that a single university would not have enough staff and students to operate. This is of course the justification of the large national and international accelerator laboratories, which of necessity will always be far away from most universities. The best one can arrange for is that access be as easy as possible for as many co-operating universities as possible.

Such central laboratories must then give the opportunity of research to all the co-operating universities. The physics professor should be able to share his activity between teaching in his university and research done by means of the central accelerator. His research students should be able to participate in this research, which should be carried out partly in the central laboratory for actual running of the experiments, and partly in the university for preparation and for data evaluation. Finally, the university professor should have full participation in the discussions and decisions by which the research programme of the central accelerator is determined.

To achieve these aims successfully, various conditions must be met by the central accelerator laboratory as well as by the universities. The former must keep its resident research staff at a size small compared to the number of university physicists working in it, and it must provide these numerous visitors with ample technical facilities. In or near the universities, on the other hand, the physics professors and research students must have at their disposal the facilities needed for the preparation of experiments and for the evaluation of experimental data, so that they are not forced to spend time unnecessarily at the accelerator laboratory. Each experiment, however, will require a period of presence at the accelerator, and the university activities of professors and students must be arranged accordingly. Finally, the scientific programme of the central accelerator must be elaborated by committees in which the university physicists are fully represented.

The present experience with CERN and the large national laboratories is that all these conditions can be met if the necessary efforts are made from all sides. Thus, CERN supplies experimental facilities to about 700 high-energy physicists and research students working in some 50 European universities, whereas no more than about 70 high-energy physicists are on the CERN staff. Among the latter, most leave CERN within five or six years. The programme of the CERN synchrotron is elaborated in three experimental committees, where all groups using the machine are represented. Similar arrangements will clearly be possible for the 300 GeV

machine, but there is room for considerable improvement. In fact, ECFA is currently engaged in a study of the problems raised by the collaboration between universities and central accelerator laboratories. Its conclusions will help to set the rules to be adopted for exploitation of the future 300 GeV machine, as well as for a proper collaboration with the smaller accelerators forming the 'base of the pyramid' recommended in the Amaldi Report.

By its fundamental character and by the richness of the new phenomena which it has uncovered, high-energy physics has always exerted a very strong attraction on young, gifted minds. In fact, the number of high-energy physicists has grown in recent years faster than was forecast by ECFA when it made manpower estimates in 1963. The attraction of large accelerators is also great on technically minded physicists. One expects, therefore, no manpower difficulty for the 300 GeV project. It should also be noted that, for a larger population, the total European high-energy effort is more modest than the USA one. This is of course one more reason to continue a resolute development of high-energy physics in Europe. Without it, the best young scientists of our continent, who are often also the most mobile ones, would not hesitate to emigrate to where better facilities are available for this fundamental part of physics.

The educational value of work around a high-energy accelerator like the 300 GeV machine is very great when the young scientists are put into close contact with the various phases of the experiments in which they participate. The breadth of knowledge of pure and applied physics, of engineering, of large-scale organization needed in high-energy physics is greater than in many other subjects. Even a young research student gets acquainted not only with advanced quantum theory and particle physics, but also with advanced electronics and computing techniques, cryogenics, optics and power engineering. It is therefore certain that young scientists who had their physics training in the high-energy field should be well prepared to enter other scientific and technical activities, including industrial work and science teaching. It is in fact expected both in the USA and in Europe that, if present trends in the development of higher education continue, the number of physicists leaving the field of high-energy physics after taking a higher degree may reach 50 % or more of those entering it, allowing for the interest of young students in the subject and the capacity of the existing and proposed laboratories to accommodate them.

All that has been said in the present chapter on the relations between accelerator laboratories and universities applies not only to the future 300 GeV accelerator, but also to present and future accelerators of smaller size which form the 'base of the pyramid' described and recommended in the Amaldi Report. While the latter machines are not the main topic of this Status Report, it may be good to recall the great importance of the 'base of the pyramid' as an indispensable complement to the 'summit programme' which consists at present of the CERN Laboratory in Meyrin and would have in the future the 300 GeV Laboratory as main facility. Indeed, as stressed repeatedly by ECFA in 1963 and again this year, the balanced development of high-energy physics

in Europe requires, in addition to the very large accelerator constructed and operated as a common effort of all countries involved, a number of smaller machines to do complementary experiments of considerable duration and to provide additional research and training facilities in closer contact with the universities.

III. The World Effort in High-Energy Physics

The success and justification of a large and expensive high-energy physics programme is particularly dependent on the quality and performance of the accelerator on which it relies. Not only does the accelerator performance directly affect the ease with which the whole range of experiments can be performed, but a good machine provides a natural pole of attraction for the ablest scientists of the time, who usually have the possibility of working where they consider they will be most effective. It is clear that the effort and money put into a new laboratory in Europe will be badly spent if the accelerator does not have a performance at least as good as, or better than, that of any other in the world for a good fraction of its life; for the same reason, it must also come into operation early enough to maintain in Europe the front-rank position gained by the existence of the CERN proton synchrotron if an exodus of the best physicists from Europe is to be avoided; if they go, the result will be an expensive, slowly dying programme manned by second-rate people.

The principal parameters governing the quality of an accelerator are the proton energy and also, for many experiments, its intensity — the number of protons accelerated per second.

The accelerators in other countries, either actual or planned, which will influence the specification of a new machine in Europe are the 70 GeV proton synchrotron at Serpukhov in the USSR, which will come into use in 1968-1969, and the two machines in the US National Plan, one a 200 GeV proton synchrotron, which it is hoped will be decided on soon, to come into use in about 1974, and, for the further future, one of 600-800 GeV.

For a European machine, which can now only start work around 1975 at the earliest, the energy should not be chosen lower than 200 GeV, to take a useful step beyond Serpukhov and to assure at least parity with the first USA machine. In both 1963 and 1966, ECFA considered it likely that a European machine would be somewhat delayed with respect to the USA, and that this should be compensated for by some increase in energy, which would lead to a very significant increase in performance for the higher energy beams and to a range of experiments in which it would be alone in the world. A much higher energy would in fact be very attractive, as witness the presence of a second machine

in the USA plans, but ECFA recommended 300 GeV for Europe to avoid the increased cost, risk and above all delay which an energy higher than 300 GeV would involve.

These arguments lead to the time-scale given below for the performance of the predominant proton accelerators in different countries, in which each continent's plans fit, roughly, into a world-wide development by steps, while still preserving the essential facilities for each continent separately.

On various occasions it has been asked whether the last step, or even the one before, could not be made on an intercontinental basis, through the construction of a 'world machine'. A meeting between very senior scientists and officials from Europe, the USSR and the USA was held in Vienna in July 1964 to explore these possibilities: it appeared rather conclusively that the step to 200-300 GeV should be taken by each continent separately, but that the idea of a world-wide collaboration to build a 1000 GeV machine should not be dropped.

Meanwhile, collaboration with the USSR on a more practical scale is developing as plans are being worked out with the authorities there for physics groups and large instruments from Europe to work at Serpukhov, and for collaboration on the development of the accelerator itself. This is the consequence of a scientific liaison between CERN and several Eastern European countries, which has been growing steadily over the past years. CERN and various USSR laboratories have exchanged staff, latterly with a Russian bubble chamber group working in CERN for several months, and the Polish high-energy physics effort, which is of very high quality, is largely sustained by an active collaboration with CERN. The planned collaboration with Serpukhov will open the way for large-scale extensions in scientific contacts and exchanges with the USSR, gradually preparing the ground for very ambitious intercontinental efforts. It is important, however, to realize that this type of collaboration can only be successful with approximately equal partners: it is not a substitute for a healthy accelerator programme for each continent separately, any more than the building up of CERN can replace national accelerator construction in Europe.

1966	Europe, USA:	30 GeV	3×10^{11} protons/second
1969	Serpukhov (USSR):	70 GeV	10^{11} protons/second
1971	Europe, USA:	Improvements to intensity of existing 30 GeV machines Completion of ISR at CERN	
1974	USA:	200 GeV	10^{13} protons/second
1976	Europe:	300 GeV	10^{13} protons/second
1980+	?	1000 GeV	? protons/second

CERN News

Council Meeting

The 33rd Session of the Council was held at CERN on 14 and 15 December under the Chairmanship of Mr. J. H. Bannier. The agenda included the presentation by the Director General of the Progress Reports on the work of the seven CERN Departments covering the whole of 1966. This represents a change from the traditional procedure where Progress Reports were presented at each Council session covering the preceding six months. From now on, detailed reports on the full year will be prepared for the December meeting and much less detailed summaries of the first six months, for the June meeting, which coincides with the publication of the CERN Annual Report.

The budget of the basic programme for 1967 was fixed, together with a firm estimate of the budget for 1968 and provisional figures for 1969 and 1970. Two important topics for the future of sub-nuclear physics in Europe were also discussed — the proposed European 300 GeV accelerator and collaboration with the Serpukhov Laboratory in the USSR where a 70 GeV proton synchrotron is being built.

The Session will be covered in some detail in the January 1967 issue of CERN COURIER.

The experimental programme

On 16 November, a 'Discussion Meeting on the High-Energy Physics Programme at CERN' brought together a large gathering of physicists from throughout Europe who use the two CERN accelerators. The aim was to present, for information and comment, the recent, current and near-future experimental programmes on the machines.

The first speaker was Dr. Charpak, who has recently become co-ordinator of experiments at the 600 MeV synchro-cyclotron. He described the situation with regard to beams and experiments at the SC (see CERN COURIER, August, p. 155).

Dr. Charpak was followed by Professor Van Hove who reviewed the physics situation especially in the light of the results of the Berkeley Conference. He listed the major areas of interest and emphasized topics where important questions are waiting for answers from experiments. Professor Gregory described the beams and experiments at the 28 GeV proton synchrotron, assigning the experiments to the items in the physics list of Professor Van Hove. We mention here some of the important changes in the arrangements for beams in the experimental halls and some of the forthcoming experiments.

An important new development at the PS is that a slow ejected proton beam-line (called e3) from straight-section 62 is nearing completion. This beam-line is being built in the southern half of the East Experimental Hall where the CERN/Munich experiment (using beam-line d22a) on the electromagnetic decays of resonances into muons came to an end in the first week of December. The new slow ejected proton beam will provide long bursts of particles (hundreds of milliseconds)

such as are required by electronic counter experiments. It will be guided to targets in the East Hall and several secondary particle beams can then be drawn from the targets. In addition to the increase in the number of available secondary beams, the beams will have high intensities enabling experiments to be completed quicker. Both these factors will serve to meet the increasing demand for counter experiments which has been one of the most significant developments in the PS experimental programme over the last two years.

Two experiments are scheduled to begin using e3 early in the new year. The first is an Aachen/CERN collaboration to gain further information about the interference of K^0 long-lived and K^0 short-lived mesons decaying into two charged pions (see, for example, CERN COURIER, October 1966, p. 195). In the new experiment, which will begin in the third week of January, the interference will be examined close to the target producing the K mesons. The second experiment will use, initially, an intense pion beam, with energies up to 20 GeV, to study the elastic

scattering at wide angles (large momentum transfer) of pions on protons in a hydrogen target. A further high energy, high intensity pion beam will be built to use e3 from July 1967.

In the northern half of the East Hall an additional beam-line (k8) to the 2 metre hydrogen bubble chamber is to be constructed for the end of 1967. It will provide low energy (1-2 GeV/c) K meson beams. It joins m6 (which has electrostatic particle separators and provides K meson beams of 2-4 GeV/c, pion beams of over 1 GeV/c and anti-proton beams up to 5 GeV/c), and u3 (which has radio-frequency particle separators and can provide K meson beams up to 10 GeV/c) as the available beams for the hydrogen chamber. After Easter 1967, an additional r.f. separator will be added to the u3 line (which will then be called u4) to give beams of K mesons and pions up to 14.5 GeV/c and anti-protons up to 17 GeV/c. All these beams are derived from the ejected proton beam e2.

The usual steady flow of collaboration experiments involving many European universities continues on the bubble chambers at CERN. Two which will begin early in the new year use the u3 beam and the 2 metre hydrogen bubble chamber. A Hamburg/Padua/Pisa experiment is scheduled to take 100 000 pictures with anti-protons of 12 GeV/c; an Aachen / Berlin / Bonn / CERN / Krakow / Warsaw experiment also has 100 000 pictures with negative pions at 16 GeV/c. The 2 metre chamber will stop operation mid-February and will then be prepared for experiments, scheduled for the summer, using deuterium as the chamber liquid.

Also among the coming bubble chamber experiments is the neutrino experiment, using the CERN heavy liquid bubble chamber, which was described in last month's CERN COURIER, together with its related counter experiment on muon conservation. These experiments are scheduled for March 1967 but already the fast ejected proton beam which produces the 'neutrino parents' is being used to test beam-line components.

When the neutrino experiment is completed in the autumn of 1967, the heavy liquid chamber will be moved to a new area which is being built behind the 2 metre hydrogen bubble chamber building. It will be used there for an experiment with high energy K mesons, which have passed through the 2 metre chamber. The interactions of these

This photograph taken at the end of November shows alignment of the magnetic channel in the northern branch of the slow ejected proton beam-line, e3, in progress. There are 10 deflecting units in this section of e3. In the background, a large bending magnet can be seen behind which the targets to provide the secondary particle beams will be placed. The beam-line is surrounded by the usual sheath of iron and concrete shielding to limit the radiation level in the rest of the East Hall.
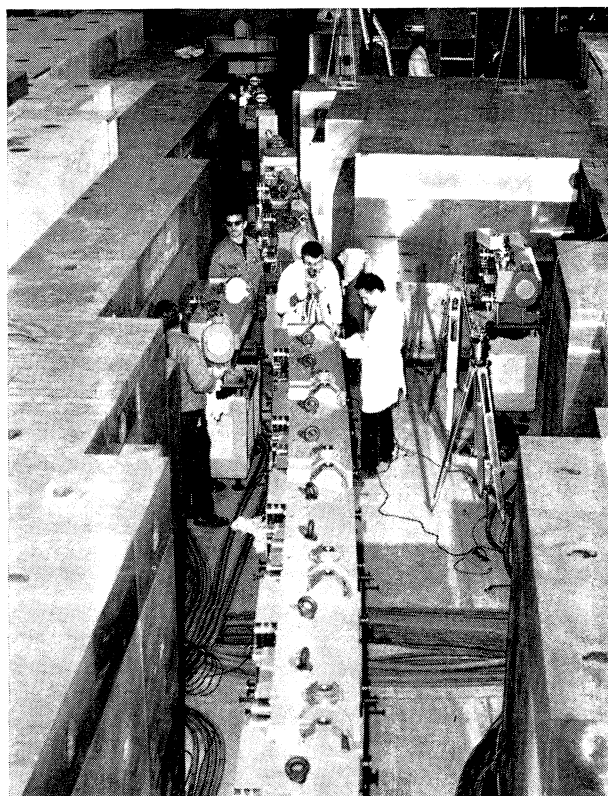
CERN/PI 287.11.66

high energy particles in the heavy liquid tend to produce a spray of particles in a very narrow cone in the direction of motion of the incoming particle. For this reason the experiment has become known as the 'JET experiment' and the area to house the bubble chamber as the 'JET area'.

Pions in medicine

The article on 'Elementary Particles in the Service of Man' in the October issue of CERN COURIER indicated that not many of the recently identified particles show promise of practical use at present. An exception is the negative pion. Beams of these particles may become useful for treatment of deep-seated inoperable tumours and some research on this possibility has been done at CERN.

The advantages of pions for the destruction of malignant tissue lie in the nature of their interaction with matter. First, the negative pions are most likely to interact at the end of their penetration paths and therefore, if their energy is carefully selected, they can pass harmlessly through healthy tissue to the region of the tumour. There, at the end of their range, they are 'captured' by nuclei and interact with nuclear matter emitting a high proportion of short-range heavily ionizing protons, alpha-particles and nuclear fragments. Since such reactions are particularly dominant in elements such as oxygen, carbon and nitrogen — the main components of tissue — a beam of negative pions offers a way of producing heavily ionizing radiation, highly localized in tissue.

Furthermore, it has been shown that tumour cells often suffer from a lack of dissolved oxygen, and this makes certain tumours resistant to X-rays and γ-rays which are the most commonly used for therapy. This resistance does not occur for heavily ionizing radiation like that created at the end of the range of negative pions.

No experimental work in treating malignant tumours with negative pions has been done yet. The pion beams available at present are too low in intensity for this purpose. For example, the beams from the CERN synchro-cyclotron would have to be increased in intensity by a factor of more than 100 to be of any practical use. In spite of this, several useful investigations of the feasibility of pion beams for therapy have already been carried out by the Health Physics Group at CERN. These investigations have covered depth and isodose distribution of a 70 MeV negative pion beam absorbed in water, average ionization densities at various penetration depths, and a study of the radiation doses from the nuclear reactions at the end of the pion range. This last problem is also of considerable interest for the radiation-protection of people using high-energy accelerators.

The results obtained so far look promising and are inspiring more experimental work, including tests using biological materials.

Computers

The CDC 6600 computer has been running steadily and the performance in recent weeks has been somewhat improved. Luciole and HPD I, the two types of automatic measuring machine for bubble chamber and optical spark chamber photographs, have been running successfully in parallel connected to the computer. The smaller CDC 3800 computer has been running very well almost continuously.

The organization of the users of the CDC 6600 series (VIM) held its fifth meeting in Dallas, USA in October. Most users appear to be well satisfied with the performance of the 6600, and many of them are planning to extend their computing facilities based on this computer. For example, the Brookhaven Laboratory is planning a system involving two 6600s connected to an extended core store.

CDC have agreed to extend the time for which CERN has an option on a 6400 computer until 15 January 1967. If the 6400 meets CERN's requirements on reliability it may be brought in as CERN's secondary computer with the advantage that it is fully compatible with the existing 6600. The 3800 will stay longer at CERN, certainly until well into 1967.

Inside the Faraday cage of the pre-injector of the proton synchrotron. At the extreme top right of the photograph, can be seen part of the upper terminal of the Cockroft-Walton generator which provides the voltage to give the protons their first acceleration to an energy of 550 keV. In the far corner, stands the reserve electrostatic generator. In the foreground, the improvised beam-loading compensation capacitor is being earthed.
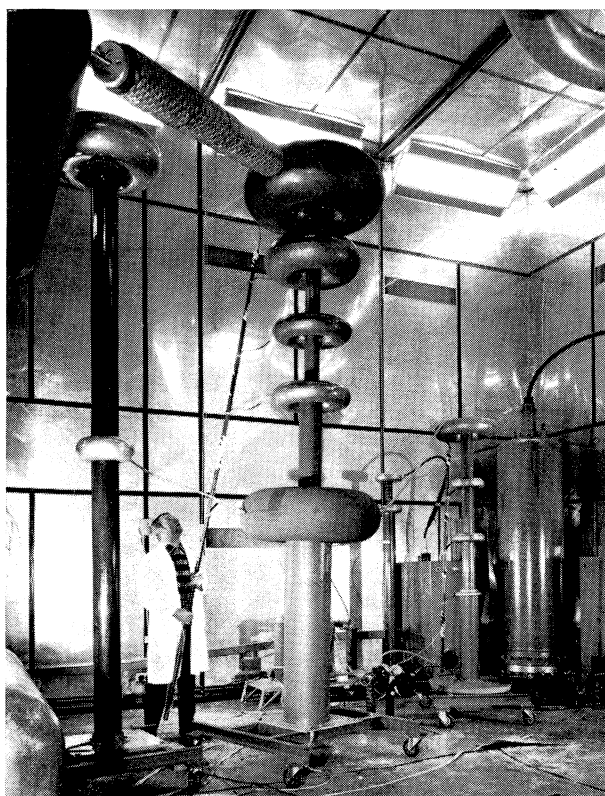
CERN/PI 124.11.66

New appointments

At the 33rd Session of the CERN Council on 15 December some major new appointments were made to senior positions in the organization of CERN, to take effect from the beginning of 1967. The most important of them was the election of Dr. G. Funke (Sweden) to be President of the Council in succession to Mr. J. H. Bannier (Netherlands) who has been President for the past three years and is therefore not eligible for re-election. Mr. Bannier has led the Council with great distinction and at this, his final session in the Chair, he presented his proposals in connection with the programme of work on the proposed 300 GeV accelerator which, by themselves, would earn him the admiration and gratitude of the community of European physicists. Both the Council and the Director General recorded their appreciation of his work and a fuller and more fitting tribute will be paid in the next issue of CERN COURIER.

Dr. Gösta Funke is no stranger to CERN since he has represented Sweden as delegate to the Council since the beginning of the Organization and has served as President of the Finance Committee. He is also active in other international organizations being President of the Council of ESO (European Southern Observatory) which is building a large European observatory in Chile. Dr. Funke lives in Stockholm where he was born in 1906. He studied physics there at the University and obtained his doctorate for research on the spectrum of acetylene. He then taught at the Technical College of Norrköping. In 1945, he moved into scientific administration becoming Secretary General of two research Councils in Sweden — the National Council for Scientific Research and the Council for Atomic Research. CERN has therefore an experienced and well qualified successor to follow Mr. Bannier.

H.E. Mr. J. Giusti del Giardino, from Italy, and Mr. J. Martin, from France, were elected as Vice Presidents of the Council in succession to Dr. Funke and Sir Harry Melville (U.K.).

Finally the Council approved the appointment of Mr. H. Laporte (France) as Head of the Technical Services and Buildings Division.

While on the subject of new appointments, we forward our congratulations to M. André Chavanne, who leads the Swiss delegation to the CERN Council, on his election to the Presidency of the Conseil d'Etat of Geneva from 1 December.

Advanced training course

At a small ceremony organized at CERN on 8 December, 32 crane drivers and car drivers working at CERN, received certificates at the end of an advanced training course which they had followed in 1965 and 1966. Several senior staff members of CERN and of the Ecole Supérieure Technique, Geneva attended the ceremony including E. Leimgrüber, Director of the Cours spéciaux du Bâtiment from the Geneva Cours Industriels du Soir, P. Tirion, ad interim Head of the Technical Services and Buildings Division, G. Vanderhaeghe, Head of the Training and Education Section at CERN, G. Leskens, representing the Safety Section, J. Mattheuws, representing the Personnel Division and other lecturers from the Cours Industriels du Soir and from CERN.

This course was organized jointly by the Training and Education Section and the Geneva Cours Industriels du Soir. It has provided the CERN drivers with 44 hours of theoretical and practical advanced training. They took three examinations to achieve their certificates.
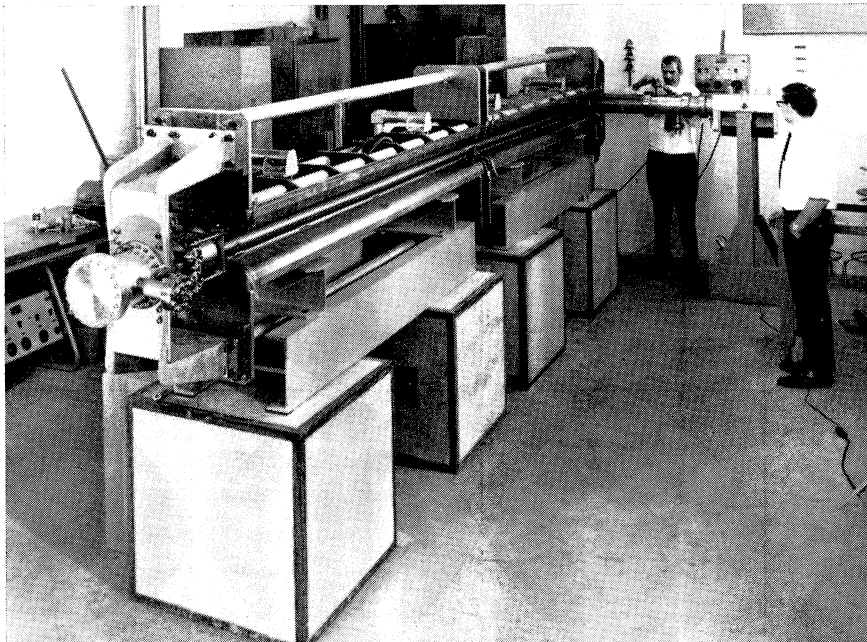
Tests continuing on the prototype vacuum chamber for the intersecting storage rings. It is here mounted inside the dummy of a long magnet unit. In the right-hand top corner can be seen an ion pump, two Bayard-Alpert gauges and a calibrated orifice for gas desorption measurements.

CERN/PI 12.11.66

The course was designed to enable the crane drivers and car drivers to acquire, by a varied course of daily practice, an increased familiarity with all the situations they are likely to meet in their work. Its aim was to complete their training, for most of them by practical experience, and to enable them to acquire systematically the knowledge which will help them to meet the requirements of their increasing work at CERN, especially in their site work and in the manipulation of their vehicles.

KN bumps

In the October issue (p. 196) we reported an experiment done by the Goldhaber group at Berkeley which analysed bubble chamber photographs of positive kaons on hydrogen. Their results indicated that the apparent resonance seen in the positive kaon-proton cross-section in an earlier Brookhaven experiment using electronic counters, could be explained, at least for the most part, as being due to production of other particles — an inelastic effect as opposed to a true resonance. This was conforting since the positive kaon-proton and positive kaon-neutron 'resonance', also observed in the Brookhaven experiment, would require an underlying model which uses more than three quarks. We reported at that time that there was insufficient data on the positive kaon-neutron system to explain away that 'resonance' in a similar way.

Results from a CERN experiment were reported at the Berkeley Conference which included information on this problem. They have since appeared as a letter in Nuovo Cimento.

The CERN experiment was done by the 'K⁺ group' which was a collaboration between CERN and the Laboratoire des Hautes Energies, Institut Interuniversitaire des Sciences Nucléaires, Brussels. They used the 81 centimetre hydrogen bubble chamber and positive kaon beams with momenta from 3 to 5 GeV/c. They observed a bump at 1.2 GeV/c positive kaon momentum which could be mistaken for a resonance. But they were able to show that it consists of contributions from four two-body interactions which amounts to the same explanation as that given by Goldhaber in his analysis of the positive kaon-proton system.

Furthermore, an extensive search for the possibility of $Y = +2$, $B = +1$ resonance has been completed by the K^+ group in the analysis of about 30 000 identified interactions. No significant evidence for such a resonance was found.

Colloquia

Two colloquia will be held at CERN in January. At the first, on Tuesday 24 January, the speaker is Professor J. Volger from Philips, Eindhoven and the subject of his talk is 'Induction Phenomena in Superconductors'. Some previous knowledge of physics will be assumed in this talk. At the second, on Thursday 26 January, the speaker will be Professor E. Gatti from the Istituto di Physica, Milano.

Tribute to Dr. Schoch

It was announced on 21 November that Dr. Arnold Schoch, Leader of the Accelerator Research Division is to leave CERN to take up an appointment as Professor at Karlsruhe. At the end of the 33rd Session of the CERN Council, the President, Mr. J. H. Bannier paid particular tribute to Dr. Schoch and expressed the gratitude of CERN for his work, especially for

The tuning-capacitor assembly of the r.f. cavity for the intersecting storage rings. It consists of 23 vacuum capacitors, 22 ferrite rings and 2 vacuum relays all positioned around the metal-ceramic vacuum seal that forms the accelerating gap.

CERN/PI 226.10.66

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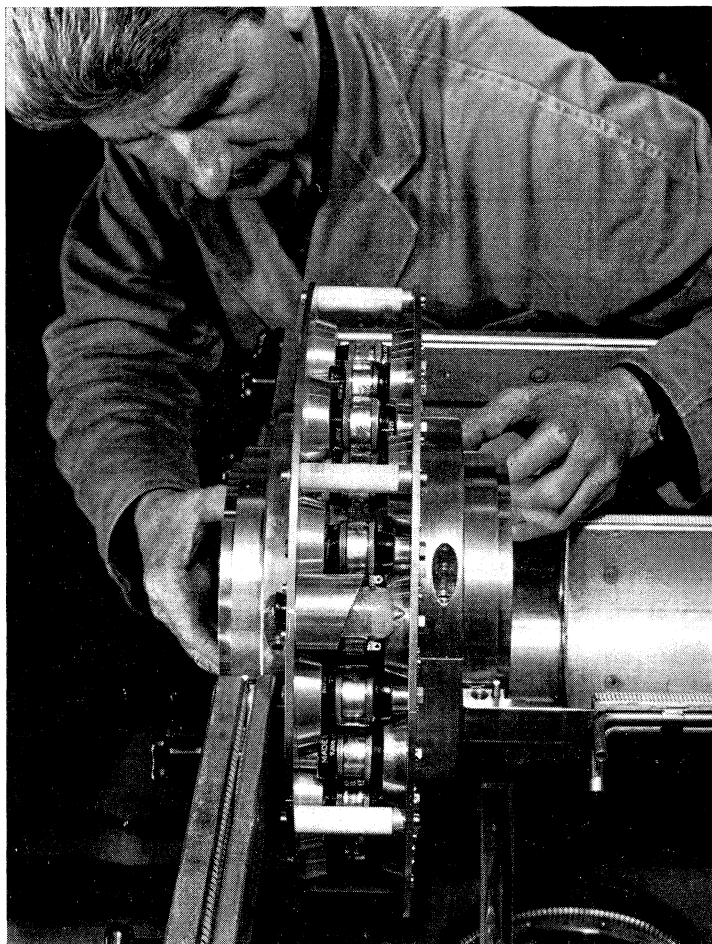
the important contribution he has made to the study of future accelerators.

Dr. Schoch arrived at CERN in 1954 from the University of Heidelberg. After some years in the Proton Synchrotron Division he became the first Leader of the Accelerator Research Division when it was formed in 1961 from the accelerator research group of the Proton Synchrotron Division. For the past six years, the AR Division has been mainly concerned with the next generation of accelerators. It produced the first design studies for the intersecting storage rings now being built at CERN and also for the proposed European 300 GeV accelerator, did the preliminary work on the radio-frequency separators, operated the electron storage ring model, CESAR and carried out other 'general studies' in accelerator physics. It has been unique in CERN in having three Division Leaders, K. Johnsen, A. Schoch and C. J. Zilverschoon, who jointly assumed responsibility for policy decision and in turn assumed the administrative responsibilities of Division Leader for one year at a time.

When the ISR project was approved by the CERN Council at the end of 1965 the ISR Division (now the ISR Construction Department) was set up under Dr. Johnsen with Dr. Zilverschoon as Deputy Division Leader, to take charge of the project. Most of the people involved in the preliminary ISR work had also concerned themselves with the 300 GeV project and it was therefore logical to include the continuing work on the 300 GeV machine also under the ISR Department. Thus the activity of the AR Division was substantially reduced.

Following Dr. Schoch's departure the remaining activities of the AR Division are to be transfered to the Intersecting Storage Rings Construction Department. The work will be divided into two groups within the ISR Department. One, under M. Pentz, will continue research with CESAR until the end of 1967, when it is planned to close down the model. The other group will be under F. Schneider concerned with general studies.

We forward our very best wishes to Dr. Schoch for his future career and echo the tribute of Mr. Bannier for the part he has played in some of the most important work emerging from CERN in recent years.

BOOKS

Theory of Cyclic Accelerators, by A. A. Kolomensky and A. N. Lebedev, translated from the Russian by M. Barbier (CERN); (Amsterdam, North-Holland Publishing Company, 1966, 420 pages, guilders 48).

The enhanced performance of cyclic accelerators and the better understanding of them belong together. Although some phenomena, such as space charge, are still under investigation, the basic concepts are well established. The purpose of this book is to summarize these concepts and present a unified theory of cyclic accelerators which was not readily available at the time it was first published (1962). Even now, the book is outstanding in the thoroughness with which the simplified equations, which are normally used, are developed from the basic laws.

The first chapter reviews the development of accelerators and their role in modern physics, and outlines the basic principles. These are taken as: the characteristics of transverse (betatron) motion, the longitudinal (synchrotron) motion, injection and ejection. The next three chapters treat the first two of these phenomena in more detail. Chapters 2 and 3 deal with betatron motion in ideal and perturbed magnetic fields respectively. Unfortunately, the notions of emittance and acceptance are omitted, and the treatment of numerical methods is rather brief. The beam behaviour under adiabatic variation of parameters and in the presence of linear and non-linear resonances is well treated. Chapter 4 is the last of the chapters devoted to basic principles and contains the theory of longitudinal motion (synchrotron oscillations, betatron acceleration).

With Chapter 5, the subject matter becomes more specialized, dealing with the synchrotron radiation emitted by electrons in cyclic accelerators, for which the theory is complete. These effects are of prime importance since they override the normal adiabatic damping. Similarly, effects, such as scattering by residual gas, have to be taken into account. This is one of the topics covered in Chapter 6 under the general heading of 'Particle losses caused by random perturbations...' The final chapter is devoted to the distinctive features of the various types of accelerator. After a concise description of the more conventional ones, the theory of the FFAG types and stochastic acceleration is outlined.

The appendices contain a few titbits such as the three-dimensional equations of motion, which in their linearized form are the basis for the theory of betatron motion.

The text of book is sufficiently detailed to lead both the student and the specialist to a deeper understanding of the phenomena. The literature quoted and the references to existing accelerators have not been updated since the original publication. This is not a serious drawback because the book deals with well established concepts. There are many examples and diagrams to illustrate and explain the theory. Accelerator physicists and engineers will certainly find it an advantage to have this book available.

W. H.

Nuclear Interactions of the Hyperons, by R. H. Dalitz (Oxford University Press, 1965, 34 sh.).

The field of hypernuclear spectroscopy is still open, because comparatively little detailed information has been obtained from the small number of events analysed so far.

Due to the very short lifetime of the hyperons (about 10^{-10} s or less), the path-length traversed by a hyperon is very short compared with the average path-length for collision in liquid hydrogen. The study of the hyperon-nucleon interaction is therefore very difficult to perform directly from hyperon-proton collisions. Instead, the hyperon-nucleon interaction can be studied indirectly by investigating the binding of Λ hyperons in nuclei. Hopefully, these studies can also yield unique information on nuclear structure.

Regarding the experimental situation, it is perhaps significant that all the data and discussion in the lectures in this book are generally relevant today, in spite of the fact that the lectures were given in 1961. The book serves as an excellent introduction for those who want to enter this field, theoretically or experimentally, or for those who want a comprehensive review of the present state of the art.

The lectures are divided into two parts: one which discusses the binding-energy data phenomenologically, and one where the hyperon-nucleon interaction is discussed by use of more sophisticated methods.

The ($_\Lambda$H^4, $_\Lambda$He^4) hypernuclei form an isospin doublet (I $= 1/2$). Any difference in the binding-energies for these mirror nuclei would provide a test of charge symmetry in the Λ-N interaction. The data given in the lectures suggests a slight, but not significant, difference in the binding of the Λ hyperon in the nuclei $_\Lambda$H^4 and $_\Lambda$He^4. However, the values are based on very poor statistics (1961). Binding-energy values quoted at the Varenna Summer School (July 1966) are obtained from much better statistics and they indicate that charge symmetry is conserved in the Λ-N interaction. However, B$_\Lambda$ derived from many-particle π^- decay modes are still systematically lower than B$_\Lambda$ from the two-body mode. Until this point has been clarified, no safe statement can be made about charge symmetry conservation.

The importance of γ-ray spectroscopy of hypernuclei is emphasized, as a means of obtaining information of the energy-level structure in the hypernuclei. $_\Lambda$Li^7 is the lightest hypernucleus for which we can be reasonably certain that stable states exist.

The second part of the lectures contains a thorough theoretical discussion of the hyperon-nucleon forces. Much of the discussion is treated in the light of unitary symmetry. No calculation of the Λ-N interaction, to include all the meson exchanges appropriate to SU (3) symmetry, has yet been performed.

At the end, the author gives a long list of problems to be studied in the future. $_{\Lambda\Lambda}$He^6 is given as an example of a nucleus by which the Λ-Λ interaction can be studied. Very recently, the $_{\Lambda\Lambda}$He^6 nucleus was uniquely identified at UCLA. It is of great interest to compare calculations and experimental data for the Λ-Λ and Λ-N interaction. The calculated scattering parameters are quite sensitive to the hard-core radius assumed for these interactions.

It is usually assumed that the same hard-core radius holds for the Λ-Λ and the Λ-N systems in the ^{1}S$_0$-state. Possible reasons why the present hypernuclear calculations may be

inadequate are the presence of a tensor component, a strong three-body ΛNN potential, etc. All these aspects are discussed in the lectures.

An interesting proposal for the study of heavy hypernuclei is mentioned. Negative K mesons would be captured in uranium which fissions; one of the energetic fragments would presumably be a large Λ hypernucleus, with a considerable path-length in an emulsion. Studies of this type of interaction and many others must wait for more intense K$^-$ beams. In the meantime, one can prepare oneself efficiently by reading the lectures of Professor Dalitz.

S. Nilsson

'Introduction à l'optique corpusculaire', by Noël J. Félici (Paris, Gauthier Villars, 1965; 12 Fr. fr.).

This short book (130 pages) is part of the general effort being made in France to modernize the old teaching methods symbolized by those large, indigestible and exhaustive treatises which all former students of the Ecole Polytechnique remember with a sinking heart.

After a short introduction, the writer deals with variation principles, which he applies first to electrostatic and then to magnetic optics. This is followed by a series of practical examples divided into three sections — Prisms; The effect of space charge, and Quadrupole lenses. The conclusion covers Liouville's theorem and its applications and takes up only four pages.

The author is an expert on electrostatics, and this bias perhaps makes the book less applicable to the everyday problems in high-energy physics at CERN, but it throws new light on common problems. He uses elementary examples, gives full mathematical treatment and keeps close to the physical meaning of the different principles which he applies. This method is all the more valuable since it provides a series of examples of simple applications of variation principles.

The introduction of the principles of Maupertin and Hamilton is of special interest. However, it is regrettable that there is no list of references, all the more so since this is an introductory book.

In conclusion, it can serve first as an introduction and then as a reference book for the application of modern methods of calculation to a series of elementary problems. It does not cover the study of the more complex problems involved in accelerators. It is presented in a format which makes it easy to consult.

Y. B.

Radioactivity in human diet, edited by R. Scott Russell (Oxford, Pergamon Press Ltd., 1966, 60 sh.).

Various authors, each a specialist in a particular aspect of the subject, have presented the latest data on radioactive elements, both natural and artificial (from fall-out), in human food. Food chains are being investigated, both on dry land and aquatic. The entry of radioactive elements in soil, sea water and fresh water, as well as their build-up in plant and animal foods and their retention in the human body are studied quantitatively. This book is an excellent review of the subject which should interest doctors and physicists and should also interest politicians.

M. Barbier

Also received:

The theory of neutron slowing down in nuclear reactors, by J. H. Ferziger and P. F. Zweifel (Oxford, Pergamon Press Ltd., 1966, 80 sh.).

Quantum statistics and cooperative phenomena, by J. G. Kirkwood, edited by F. Stillinger (New York, Gordon and Breach Science Publishers, 1965, $ 4.95 paper, $ 8.00 cloth).

Analytical chemistry, vol. 6, edited by D. C. Stewart and H. A. Elion (Oxford, Pergamon Press Ltd., 1966, 90 sh.).

Tritium and its compounds, by E. A. Evans (London, Butterworth and Co., 1966, 100 sh.).

Reviews of plasma physics, edited by M. A. Leontovich, translated by H. Lashinsky (New York, Plenum Publishing Co., 1966, $ 12.50).

Law and administration vol. 4, edited by J. L. Weinstein (Oxford, Pergamon Press Ltd., 1966, 100 sh.).

An atlas of models of crystal surfaces, by J. F. Nicholas (New York, Gordon and Breach Science Publishers, 1965).

Mechanical working of steel 2, edited by T. G. Bradbury (New York, Gordon and Breach Science Publishers Inc., 1965, cloth $ 27.50, paper $ 14.50).

The Sorby centennial symposium on the history of metallurgy, edited by Cyril Stanley Smith (New York, Gordon and Breach Science Publishers Inc., 1965, professional edition).

Precipitation from iron-base alloys, edited by G. R. Speich and J. B. Clark (New York, Gordon and Breach Science Publishers Inc., 1965, cloth $ 21, paper $ 8.50).

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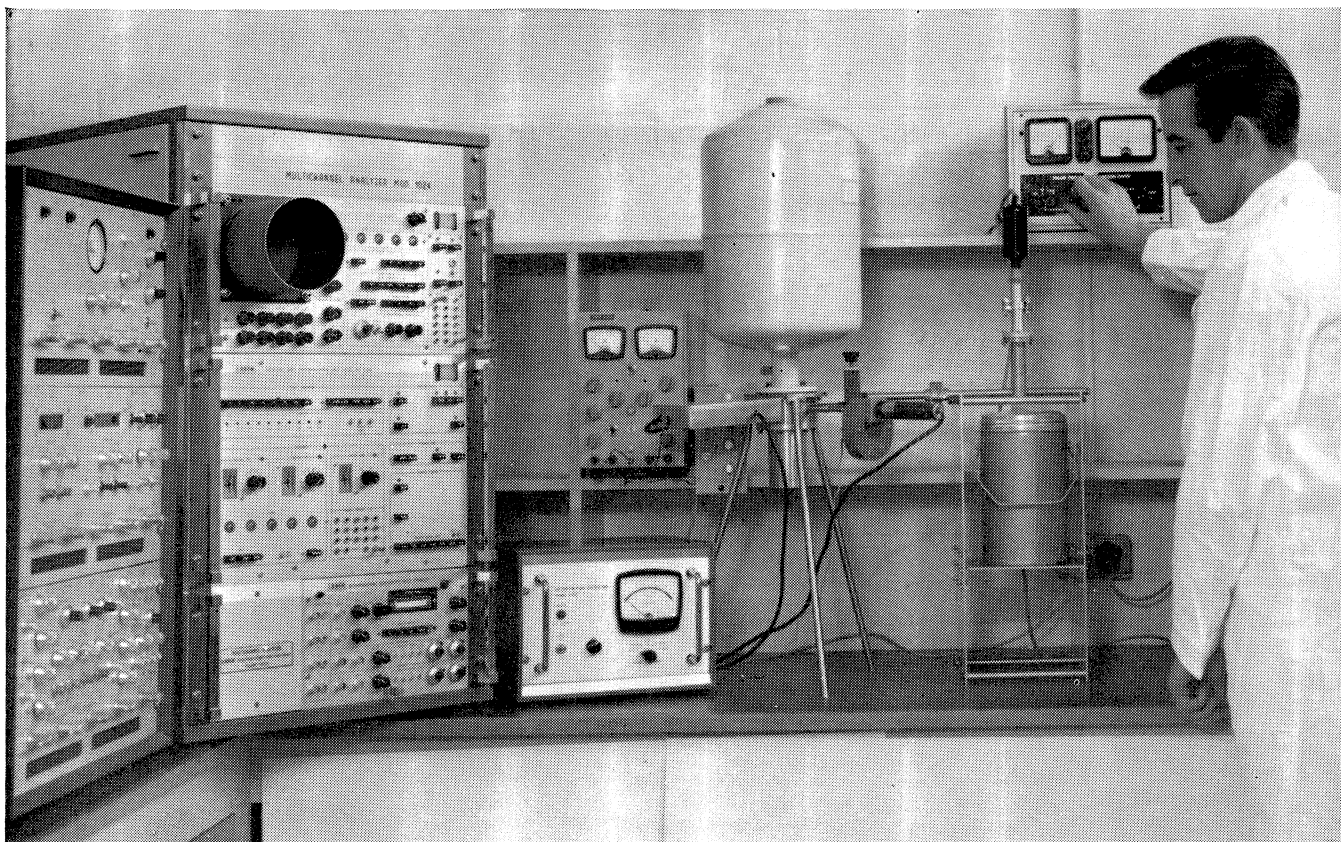
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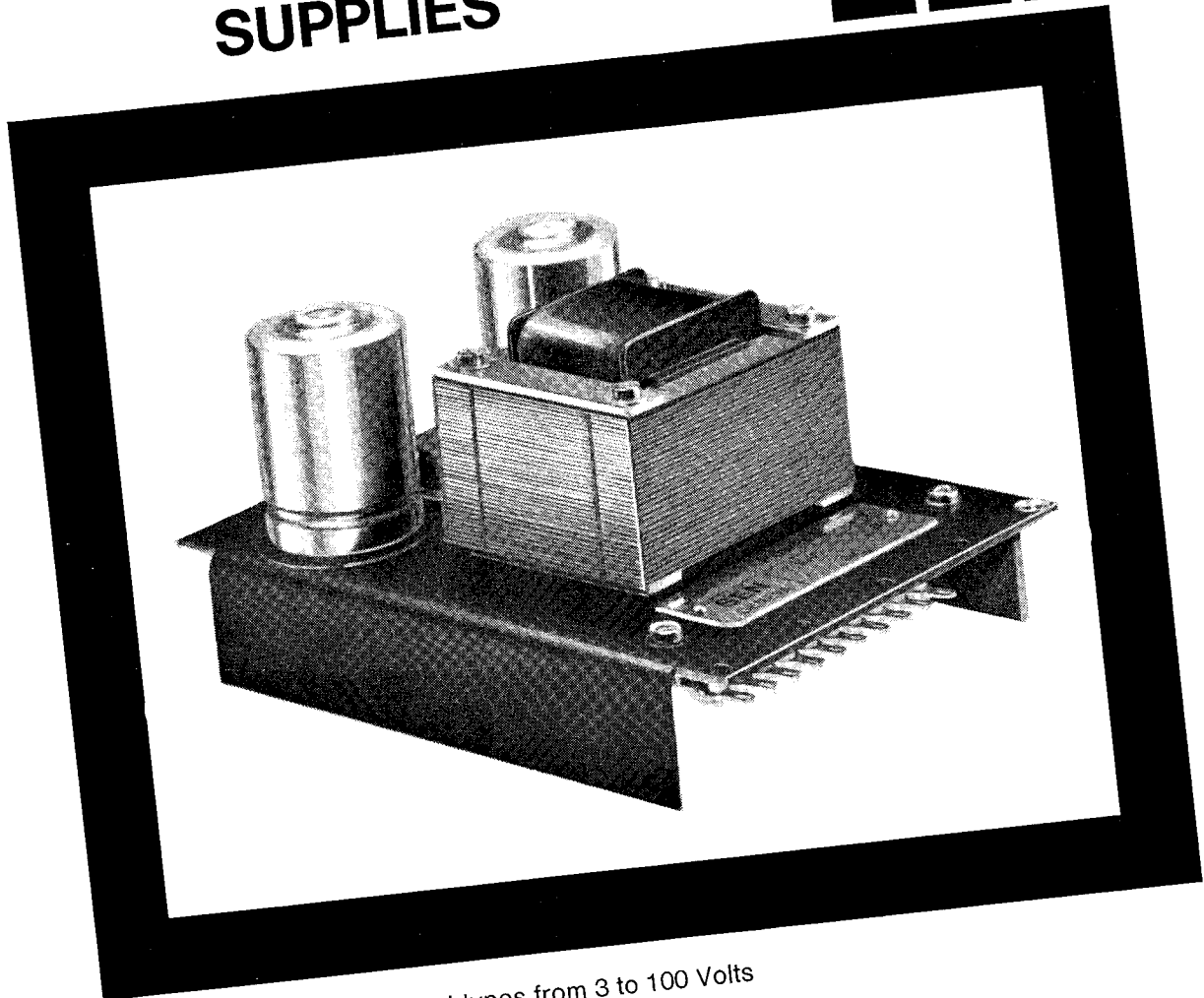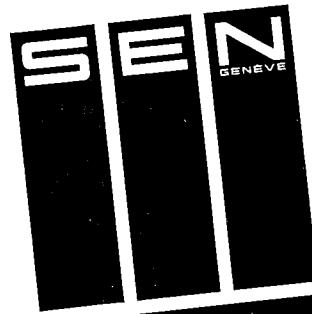
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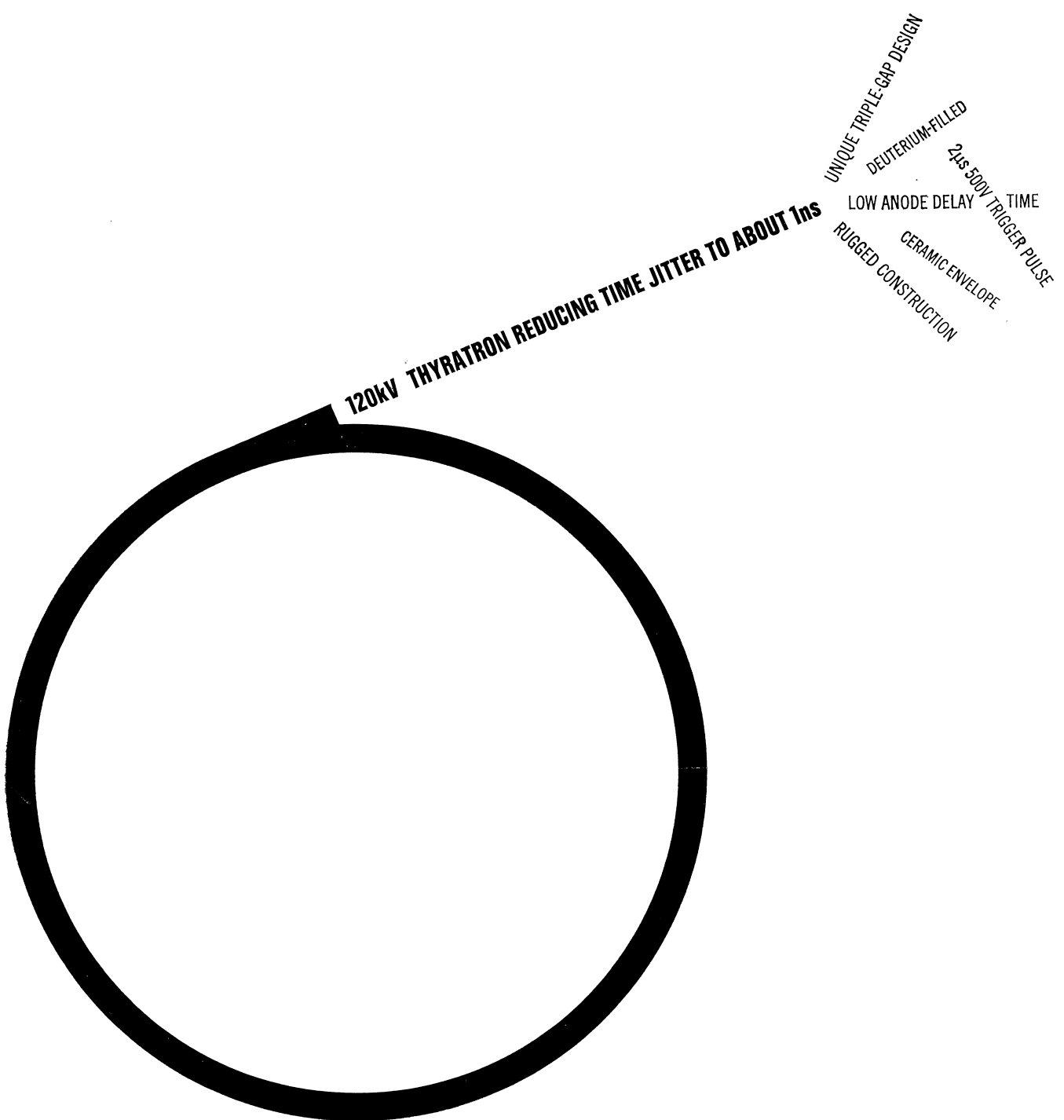
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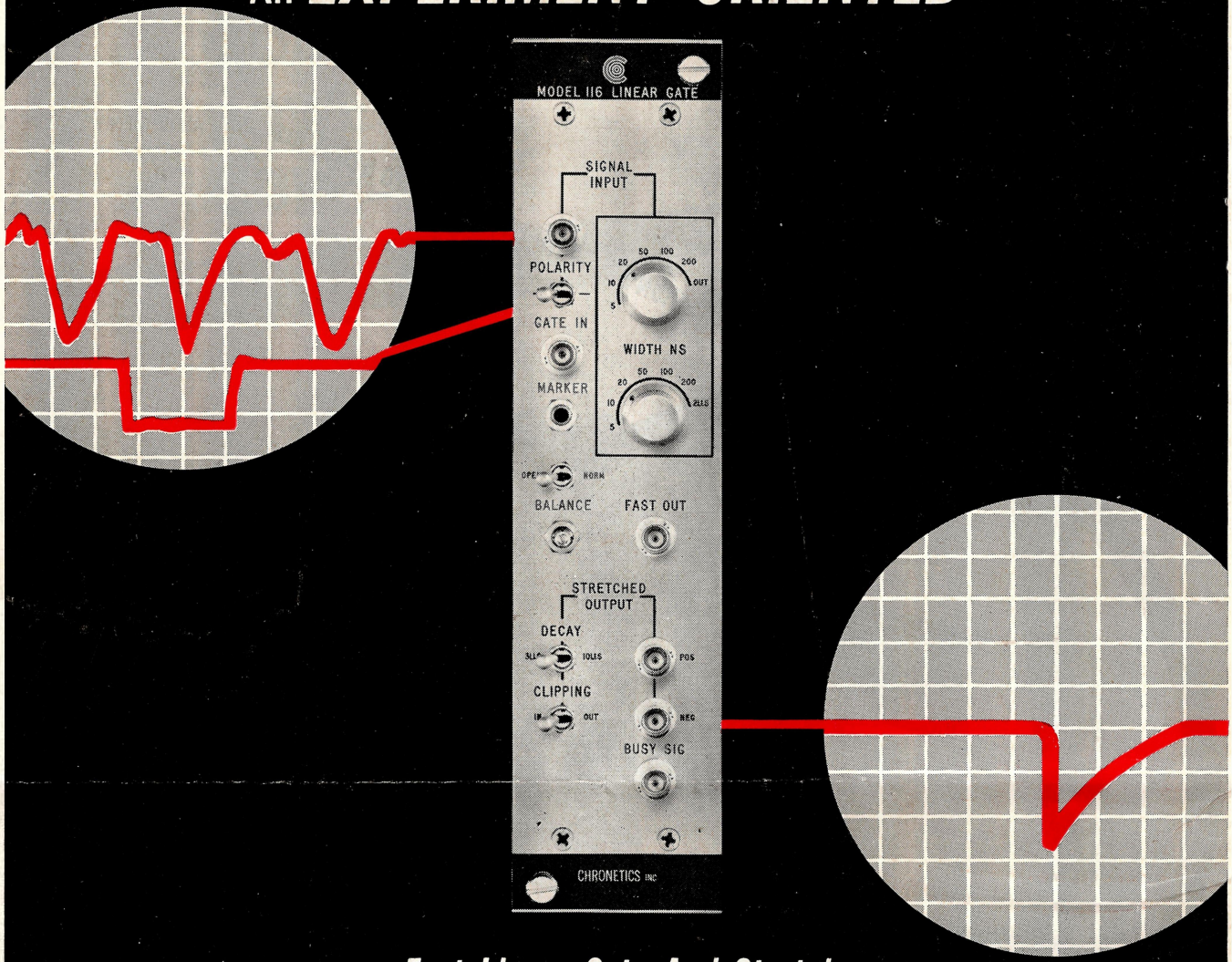
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