CERN COURIER

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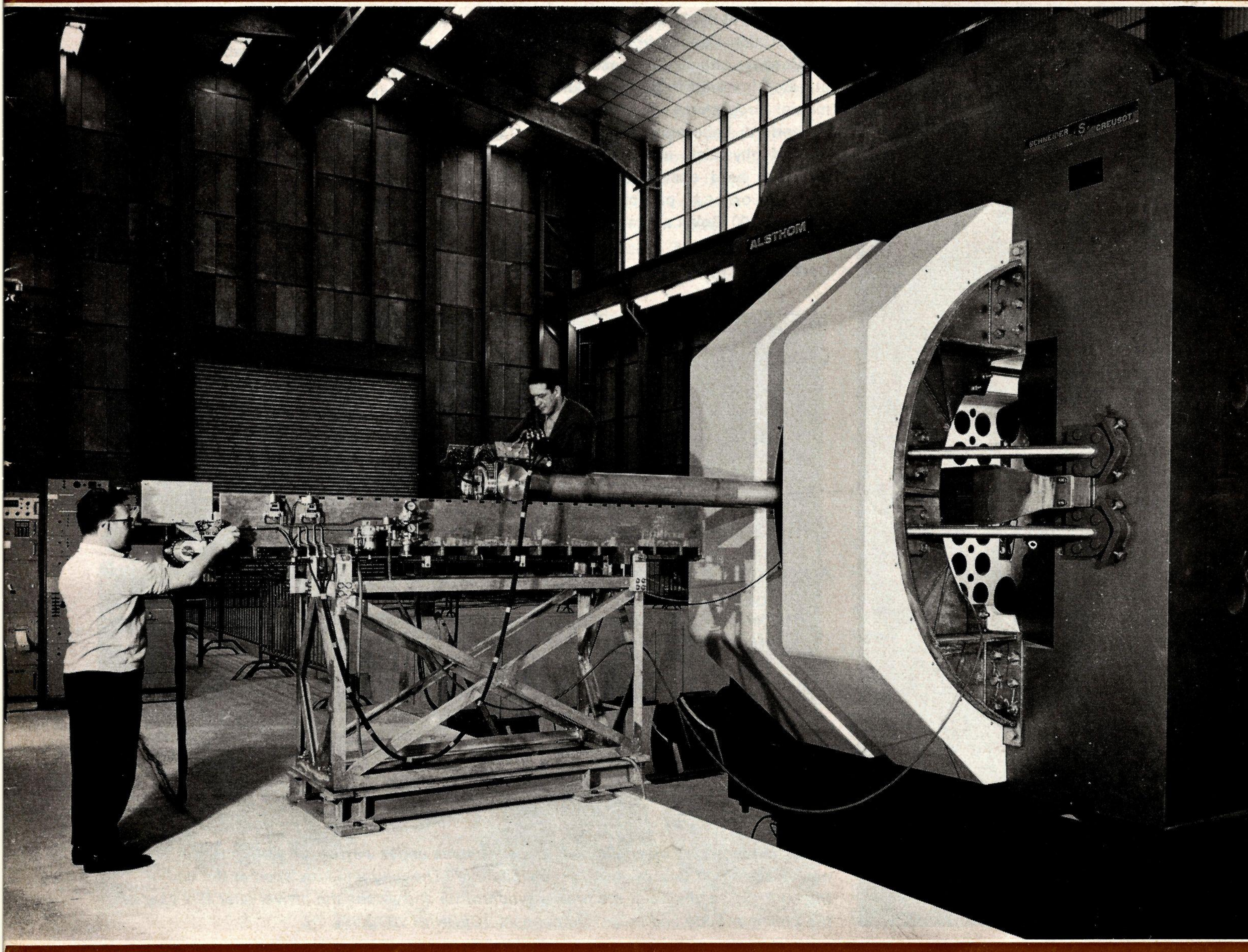
European Organization for Nuclear Research



CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientifice and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of sub-nuclear physics. This branch of science is concerned with the fundamental questions of the basic laws governing the structure of matter. CERN is one of the world's leading Laboratories in this field.

The experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). At the latter machine, large intersecting storage rings (ISR), for experiments with colliding proton beams, are under construction. Scientists from many European Universities, as well as from CERN itself, take part in the experiments and it is estimated that some 1200 physicists draw their research material from CERN.

The Laboratory is situated at Meyrin near Geneva in Switzerland. The site covers approximately 80 hectares equally divided on either side of the frontier between France and Switzerland. The staff totals about 2650 people and, in addition, there are over 400 Fellows and Visiting Scientists.

Thirteen European countries participate in the work of CERN, contributing to the cost of the basic programme, 235.2 million Swiss francs in 1969, in proportion to their net national income. Supplementary programmes cover the construction of the ISR and studies for a proposed 300 GeV proton synchrotron.

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Comment

A good month for collaboration. This issue is liberally sprinkled with news of people getting together who ten years ago would have been doing their research apart. In some areas this is partly sheer necessity as the scale and cost of research equipment has climbed, but also, as Professor Bernardini remarked about the speed with which the European Physical Society came into being, 'the seeds were already sown'.

On collaboration at sub-nuclear physics research centres, there is the historic event of the publication of results from the first CERN/Serpukhov experiment carried out at the 76 GeV accelerator in the Soviet Union. Reports from Dubna and ITEP in Moscow show how these two centres are also involved in the Serpukhov experimental programme. The report from the Rutherford Laboratory indicates how far the UK physicists are prepared to go, in terms of hard decisions on the national scale, in order to participate in the international 300 GeV Laboratory.

Also there has been the Inaugural Conference in Florence of the European Physical Society. The Conference was a great success. There was some really exciting physics reported and for physicists to have their eyes opened to progress in fields other than those in which they are working was a refreshing and valuable experience. The Society could usefully organize this sort of meeting, where top-class people present concise and penetrating reviews of their field, regularly — perhaps at three or four year intervals. In terms of collaboration also the Conference was a great success. Strong contingents of physicists were present from practically every country in Europe.

These events may not be headline news and they take place in a world where conflict between countries is still the norm. But if this situation is to be changed it is likely to evolve from many limited efforts in collaboration like these.

Contents

Cover photograph : Magnetic field measurements under way on the large magnet of the new heavy liquid bubble chamber 'Gargamelle'. The magnet is installed at the end of the neutrino beam-line at the proton synchrotron and awaits the arrival later this year of the chamber body and other components. (CERN/PI 239.3.69)

CERN News

Equipment from CERN installed in the experimental hall at the Serpukhov 76 GeV accelerator. On the left, the large horizontal cylinder of a DISC Cherenkov counter can be distinguished; in the centre are racks of associated electronics. The secondary particle beam comes in from the right.

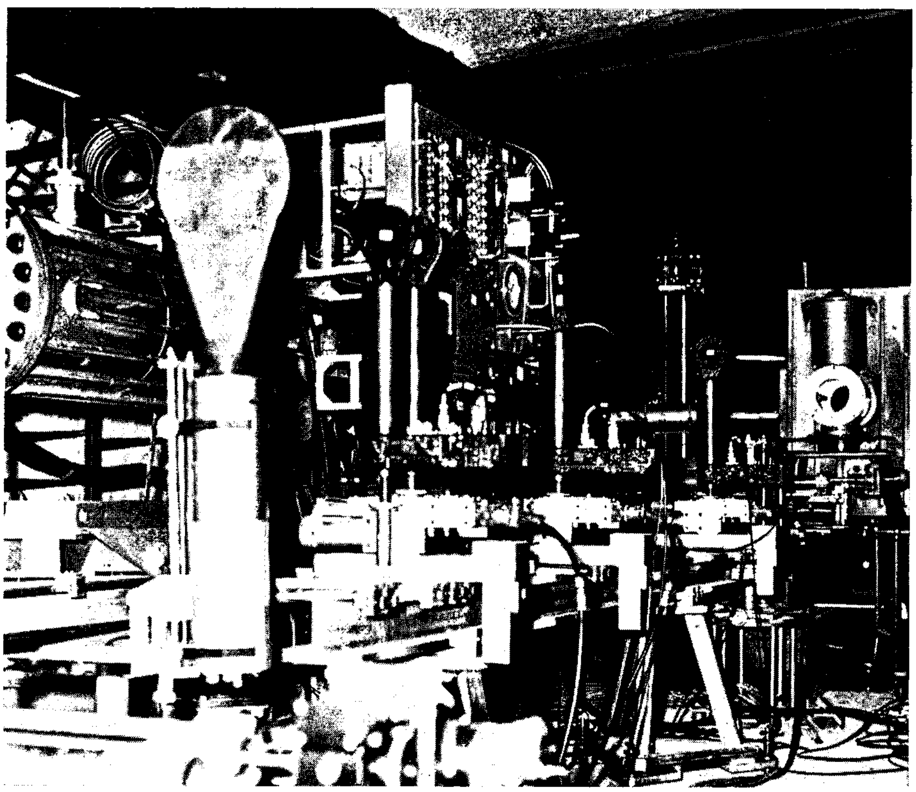
(Photo Serpukhov)

Particle yields at Serpukhov

Results from the first collaborative experiment to be carried out at the Serpukhov 76 GeV proton synchrotron by a joint team of CERN and Soviet scientists were reported in Physics Letters, 31 March*. The experiment aimed to measure particle 'yields' (the numbers of secondary particles of different types yielded when the accelerated beam bombards a target) at the higher energies available from the Serpukhov machine.

These measurements are important for several reasons. They provide more data on particle production processes at high energy, extending the extensive measurements carried out up to the energies (about 30 GeV) of the Brookhaven and CERN machines; they are essential for the planning of the future experimental programme at Serpukhov to enable the intensities of secondary particle beams at the machine to be predicted with good accuracy; and they also serve as a useful intermediate step, between 30 GeV and several hundred GeV, to estimate the particle yields which will be available at the Batavia 200 GeV and the European 300 GeV accelerators. At the same time, the measurements served to test detection techniques for identifying particles of higher energy.

The experiment was carried out in the last few months of 1968. For most of the time, the synchrotron was operated at 70 GeV with an average beam intensity of 3×10^{11} protons per pulse and a pulse rate of 1 per 7 s. Cylindrical aluminium targets (21 mm long and 2 mm diameter) were used in three positions inside the magnet ring so that the beam-line, where the detectors were installed, could take the negative secondary particles coming off in the forward direction or at very small angles (particles emitted at a tangent to the ring) at three momenta 40, 50 and 60 GeV/c depending on the target position. Some data was also collected with the synchrotron running at lower energy (at 20 GeV and then at 43 GeV) to tie up with the information from existing machines and to provide Serpukhov with knowledge of beam intensities for experiments below full energy.



The composition of the beam was measured by various combinations of Cherenkov counters of different design (as many as four independent detection techniques could be used which provided a useful cross-check of the measurements). There were two differential Cherenkov counters ('DISCs'), which record particles in a narrow velocity range (detecting the Cherenkov light emitted within a small angular spread), and three threshold Cherenkov counters which record all charged particles with velocities above a selected value (the Serpukhov team have developed excellent threshold counters). It was demonstrated in the course of the experiment that Cherenkov counter techniques provide a clear identification of particles up to the top momentum investigated (60 GeV/c) and they can confidently be incorporated in experiments planned for the 200 and 300 GeV machines.

The yields of negative pions, negative kaons and antiprotons were measured, and the main results can be expressed briefly as follows:

The yield of pions was as expected, but the kaons and antiprotons were less abundant than expected. (Approximate figures for a 70 GeV incident beam of 10^{12} protons and secondary particles at 50 GeV are — 10^5 negative pions, just over 10^3 negative kaons and just under 10^2 antiprotons.

The yields decrease as the secondary particle beam energy increases, the decrease being at about the expected rate for pions but faster than expected for kaons and antiprotons. This means that the ratio of kaons and antiprotons to pions falls off rapidly with increasing energy which has important implications when it is necessary to sift out one type of particle from the others.

By 'expected' is meant the prediction of a particular model (called the statistical model) of the process of secondary particle production. This is one of several models, but the one which has been most thoroughly worked out so that it gives figures for Serpukhov energies. It con-

Two beam-lines coming from the Serpukhov accelerator (the synchrotron itself curves round top left). The beam-lines diverge from a bending magnet, the one on the left leading to the joint CERN/Serpukhov yields experiment and the one on the right to the Serpukhov quark experiment. The first collimators on each line can be seen at the bottom of the photograph.

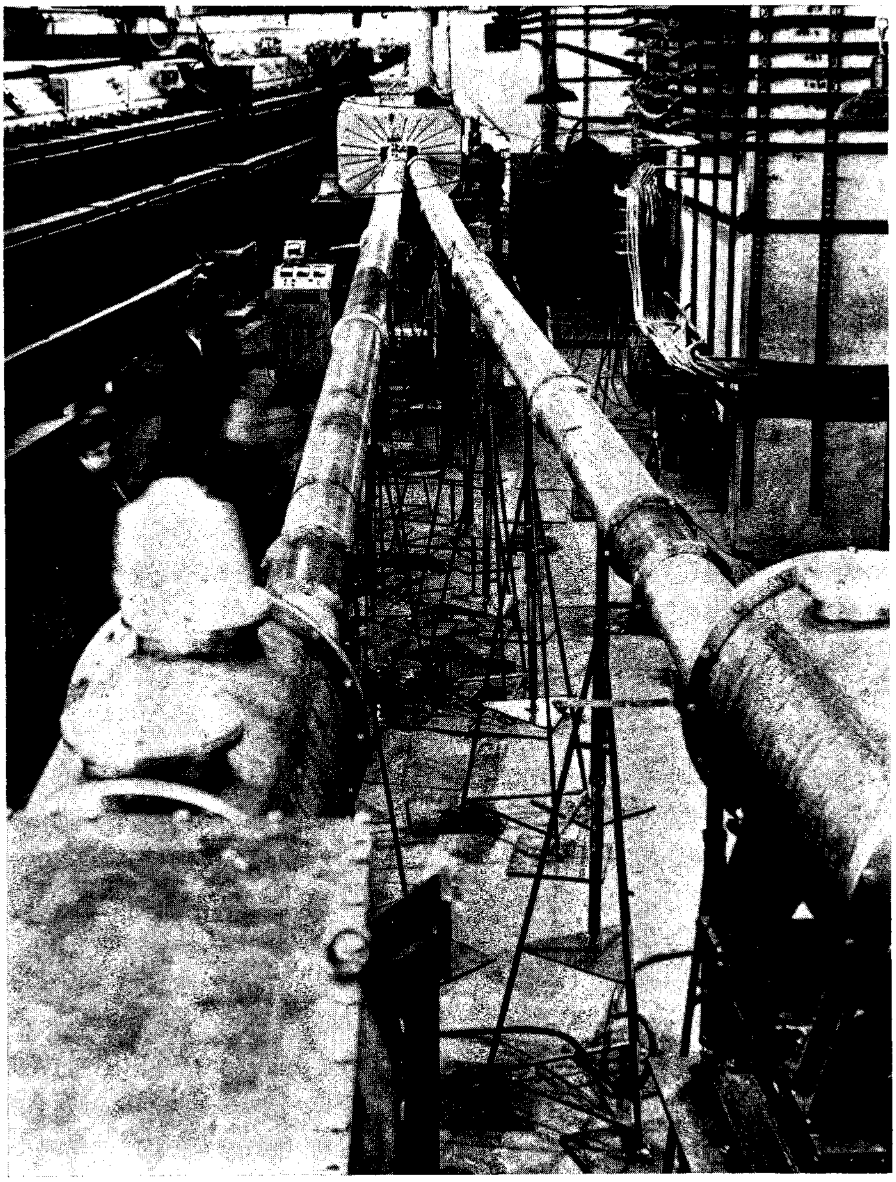
(Photo Serpukhov)

siders all the possible interactions (many hundreds of them) which can take place when a high energy proton collides with a nucleon in the target and the probability of each of the interactions. A statistical calculation then gives figures for what can be expected to come out of the target on average. The results of the experiment imply that further refinement of the model is needed.

The joint team is now doing total cross-section measurements — taking a secondary beam and firing it at a hydrogen target to find the probability of a beam particle interacting with a proton (a hydrogen nucleus).

The collaboration of scientists from Serpukhov and CERN has been working smoothly and rapidly and has provided an excellent start to the new venture of co-operation between the two Laboratories.

* 'Negative particle production at the 70 GeV IHEP accelerator'



Yu.B. Bushnin, S.P. Denisov, S.V. Donskov, A.F. Dunaitsev, Yu.P. Gorin, V.A. Kachanov, Yu.S. Khodirev, V.I. Kotov, V.M. Kutyin, A.I. Petrukhin, Yu.D. Prokoshkin, E.A. Razuvaev, R.S. Shuvalov and D.A. Stoyanova (Institute for High Energy Physics, Serpukhov). J.V. Allaby, F. Binon, A.N. Diddens, P. Duteil, G. Giacomelli, R. Meunier, J.-P. Peigneux, K. Schlüpmann, M. Spighel, C.A. Stahlbrandt, J.-P. Stroot and A.M. Wetherell (CERN).

Towards the 300 GeV Laboratory

Dr. J.B. Adams arrived at CERN at the beginning of April to take over the Direction of the 300 GeV Laboratory programme.

The immediate task is to finalize the documentation on which the Council will base its decisions. The documents include, in particular, the exact definition of the construction programme for the new laboratory and further information on the proposed sites.

Several of the detailed design aspects of the 300 GeV accelerator have been studied during the past year in Working Groups set up by the 300 GeV Steering Committee, chaired by Professor E. Amaldi. The membership of these Groups includes CERN staff and is mainly composed of staff belonging to the various national accelerator groups in Europe. The Convenors of the Working Groups met at CERN towards the end of April to present the results of their studies and to consider further work for the remainder of this year. One Working Group has been reviewing the research on the Electron Ring Accelerator technique which is under investigation in various laboratories in the Soviet Union, USA and in Europe.

Assuming that the Council decisions on the new Laboratory, its programme and its location, are taken before the end of the year, the team to be responsible for the construction phase will be built up first at CERN, Meyrin. They will transfer to the new site probably about a year after the Council decision to launch the programme. The final design of the Laboratory and the accelerator, which depends to some extent on the characteristics of the chosen site, will be determined during that year, using the facilities which exist at the CERN Meyrin Laboratory.

A group of Members of Parliament from Austria visited CERN on 21 March to tour the site and discuss the future of high energy physics in Europe. They are here having a demonstration of the new 'display' system connected to a CDC 3100 computer.

Quarks still elusive

An experiment at the CERN proton synchrotron has searched, unsuccessfully, for the elusive quarks. The experiment pushed detection techniques as hard as possible so as to be able to see these particles even if they are produced only very rarely (down to a production cross-section of about 10^{-39} cm^2, a hundred times lower than previously investigated) and it can be concluded that the likelihood of observing quarks at existing accelerator energies is now very remote.

The synchrotron was operated at an energy of 27 GeV and the proton beam was directed onto a target positioned in the magnet ring (straight-section 1). A special beam-line (d28) was built in the south experimental hall to catch quarks, making use of their distinctive property of carrying a fraction of the normal electron charge.

Quarks are the particles which have been postulated to explain the orderly grouping of particles. The orderly grouping could be the result of the observed particles being different combinations of more fundamental objects called quarks. This demands however that an individual quark carries a charge 1/3 or 2/3 of the charge on the electron. The fractional charges provide an excellent handle to get hold of the quarks if they exist.

The beam-line was tuned to a 'super-momentum' of over 30 GeV/c. This meant that particles carrying normal charge, which, because of conservation laws, cannot come from the target with a momentum higher than the moment of the incident proton (i.e. they would all be below 30 GeV/c), would not be able to find their way through the beam-line magnets to the detectors. On the other hand, a particle of about 10 GeV/c carrying 1/3 charge would be guided to the detectors.

Advantage was taken of the fact that particles carrying 1/3 charge will produce only 1/9 of the ionization of a normal particle. Scintillation counters were set to record only particles giving such low ionization and, in addition, a streamer chamber was installed (the first use of a streamer chamber — see CERN COURIER vol. 7, page 219 — at the CERN proton synchrotron) which gives tracks of a density depending upon the ionization.

CERN/PI 292.3.69

Particles with charge of $\pm$ 1/3 and $\pm$ 2/3 were looked for but none was found.

A quark search has also been carried out by Soviet scientists at the higher energies available from the Serpukhov 76 GeV machine, but again without success.

Extension to central computers

At its meeting on 11 March, the Finance Committee approved the extension of the central computing system by the conversion of the CDC 6400 computer into a 6500, together with the purchase of more peripheral equipment. This extension will serve as an interim solution of CERN's computing needs for the next few years.

The use of computers is by now an integral part of practically all the scientific and technical work of the Laboratory. In reaching this situation, the demand for computing capacity has for ten years been doubling every year (see CERN COURIER vol. 7, page 166). The existing central computing system, consisting of a CDC 6600 and a CDC 6400 computer, can cope with the present demand — it handles about 1000 jobs per day catering for about 700 computer users — but to prepare for the years to come further extensions are necessary.

In 1967, a thorough study of the future needs began. It revealed that, although the growth rate in demand is expected to fall to a doubling every two years, a new, much larger, system will be required to give an increase in computing capacity by a factor of four in 1972 ideally with the possibility of extension to a factor of ten in later years.

The two major uses of the central computing system are for the analysis of bubble chamber experiments (about a third of the total load) and of electronics experiments (also about a third). The growing appetite for computers in both these fields is a combination of increased facilities for experiments as the various elements of

Computers at CERN

A list of the computers in use on the site in April 1969 (including those brought by visiting teams for use in experiments)

Type	Quantity
CDC 6600	1
CDC 6400	1
CDC 3100	3
CDC 1700	1
IBM/360 - 44	1
IBM/360 - 30	1
IBM 1800	5
IBM 1130	2
IBM 1401	1
Honeywell DDP 516	2
SDS 920	1
PDP 9	4
PDP 8	3
Varian 620 I	1
Hewlett Packard P 2115	2

the improvements programme are completed, the trend towards 'high statistics' experiments collecting more data to push the accuracy of the results much further, and the technological developments in detectors which make it possible to collect data much more quickly. Among the main contributors to the future demand will be the 3.7 m hydrogen bubble chamber (for completion in 1971), the Omega project (for completion in 1971), the 2 m hydrogen bubble chamber, now capable of taking pictures at twice its former rate, and wire spark chambers coming into increasing use capable of very high data-taking rates.

When computer firms in Europe and USA were contacted in search of new computers considerably larger than the existing CDC 6600, it emerged that none was likely to be available as a standard, proven machine before 1972. To cover the CERN needs until then, the firms were invited to propose an 'interim system'.

The most economical and convenient offer was that of CDC to enlarge the present 6400 computer by the addition of 65 536 words of central memory and of a second central processor, which comes close to doubling the capacity of the machine. This upgrades the 6400 to a 6500 at a cost of 4.52 million Swiss francs. Various items of peripheral equipment are needed to keep pace with these extensions, the main items being an additional disk and drum, and more printing capacity (totalling about 2 million Swiss francs).

This solution has also the advantages that no new buildings are needed to accommodate the computer extension and that, from the point of view of the users preparing programmes for the machines, there is no change.

Power supply overhaul

An overhaul of the new magnet power supply of the proton synchrotron (see CERN COURIER vol. 7, page 87), manufactured by Siemens was carried out in March. The accelerator continued in operation at lower repetition rate during the overhaul using the old power supply.

The new supply had been in operation since the 1968 shutdown. Operation has been very satisfactory and has increased the repetition rates at different energies to the intended values. Some problems have arisen with the mercury arc rectifiers. The system to switch off the current has failed many times and at the peak voltage of 10 800 V (which will not actually be used for machine operation until 1972 when the r.f. system in the synchrotron ring has been modified to increase the rate of acceleration) arc-back became troublesome. These problems are now being investigated by the manufacturer.

It was scheduled in advance to take a good look at the power supply after about six months of operation to see how well it was standing up to its arduous pulsed regime. The investigation revealed that practically everything is in good shape. There was no sign of metal fatigue or of uneven wearing. Bearings were repolished and the damping system of the large, floating, concrete platform on which the power supply is mounted was modified to increase the damping of the induced movements.

The next overhaul is scheduled to be carried out in 1 1/2 to 2 years time.

Magnet for ISR interaction region

A decision has been taken on the large, general-purpose, magnet system to be installed at one of the interaction regions (I4) of the intersecting storage rings. The system is 'general-purpose' because it is intended to serve for a wide variety of experiments.

To achieve all the desirable properties of such a system is very difficult. Ideally, the magnet should make it possible to measure accurately the momenta of all the charged particles coming from the interactions, should permit reasonably straightforward event reconstruction (tracing particles back to the positions where they were produced), should have space and access for efficient configurations of detectors, and should not disturb the stored beams circulating in the rings. (The beam paths will be bent in the magnet system but the beams should emerge from the interaction region as if there were no magnet there, all deviations being compensated.) In addition to the physics criteria, there are practical considerations such as physical size to be accommodated in the interaction region, cost for construction and operation, and time-scale for construction (since the magnet should be available early in the experimental programme).

Several systems were proposed which met these different requirements to different degrees but no system was ideal in all respects. After long discussions, it has been decided to build a simplified version of one of the proposals known as the split-field magnet.

From the centre of the interaction region, the split-field magnet system will have two arms, one on either side, each 5 m long, 2 m wide (increasing to 3 m towards the centre) with a gap height of about 1 m. The field goes in opposite directions in the two arms. The total weight of magnet will be in the region of 1000 tons. Compensating magnets are needed downstream on each beam to restore the circulating beams to their correct trajectories.

Design and construction of the system has been assigned to the Magnet Group of the ISR Department and the aim is to have the magnet in operation in the second half of 1972.

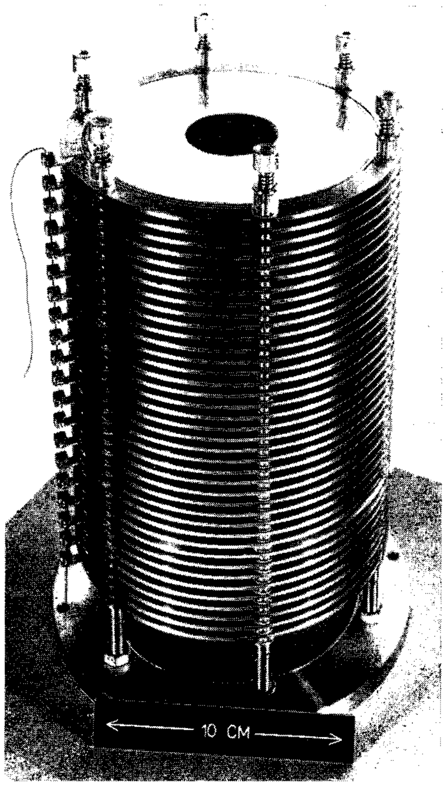
Secondary emission chambers (SEC)

Yet another method (in use at CERN since 1965) of carrying out intensity and position measurements on a high energy proton beam is the use of secondary emission chambers ; earlier this year information has appeared in CERN COURIER on the ionization beam scanner (page 9) and on beam current transformers (page 67). All these methods, and others, are being developed because each has its virtues and limitations. In the case of the secondary emission chamber, it is the only device which can give intensity and distribution measurements for 'long-spill' beams when the burst of charged particles may last for a few hundred ms. It is therefore used particularly in the monitoring of slow ejected proton beams.

The SEC method is based on the phenomenon of emission of electrons from the surface of a foil when a high energy charged particle is incident on it. The high energy particle can give sufficient energy to the electrons of the atoms near the surface for them to escape from the foil. The phenomenon is independent of the foil thickness but in practice very thin foils (a few microns of aluminium) are used so that the SEC is almost invisible to the high energy beam which passes through it, causing negligeable deterioration, due to scattering, in beam quality. To give an idea of the scale of the phenomenon, 100 protons with an energy of say 20 GeV will cause about five electrons to be emitted from a foil (2.5 from each surface on average).

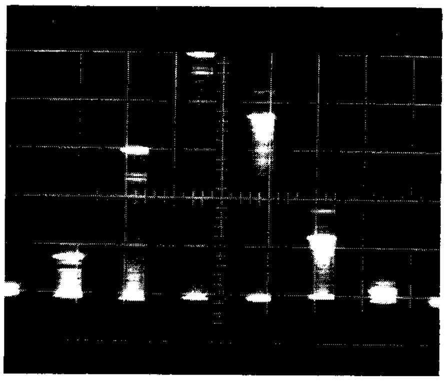
A secondary emission chamber is built up as follows. A series of foils are assembled parallel to one another separated by a distance of a few mm. Alternate foils are connected to a voltage line (which gives them a positive potential of 50 V or above). The other alternate foils are connected to a charge measuring device. This assembly is inserted into the path of a particle beam with the foils perpendicular to the beam direction. Electrons emitted from the foil surfaces are drawn to the positively biased foils and thus a flow of charge takes place. The recorded signal is proportional to the intensity of the incident beam to very good accuracy; effects such as interactions with nuclei in the foils being responsible for only a few percent of the signal. The foils have to be enclosed in a good clean vacuum (better than 10^{-6} torr) since the emitted electrons are of low energy (around 10 eV) and the SEC could not operate at high pressure.

Various changes can be rung on this simple system. The foils can be divided each into several separate strips and the signals recorded from the separate strips will give the beam position and the way in which the beam intensity varies over the cross-section of the beam. (Such a device has been given the name 'toposcope' since it reveals the topology of the beam.) Another application is in the alignment of beams when a SEC is built of foils with a central circular aperture. If the beam is correctly aligned it passes through the central aperture and there is

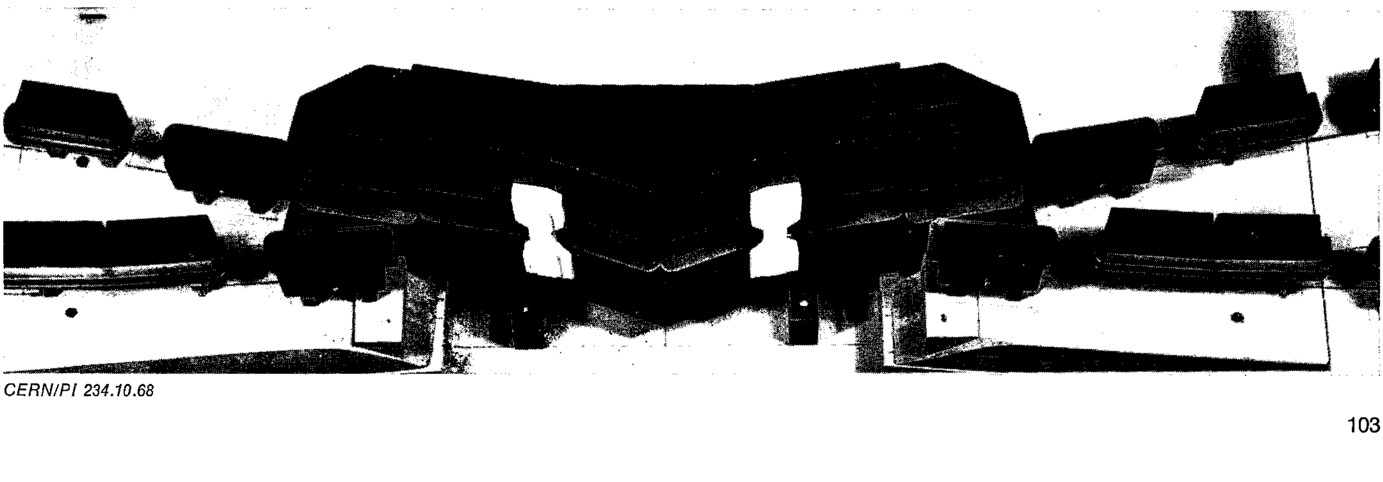


CERN/PI 63.1.67

An assembly of 40 foils for a secondary emission chamber (SEC). The foils are separated by glass insulators and the connections on alternate foils which are taken to positive voltage can be seen on the left. The top twenty foils have a central aperture and serve to help beam control by giving signals only when the beam is not well collimated. The lower foils cover the whole aperture and give signals proportional to beam intensity.



The lower photograph illustrates typical signals of beam intensity and cross-sectional distribution from a SEC made of eight foil strips — each strip giving one of the signals shown. The burst of protons lasted 100 ms and the striated appearance of the signals shows that the protons received by each strip were not constant in number during the full time of the burst. The SEC can pick out the microscopic structure of the burst.



CERN/PI 234.10.68

A model of a split-field magnet system. A simplified version of such a system has been chosen for installation in one of the interaction regions of the ISR. The split-field magnet is symmetric about its centre, the magnetic field being in opposite directions in each half. The actual ISR magnets are positioned to the right and left.

no reading from the SEC ; if the beam hits the foils, the beam-line components need adjustment. Used in these ways, SECs could be used in automatic control systems for beam-lines sending signals to computers which then control power supply settings.

There are now five SECs constructed for use at the proton synchrotron, three of them are installed in the slow ejected beam e3 in the East Hall. They cover all the functions mentioned above and have proved very satisfactory and reliable instruments.

The problem of the calibration of such instruments is a complex one which will not be covered here. Anyone who wishes to dig deeper on this and on the whole subject of beam monitoring is referred to the Proceedings of the Symposium on Beam Intensity Measurement held at the Daresbury Laboratory in April 1968.

Infra-red link

The first stage of acceleration in the synchrotron is the 'pre-injector' which accelerates protons to an energy of 500 keV before they are fed into the first tank of the linear accelerator. It is the only stage of the machine where acceleration takes place under the influence of a d.c. voltage — throughout the rest of the accelerator radio-frequency fields are used. Since many components in the pre-injector are taken to a potential of half a million volts it poses a few problems not met with elsewhere in the machine.

The proton source end of the pre-injector is at a potential of +500 kV and this involves having all the source supplies and controls installed on a platform mounted on insulating legs 2 m high. It is then necessary to send signals to this insulated equipment and to receive information back. A cable, carrying information electrically, cannot be used because of the voltage difference and mechanical communication via long insulating rods is not appropriate to the type of information transmission that is required.

Up to now two systems have been in use :

1) A cathode ray tube sends a light signal to the platform where a photomultiplier converts it into an electronic signal. This system has a fast response time and is used to trigger equipment where precise timing of the source pulses is required. It involves, however, complex and bulky units (particularly a 1 kV power supply for the photo-multiplier on the platform).
2) A system involving light signals sent via a light-guide. It involves the use of LAS light-sensitive control rectifiers which switch on motors to set potentiometers and thus set the parameters of the different source components. A television camera observes the equipment which is being controlled.

As part of the PS improvements programme more effort is going into achieving the best possible beam from the proton source. This seems to have a marked influence on the ultimate accelerated beam intensity — see the note on page 105 — and it is important to be able to study the influence on beam quality of variations in the many parameters controlling the source operation. To transmit this information a new system is being installed which uses infra-red.

This has the advantages of rapid response rate (data can be transmitted at a frequency of 500 kHz), of high efficiency (by precise superposition of emission and receiving spectra), and of not being sensitive to surrounding light. The units are also inexpensive, small and light (fully-transistorized). The emitter uses a gallium-arsenide semi-conductor which produces a very clean line in the infra-red ($\lambda = 0.9\,\mu$), and the receiver uses a 'fotofet' field effect, light-sensitive transistor.

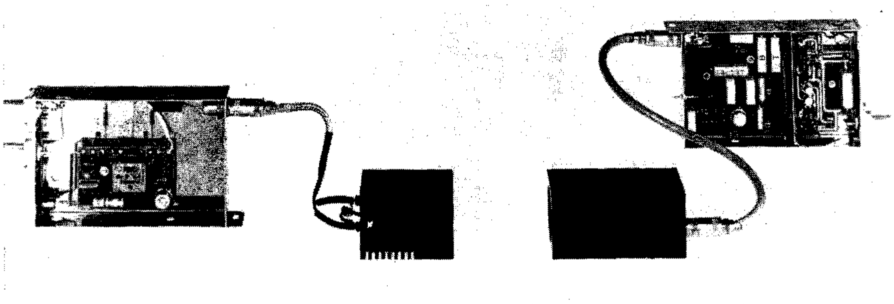
A single infra-red link operated in multiplex fashion can be used to transmit information on the operating parameters of the source. (The source is a duoplasmatron type and important parameters are — source current and voltage, voltage on the intermediate electrode, current settings in two source magnets, filament current, pulse length, and hydrogen pressure.)

In May, two infra-red links will be brought into operation — one to trigger the source and the other to pass information initially on a single source parameter. Later the final assembly will incorporate the multiplex system which is still being developed. In the meantime, the light-guide system will remain in use but the cathode ray tube and photomultiplier will be removed.

One further point on the infra-red link. Information is transmitted in digital form and this is ideal for coupling directly into the IBM 1800 control computer of the accelerator. At some future time the studies of source behaviour and its monitoring and control are likely to take place by the intermediary of the control computer.

Gargamelle magnet measurements

The pulsed beam transport group in the Nuclear Physics Apparatus Division is carrying out detailed measurements of the magnetic field in the large magnet of the new heavy liquid bubble chamber, Gargamelle. These measurements are checking that the field configuration agrees with the design calculations and are proving the equipment which will carry out a field



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The units of the infra-red link for sending trigger signals to the synchrotron ion source platform. On the left is the emitter (gallium-arsenide semi-conductor) and, on the right is the receiver ('fotofet' — field effect transistor). The associated electronics are in the two small rectangular boxes.

The measuring equipment used in the Gargamelle magnet. This view taken inside the magnet complements the photograph on the cover of this issue which shows the exterior view of the equipment. The probe can be positioned at different points along the arm and can move around the magnetic field describing co-axial cylinders.

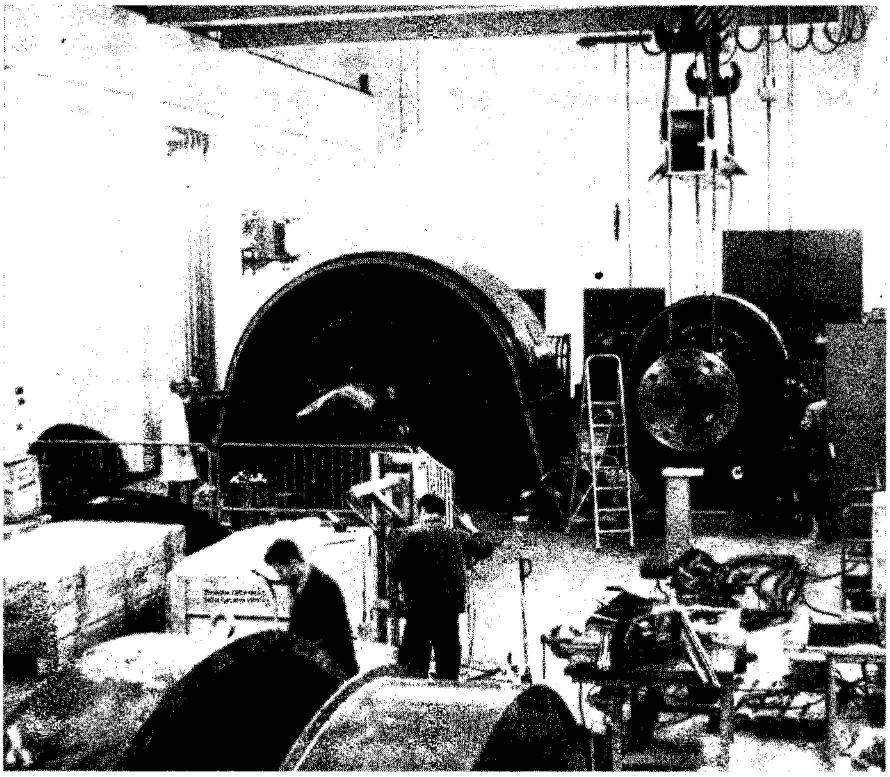
The new extraction grid fitted to the ion source of the proton synchrotron. Since it has been fitted on the machine a beam of better quality has been achieved. It was machined in the CERN workshops from tantalum by the electro-erosion technique.

The new magnet power supply being taken apart after six months of operation for an overhaul (see the note on page 102).

plot inside the chamber body when it is installed in the magnet later this year.

Measurements are taken at positions 100 mm apart (the actual positions being read-off in practice in cylindrical co-ordinates) giving a total of 10 000 readings in the magnet aperture (10 m^3). The probe can be positioned to an accuracy of 0.5 mm and the value of the magnetic field (obtained using the Hall effect) is measured to an accuracy of one part in a thousand.

All the readings are recorded on punched tape and are later transferred to magnetic tape which is fed to an IBM 1401 computer to give the field plot.



PS intensity up

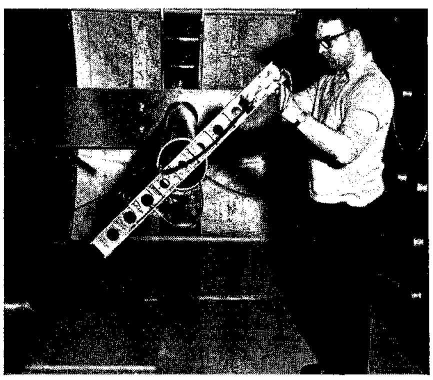
On 17 April, the 28 GeV proton synchrotron produced an average intensity of 1.54 $\times$ 10^{12} protons per pulse over a hundred consecutive pulses reaching a peak intensity of 1.59 $\times$ 10^{12}. This is the highest intensity ever achieved at the PS and it has followed a fairly steady improvement over the years of operation of the machine.

When the PS was designed, estimating intensity was a hazardous exercise since the accelerator incorporated the newly evolved strong focusing principle and a few unknowns had to be confronted. A figure of 10^{10} protons per pulse was predicted but this was exceeded early in the machine's life. Maximum intensity figures over the years have been 3.8 $\times$ 10^{11} in 1961, 8.9 $\times$ 10^{11} in 1963, 1.09 $\times$ 10^{12} in 1965, 1.15 $\times$ 10^{12} in 1967 and 1.31 $\times$ 10^{12} in 1968.

The steady improvement has been a consequence of many inter-related modifications to the accelerator (such as better tuning of the radio-frequency accelerating cavities, better correction of the magnet field configuration, ...). But the improvement seems to have been particularly related to the quality of the beam fed into the synchrotron ring. The latest advance has followed modifications to the proton source itself.

One of these modifications has involved the replacement of the grid on the extraction electrode which carries a negative voltage of 65 kV to pull the protons from the source. The old version had separate planes of tantalum wires at right angles. Although these planes lay side by side, the slight difference in distance to the plasma seemed to produce asymmetry in the beam. Also if a wire fused, the machine had to be stopped to put it right. The new grid (see photo) is machined by electro-erosion from a tantalum plate 0.013 mm thick (made in the West Workshop with equipment on loan from 'Ateliers des Charmilles', Geneva). It has given a more symmetric beam and continues to work if a filament is fused.

A second improvement on the source has been the use of high purity hydrogen. Bottles of hydrogen from 'Air Liquide' are being used which are filled by a special process (dry membrane) to give 99.998 % pure hydrogen. Linac beam instability encountered in February and March seemed to be related to hydrogen purity.



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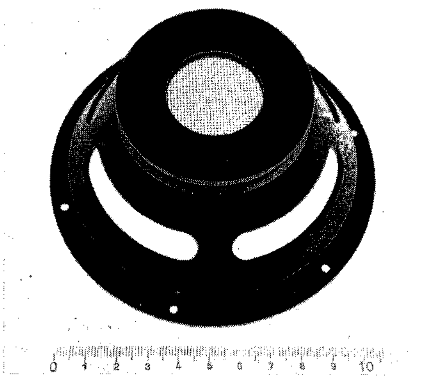


European Physical Society Inaugural Conference

With a blaze of trumpets, announcing the Mayor of Florence, the Inaugural Conference of the European Physical Society opened in the splendour of the Palazzo Vecchio on 8 April. For five days Florence was the scene of reviews by leading figures from European science of 'The Growth Points of Physics' and of the first General Assembly and constitution of the first Council of the Society.

More than 850 scientists attended the Conference and CERN was well represented both among the participants and among the speakers. A plenary session on 'Trends in High Energy Physics' was shared by L. Van Hove and T.D. Lee (Columbia University/CERN) who stepped in to give the talk at short notice.

Van Hove reported the interesting developments within the past year in evolving a systematic description of collisions involving strongly interacting particles. The developments have evolved around the 'Veneziano model' which has absorbed the ideas that, 1) the Regge trajectories could continue to higher masses well beyond the investigated region, being populated by a limitless number of particles, and 2) some form of duality exists between processes involving the production of resonances and the processes involving the exchange of particles. The model equates the sum of all the possible resonances with the sum of all the possible exchanged particles. The consequences of the model are being worked out and agree strikingly well with observation. The model also looks hopeful for treating many-body collisions. The orderly representation of the observed phenomena which it gives could prove another valuable clue to a satisfactory theory.

Lee reported on the latest developments in electromagnetic and weak interaction theories concentrating in particular on the effort to solve the problems arising in weak interaction theory when the 'first order' equations are extended to higher order. When, for example, the higher order theory is used to calculate the mass difference between the charged and neutral pions, the result comes out as infinity. Attempts to reformulate the equations have a very limited number of possibilities to play with. Lee and G.C. Wick tackled one of these in a way which will resolve difficulties in the theory while introducing revolutionary thoughts on causality on a microscopic scale.

Other speakers during the Conference who are at CERN or closely associated with CERN were V.F. Weisskopf (Physics in Europe in the 20th century), C. Rubbia (Current Problems on Weak Interactions), W. Paul (Experimental Aspects of Atomic and Molecular Collisions), and F.J.M. Farley (Status of Quantum Electrodynamics).

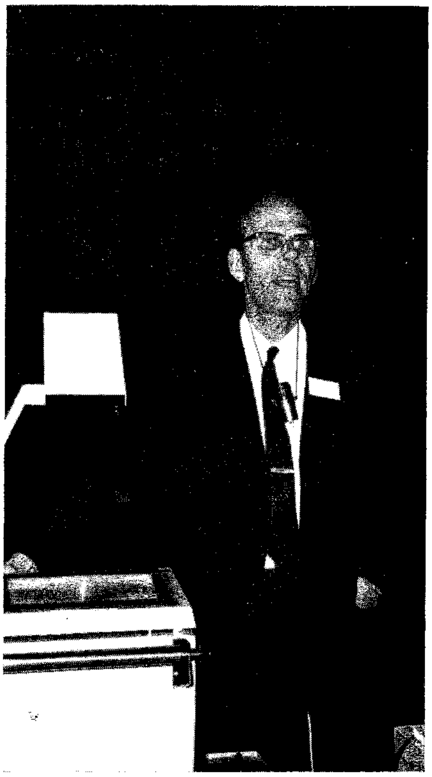
Two of the highlights of the week were brilliant talks by A. Hewish (Cambridge) on 'Pulsars' and by D.W. Sciama (Cambridge) on 'The Recent Renaissance of Observational Cosmology'. They were brilliant both in their exposition and in their physics content and gave evidence of the dramatic experimental observations and fascinating thinking in the field of astronomy over the past few years — making it the fastest growing of the 'growth points of physics' at present.

In his talk on 'The Old Days at the Cavendish' P.M.S. Blackett pleaded that

Left : G. Bernardini, President of the European Physical Society, addresses the inaugural session of the Florence Conference in the Palazzo Vecchio. Behind him are the heralds and the standard of the Mayor of Florence, L. Bausi (seated, centre of photograph) and on the right is C.A. Funaioli, representing the Italian government.

Below : L. Van Hove (top photograph) and T.D. Lee who shared a Plenary Session on 'Trends in High Energy Physics'.

(Foto Torrini)



experimentors should have their eyes wide open for the 'accidental' observation and his plea gained weight from the fact that two of the most exciting recent observations in astronomy have been 'accidents'.

One was the detection of the first pulsar (CP1919) in July 1967. The Cambridge telescope picked up radio signals pulsing with remarkable regularity every 1 1/3 second. By now about 40 such pulsars are under investigation and increasing knowledge of their properties has already led to a convincing theory of the mechanism behind them. The signals are believed to be beamed synchrotron radiation (a 'lighthouse' effect) coming from around spinning neutron stars (a dense state of matter which has suffered gravitational collapse). Though these sources are hundreds of light years away their diameter can be only a few hundred kilometres across. They are the remaining cores of super novae explosions.

Another 'accident' was the detection in 1965 of the background radiation of the universe. Radio telescopes can pick up radiation, corresponding by now to a temperature of about 3°K, which lingers from the first tens of seconds of the mighty explosion 10^{10} years ago which was the origin of our universe. Measurement of this radiation, which is isotropic, has given heavy weight to the 'big bang' theory as opposed to the 'steady state' theory of the evolution of the universe. That all this fascinating knowledge and speculation can come from listening to the sky is one of the wonders of modern physics.

These are just two of the topics in astronomy developed in much more detail during the talks at the Conference. Since, when dealing with cosmological phenomena, matter is being considered under extreme conditions such as are produced in high energy particle collisions, the knowledge of particle interactions which has emerged from research at accelerators is proving an important input into the cosmological theories.

General Assembly and First Council

In the evening of 9 April the first General Assembly of the European Physical Society was held. Reports were received from the officers elected to guide the affairs of the Society during the period between the foundation in Geneva on 26 September 1968 until the Council could be constituted. Since the foundation, the National Academies of Bulgaria and Turkey have been added to the 18 National Societies who initially joined and the total of individual members has risen to 445.

The Main Secretariat is functioning in Geneva with branch offices in London and Prague. Many donations were received by the Society to help bring it into being but to guarantee its long-term activities the Society needs to have an assured annual income. One important way in which the Society will be strengthened both financially and in influence would be for the number of individual members to grow considerably. (Application forms are available from the Main Secretariat, 7 route de Drize, 1227 Carouge-Geneva).

Committees have been created to formulate EPS policy on Physics Journals in Europe and on European Physics Conferences. The Chairmen of these Committees, respectively J. de Boer (Amsterdam) and G.H. Stafford (Chilton), reported on their work so far. In both cases the role of the EPS is seen not as that of initiating new journals and new conferences to add to the present proliferation, but as one of coordination which will help establish standards and will avoid needless duplication.

At the end of the General Assembly the ballot was opened for the election of five representatives of the individual members to join the 45 delegates of the National Societies on the EPS Council. G. Bernardini (Pisa), L. Hrivnak (Zilina), L. Jansen (Geneva), A. Kastler (Paris) and V.F. Weisskopf (Cambridge, USA) were elected.

At the first Council Session on 11 April the Executive Committee was elected as :

President :	G. Bernardini
Vice-President :	E. Rudberg (Stockholm)
Secretary :	L. Jansen
Vice-Secretary :	F. Janouch (Prague)
Treasurer :	L. Cohen (London)
Vice-Treasurer :	G.J. Béné (Geneva)
Members :	L.A. Artsimovich (Moscow)
	H. Curien (Paris)
	J. de Boer (Amsterdam)
	I. Slaus (Zagreb)
	G. Szigeti (Budapest).

Around the Laboratories

The 240 MeV electron storage ring at the University of Wisconsin. The ring is 3 m in diameter ; the eight bending magnets can be readily picked out (seven in view) and the single r.f. accelerating cavity is on the right.

(Photo Wisconsin)

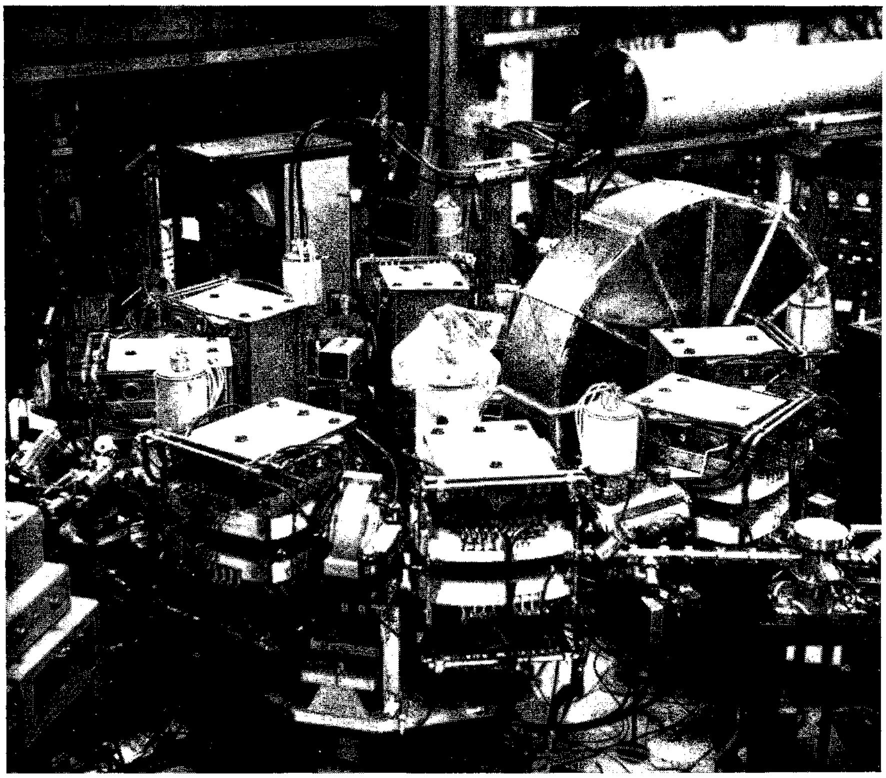
WISCONSIN
Electron ring

A storage ring not covered in the special issue on storage rings in November of last year, for lack of up-to-date knowledge, was the 240 MeV electron ring at the Physical Sciences Laboratory of the University of Wisconsin. A paper on the performance of the ring, which has been in operation for just over a year, was given by E.M. Rowe at the Washington Conference in March.

The ring was initially intended as a 200 MeV electron-positron device to be used mainly for research in storage ring technology. Construction began in June 1965 under the auspices of the since-disbanded MURA (Midwestern Universities Research Association) where the idea of experiments using colliding beams was studied for the first time. The ring was completed in November 1967 and electrons were stored and accelerated to 240 MeV in March 1968.

A few parameters are as follows: Electrons are injected for a single turn (up to 10^{11} per pulse) at 45 MeV from the MURA 50 MeV FFAG synchrotron at a maximum injection rate of 3 pulses per second ; they can then be accelerated or decelerated to any energy in the range 10 to 240 MeV. The ring is 3 m in diameter with separated-function magnets giving fields just over 12 kG at peak energy. A stainless steel vacuum vessel has a useful aperture 60 mm horizontal and 20 mm vertical and is pumped to 5×10^{-10} torr. One r.f. cavity, operating at 31.9 MHz gives a maximum of 15 keV per turn (shortly to be increased to 50 keV).

Clever tricks are played at injection to achieve virtually 100 % injection efficiency. Signals are taken from the bunched beam in the synchrotron and are passed to the storage ring r.f. system. In this way the r.f. cavity voltage is swinging in tune with the incoming particle bunches which arrive at exactly the right time to be captured in the ring. The bunched beam in the synchrotron has thus acted as a master oscillator. This essentially simple system has proved more efficient than any other injection technique.



During the year of operation several phenomena have been investigated, two of which are mentioned here. Measurements of beam lifetime were consistent with the vacuum chamber pressure at low beam intensities but the rate of beam loss, and the pressure, increased as the intensity was increased. This was traced to the presence of positive ions, which tend to concentrate in the negative beam, locally raising the effective pressure (to nearly 10^{-8} torr) and hence the scattering of the beam particles. Deliberately increasing the cross-section of the beam (to reduce the positive ion density) increased the beam lifetime. 'Clearing electrodes' which suck ions from the vacuum vessel could only be installed around about half of the ring.

A phenomenon which does not seem to have given trouble elsewhere is photo-etching of the inside of the stainless steel vacuum chamber by synchrotron radiation. This produced multipacting in the r.f. cavity after several months of operation — material etched off the vacuum chamber had been deposited on the alumina r.f. window and was a source of secondary electrons which took cavity power. The accelerating gap has now been successfully modified to avoid these problems.

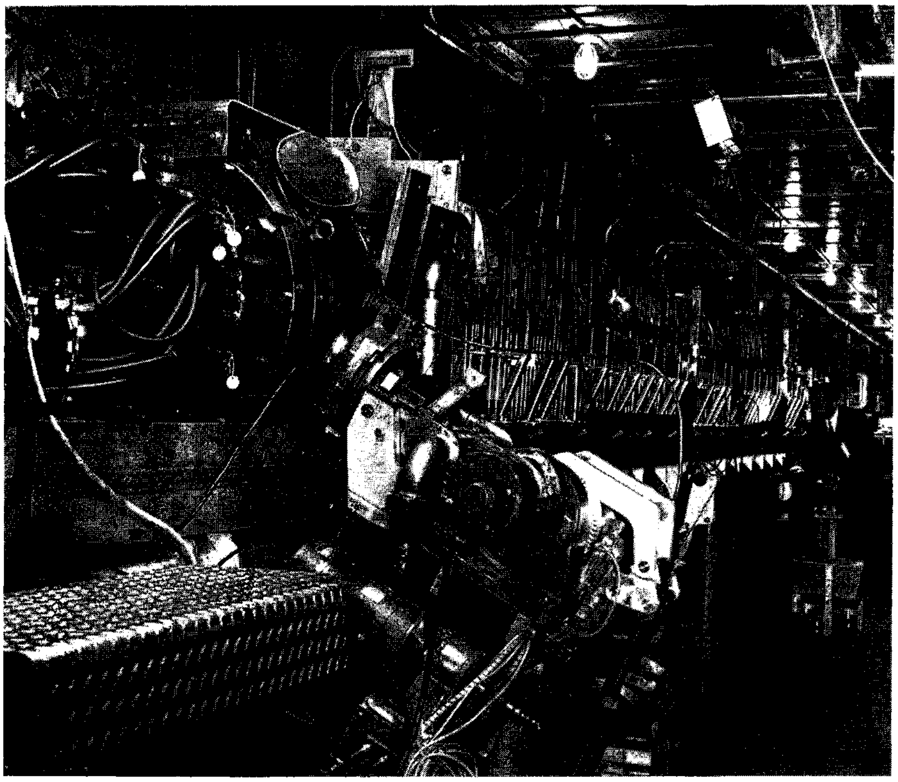
An unexpected use of the ring has been in experiments using the synchrotron radiation for spectroscopy in the far ultraviolet region. Since June of last year the machine has been operated continuously as a source of ultraviolet radiation for solid-state and atomic physics research. During this time the performance and reliability of the storage ring have steadily improved.

STANFORD
Profuse positrons

Antiparticles are by now such a familiar component of the high energy physics world that it is easy to forget how quickly they have moved from speculation, to first identification, to everyday use as beams at high energy accelerators. They emerged from the equations of P.A.M. Dirac in 1928 as particles corresponding to negative energy states (if you push them away they move towards you) and the observation of the first positive electron, or positron, came four years later

The position along the 20 GeV electron linear accelerator at Stanford where positrons are created. The beam travels from left to right and in the large cylinder (fed by the heavy cabling on the left) the electrons strike heavy metal targets mounted on a rotating wheel. This is immediately followed by a long solenoid to help focus the resulting positrons which are then accelerated along the remainder of the length of the machine.

(Photo Stanford)



when C.D. Anderson and S.H. Neddermeyer saw pair production of the electron and positron in cosmic rays. Observation of the antiproton had to await the construction of high energy accelerators and came in 1956 from a famous experiment on the Bevatron at Berkeley.

Now antiparticles can be produced in quantity and separated into beams to be used in experiments. One interest in such experiments is that it is intriguing to know about the behaviour of antimatter as a clue to why there is such striking asymmetry in the Universe. This asymmetry may be just local — averaging out over the whole universe there may be as much antimatter as matter — but it is because our galaxy is composed only of matter that our immediate environment can exist.

Producing intense beams of positrons has become standard practice. They are used in scattering experiments on stationary targets, in colliding beam experiments with electrons (see CERN COURIER vol. 8, pages 288-291) and for the production of 'tertiary' beams of annihilation photons.

The production of positron beams differs in several ways from that of other antiparticle beams. In principle their intensity can exceed that of the electron beam which initiates them (each incoming electron producing a cascade of positrons and electrons in the target) and also they can be further accelerated in a electron linear accelerator using the other half of the wave which accelerates electrons. (This half of the wave which would decelerate electrons will accelerate the oppositely charged positrons.)

The production techniques have been studied at many Laboratories. At Stanford, the first positron beam was achieved in 1958 on the Mark III linac, a 350 MeV electron beam yielding a few hundred positrons per pulse at 200 MeV. This was eventually extended to 3×10^7 positrons per pulse at 60 pulses per second using the techniques described below.

When an electron collides with an atom in a target (the target usually being described as a 'converter' when positrons are being produced) it is decelerated by electric fields in the atom and emits a photon. If the incident electron energy is sufficiently high, the photon can have an energy greater than 1 MeV and can, interacting with other atoms in the converter, yield an electron and a positron by pair production. If the incident electron energy is much higher, a cascade occurs with successive generations of photons, electrons and positrons. An incident electron of 5 GeV such as is currently used for positron production on the 20 GeV electron linear accelerator at Stanford can produce as many thirty low energy positrons from the converter.

The most efficient converters are high density materials such as lead and tungsten (a typical example being a water-cooled tungsten cylinder, 2 cm diameter 0.5 cm long) but other materials such as copper may be more appropriate for use in an accelerator because of heat conductivity, radiation resistance, good vacuum properties and ease of machining. With the intense electron beam of the 20 GeV machine, the heat problem is considerable (200 kW of power) and converters have been considered in the form of wands dipping into the beam on occasional pulses, wheels and brushes rotating through the beam, and liquids flowing through the beam into a heat exchanger. The optimum thickness is that giving the maximum number of positrons, but thinner converters may be used if relatively high energy positrons are required.

Next comes the problem of catching the emerging positrons into a focused beam. The acceleration process itself gives some focusing by reducing the transverse momentum as the energy in the forward direction increases, effectively pulling the positrons towards the axis. Also a co-axial solenoid wrapped around the beam pipe, to give a magnetic field parallel to the axis of the accelerator, produces focusing when the particles spiral round in a helix of increasing pitch as they are accelerated. Such a solenoid is most useful close to the converter and a short solenoid (3 to 10 m long) can be supplemented by quadrupole focusing lenses positioned at carefully chosen intervals downstream.

For those interested in further detail on the production and use of positron beams, there is an article by D. Yount in the February issue of 'Physics Today' from which much of the above information is extracted.

RUTHERFORD/ DARESBURY

Changes pending

On 21 March, Professor B.H. Flowers, Chairman of the UK Science Research Council and delegate to the CERN Council spoke at the Rutherford Laboratory on the country's future high energy physics programme and its possible implications for the Laboratory.

Despite the decision of the UK government, announced in June 1968, not to participate in the European 300 GeV project, it remains the policy of the SRC, in line with the priorities given by the high energy physics community, to press for a reversal of this decision. However, if the UK does join in construction of the 300 GeV machine, the SRC has some hard decisions to implement with regard to the national Laboratories. To keep the overall growth-rate of expenditure on high energy physics within 4 % per annum while participating in the 300 GeV involves cutting back one or both of the national Laboratories — Rutherford Laboratory with its 7 GeV proton synchrotron 'NIMROD' and Daresbury Laboratory with its 4 GeV electron synchrotron 'NINA'.

This has been known for some time, but Professor Flowers in his recent talk indicated where it had been decided that the axe had to fall. The SRC is prepared to reduce the operation of NIMROD from 1970 eventually closing it down in 1975. The supporting staff of the Laboratory would be reduced to about 800. The Laboratory could then serve as a 'staging post' for experiments to be mounted on the European accelerators, and as a centre for carrying out other kinds of research falling under the SRC.

Without NIMROD the number of high energy physicists in the UK who could have access to big machines to do their research would fall and thus the high energy physics community would have to be reduced in number. The SRC would help this along by reducing the number of research students in high energy physics that it supports. Also it could be expected that the demand from UK physicists for use of European facilities, which has not been very great in the past due to their having access to the national machines, would grow.

At Daresbury a change will come in the autumn when Professor A.W. Merrison, who has been Director of the Laboratory since it came into being, moves to Bristol University to take up an appointment as Vice-Chancellor. Professor Merrison was seconded from Liverpool University in 1962, initially for five years, to direct construction of NINA. When the machine came into operation at the end of 1966, he stayed for the start of the experimental programme.

Professor Merrison is well known at CERN where he did research in one of the first experimental teams. Since returning to the UK he has been a frequent visitor, serving, for example, on the 300 GeV Steering Committee and on the Scientific Policy Committee. His many friends wish him every success in his new appointment and add their congratulations on his election in March as a Fellow of the Royal Society.

DUBNA

Council Session

The 25th Session of the Scientific Council of the Joint Institute for Nuclear Research, Dubna, has recently taken place. The Institute's Directorate and the Directors of the six separate laboratories reported on the research undertaken by the Organization and the development of international relations during 1968. The plans for the coming year were also reviewed.

The Institute's physicists have been involved in the first experiments on the 76 GeV accelerator at Serpukhov. Results have been obtained on proton-proton scattering over a range of energies that had not hitherto been investigated. The irradiation of photographic emulsions has been carried out for the first time in pion beams with an energy of 40 and 60 GeV. The exposed photographic emulsions have been dispatched to laboratories in the participating countries of JINR for processing. Apparatus is being prepared for a whole series of other experiments. The 2 m propane bubble chamber has been transferred to Serpukhov and is being assembled in the pion beam.

The development of facilities for automating the experiments and of the associated computer techniques has continued. The organization of measurement centres in all experimental laboratories of the Institute has been completed. A new powerful computer has been brought into operation and will be equipped to use FORTRAN.

Improvements have been carried out to some of the main installations of the JINR (see CERN COURIER vol. 9, page 46). The multiply-charged ion cyclotron has been rebuilt with a pole diameter of 200 cm, and brought into operation. Assembly work is in progress on the reconstructed model of the pulsed reactor for high-speed neutrons, the average power of which has been increased to 20 kW. At the synchrophasotron the efficiency of the fast ejection of the proton beam has been increased to 80 %. Work has been completed on the meson channel of the synchro-cyclotron resulting in a threefold increase of beam intensity. A project for a high-power 700 MeV phasotron has been finalized and its main components are being designed. A new type of cyclotron has been proposed which will make it possible to obtain beams of several types of particle (protons, deuterons, alpha-particles, lithium nuclei) with a high energy resolution (up to 10^{-4}) and intensity (100 μA).

On the subject of international relations, Dubna physicists are carrying out, in collaboration with physicists from national laboratories of other countries, more than 200 experiments. In 1969, the Institute is organizing a number of international conferences, among which are a School on Nuclear Physics in Alushta (USSR) and a Seminar on Nuclear Electronics in Varna (Bulgaria). The JINR is also organising for leading scientists, in collaboration with CERN, a Seminar on the future development of high energy physics.

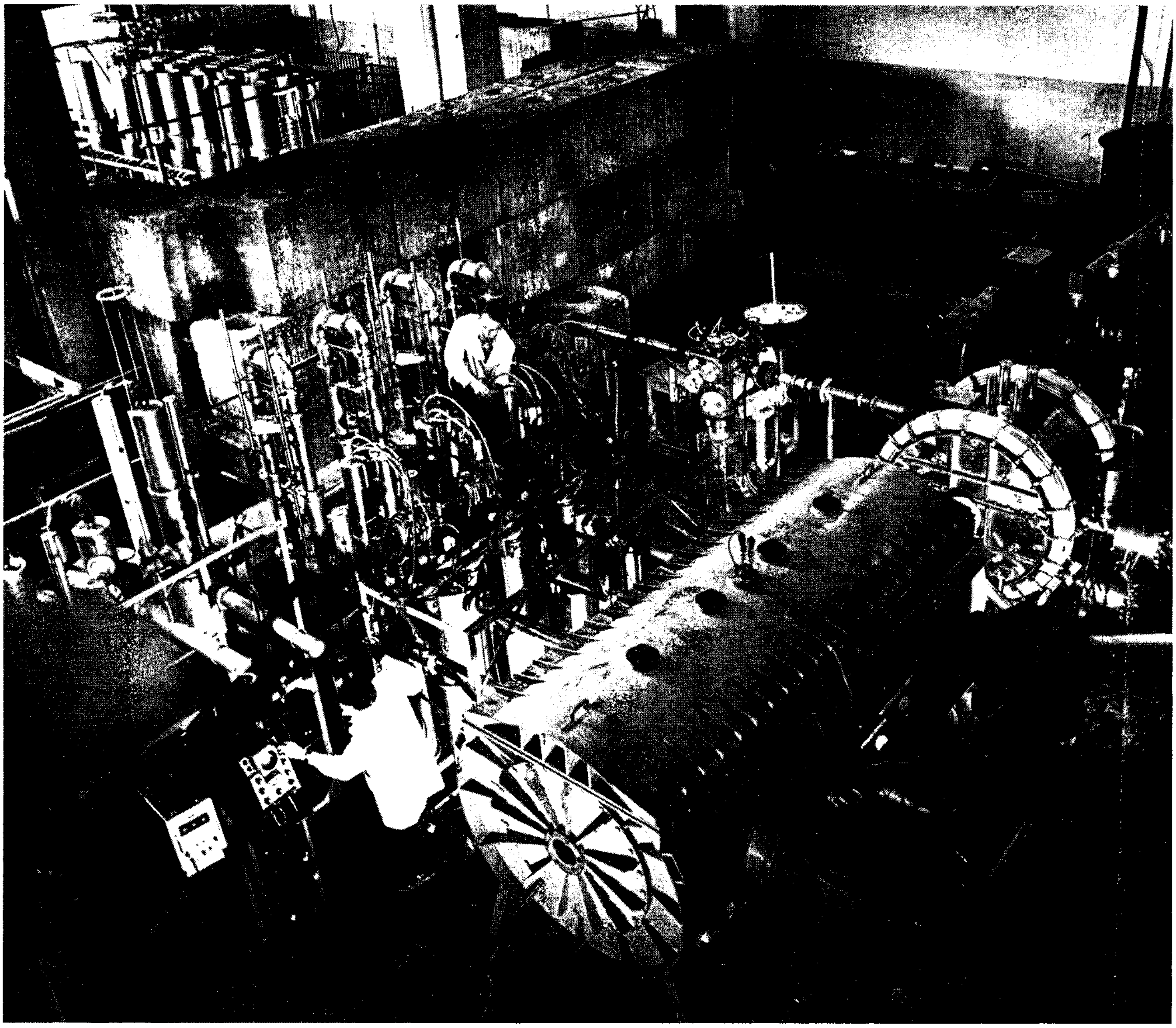
Appointments

The Council re-elected for a further two-year period Professor N. Sodnoma (Bulgaria) as Deputy Director of the Institute. Another re-election was that of Professor

A general view of the electron ring accelerator at Dubna where research on this new acceleration technique was initiated. The electron beam comes in from top left to the compressor (top narrow cylinder). There electron rings are formed, compressed and filled with protons. The compressed rings are then accelerated along the long cylinder.

At the Washington conference in March it was reported that particles had been extracted from the compressor but it remained to be analyzed whether these were electron rings still holding protons.

(Photo Dubna)



A.M. Baldin as Director of the High Energy Laboratory.

First experiments with 70 GeV protons

A group of Dubna physicists is carrying out, in collaboration with staff of the Institute of High Energy Physics (Serpukhov), investigations on elastic scattering of protons on protons in the 10-70 GeV range. Two types of target are used: a thin polyethylene film and a localized stream of hydrogen gas. The electronic of the detectors are linked directly with a computer. The relative accuracy achieved in measuring the differential cross-section is about 3 %.

At the present time, the experiment on the diffraction cone in proton-proton scattering is being completed. It has been confirmed that the effective radius of the proton in the 10-70 GeV range increases with energy. This information is important for verifying certain theoretical concepts. The next steps in this work will be measurements at very small angles, where Coulomb scattering is substantial.

New Acceleration Methods

At the request of the JINR, the Soviet government has supported the establishment of a new department in the Institute to study new methods of acceleration. The department was set up by the late V.I. Veksler and is at present directed by his pupil V.P. Sarantsev. Research is being carried out on the collective method for accelerating charged particles (known as the 'Electron Ring Accelerator', see CERN COURIER vol. 9, page 401). At present, Dubna has obtained the first results in accelerating an annular cluster.

Research on this new method indicates that it may be possible to build an accelerator for multiply-charged ions with an energy of 5 to 10 MeV/nucleon and an intensity of up to 10^{14} ions/s, as well as a proton accelerator with an energy of .1 to 2 GeV having a beam intensity of up to 10^{15} protons/s. Extension of these figures show the great possibilities which may be offered to physicists by the development of this new method of acceleration.

Ultracold neutrons

Theoretical work has shown that neutrons with very low velocities — up to several metres per second (ultracold neutrons, UCN) — should experience total internal reflection within a vacuum vessel at any angle of incidence. These neutrons can thus be accumulated and kept in an enclosed space. An experiment was set up at the pulsed reactor to study these UCNs. A copper vacuum tube 10 cm in diameter and 10 m long was inserted between the active zone of the reactor and the experimental hall. For copper, the limiting velocity of the neutrons experiencing total internal reflection is 5.7 m/s. The detector was located outside the direct path of the beam. The reactor was operated at 1 pulse per 5 s with an average power of 6 kW. Counting of the neutrons began 1 s after the reactor pulse, and the UCN counting speed was 0.01 pulses per second. The counting speed dropped to half this value when the tube was filled with helium at a pressure of 1 torr, which corresponds to a neutron diffusion time in the tube of 250 s. The results of the experiments make it possible to plan delicate experiments using UCNs for the measurement of the half-life of the neutron and its electric dipole moment.

Ultra-heavy elements

The existence has been predicted of a range of heavy elements, beyond those observed sor far, which could be relatively stable with respect to spontaneous fission. Last year, in their studies of the composition of cosmic rays, British physicists discovered tracks of heavy particles on photographic emulsions with a charge of 106 to 110.

At Dubna, experiments have searched for spontaneous fission in lead. Layers of lead were placed for long periods in contact with dielectric detectors (mylar, glass); in other experiments lead was built in to the detectors (crystal, lead glass). About 100 events of possible spontaneous fission of the lead were recorded. A possible explanation for the data obtained is that the effect is caused by the spontaneous fission of nuclei of an ultra-heavy element (114) which is the chemical analog of lead, and which could be present as a very small impurity (10^{-12} to 10^{-13}) in ordinary lead, having a spontaneous fission rate of 10^8 to 10^9 years.

Muon capture

Studies have been carried out over a number of years at the synchro-cyclotron concerning the processes by which neutrons emerge during the capture of muons by nuclei. It had been previously noted that there was large asymmetry in the escape of neutrons in these processes, and the energy dependence of the asymmetry was measured.

In order to study the mechanism of muon capture and interpret the anomalies observed, a new experiment was carried out in which careful measurements were made of the neutron spectra in the 1.5 to 14 MeV range. With the resolution achieved in the experiment (about 0.5 MeV for the neutron energy) the spectra relating to neutrons obtained during the capture of negatively charged muons by sulphur and calcium were found.

Peaks in the measured spectrum for muon capture in sulphur and calcium are the first direct proof of the formation, during muon-capture, of excited states, confirming the conclusions of a theory of 'resonance' absorption of muons by nuclei, put forward by Soviet theoreticians. These data show that there exists an interesting possibility of studying, these states of nuclei by means of muon capture.

ITEP Moscow
Experimental Programme

The Institute of Theoretical and Experimental Physics, Moscow, has facilities for research in high energy physics and in nuclear physics. The nuclear physics is carried out on a heavy water reactor (neutron flux 10^9/cm^{2}s) and on a small cyclotron. A major achievement has been the observation of parity non-conservation (occurring at the rate of 1 in 10^5) using the capture of polarized neutrons in cadmium 114 and looking at the emitted gamma. (A similar elegant experiment was carried out at Leningrad looking at the circular polarization of gammas.)

The high energy physics programme is centred on a 7 GeV proton synchrotron which came into operation in 1961. It is an alternating gradient machine with fields rising from 90 G at injection (from an electrostatic injector at 4 MeV) to 9.5 kG at full energy. The diameter is 80 m and the vacuum vessel aperture 8 × 11 cm. It is now operating at an intensity of 4×10^{11} protons per pulse and a pulse rate of 1 per 4 s.

A Dubna/ITEP team are using a 150 litre xenon bubble chamber to look at the decay of the long-lived neutral kaon into two neutral pions (a similar experiment to the CERN/Ecole Polytechnique/Orsay experiment reported at Vienna — see CERN COURIER vol. 8, page 243). They hope to have taken 600 000 pictures by the end of this year, 100 000 are already being measured. If η_{00}, the parameter over which considerable experimental conflict reigns at present, has the value of 2, as predicted by the superweak theory, then about 120 pictures of the decay should be observed.

A few weeks ago a 2 m hydrogen chamber came into operation and is being used initially with negative pion beams.

Among the spark chamber experiments is a survey of backward charge exchange scattering over the range 0.5 to 3.8 GeV/c

$$\pi^- + p \rightarrow \pi^0 + n$$

A missing mass spectrometer uses a negative pion beam to look for negative

1. *A magnet cycle of the Bevatron showing three long spills at different energies (for BeV, Europeans read GeV). The current fed to the accelerator (in amperes) is plotted on the y-axis. The repetition rate in this mode of operation is 8 cycles per minute.*

2. *Another magnet cycle giving two fast pulses for a bubble chamber followed by two long spills at different energies. The repetition rate is here 10 cycles per minute.*

(Diagrams LRL)

bosons and another large magnetic spectrometer is studying rho production. This spectrometer has a magnetic field volume 3 × 0.8 × 0.5 m³ in which spark chambers are installed.

The Institute also takes part in research at the Serpukhov 76 GeV accelerator. Four experiments involving ITEP are already planned. The first (almost ready) will look at pion-proton and pion-neutron scattering

$$\pi^- + p \rightarrow \pi^0 + n$$
$$\pi^- + n \rightarrow \pi^- + n$$

The second will take a 60 GeV/c negative pion beam into a huge magnetic spectrometer, 6 × 1.5 × 0.7 m³. Optical spark chambers will be installed in the field volume and a mirror system will bring the information from the chambers through twelve apertures in the upper yoke of the magnet onto film. The spectrometer will be completed in a few months time.

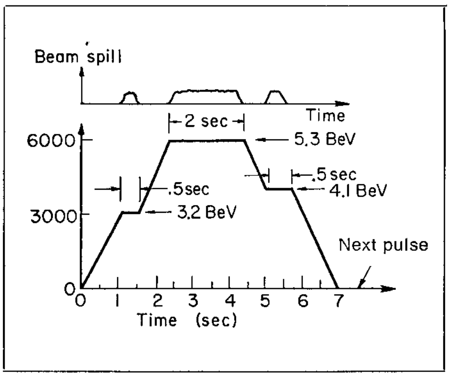
The third experiment will be a survey of polarization, A and R parameters using pion, kaon and proton beams onto a polarized proton target (an organic target rather than the conventional LMN target). Wire spark chambers will be used among the detectors. This experiment is scheduled to start at the end of this year. The fourth experiment is in the early planning stage and will not start until 1971. It will be a survey of the neutron-proton interaction at high energy.

BERKELEY

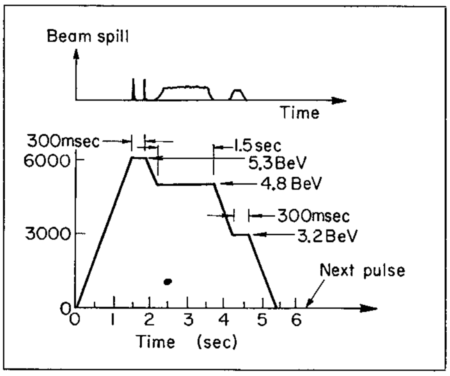
Bevatron control

The successful completion of two independent control projects has given new capability and more flexibility in the operation of the 6 GeV Bevatron at the Lawrence Radiation Laboratory, Berkeley. The projects have concerned (1) gymnastics with the power pulse to the accelerator magnets to give a variety of conditions under which the accelerated beam can be used, and (2) computer control of an ejected proton beam.

A new method of producing the flat-top pulse has resulted in a substantial improvement in flat-top modes of operation. Pulse lengths of up to 2 s are now common practice and various combinations of 'front-porch', 'flat-top' and 'back-porch' pulses are flexibly achieved. (Two such combinations which have been used recently are shown in the diagrams). These terms, which come from the shape of the current pulse fed to the accelerator magnets (they can be deduced from the diagrams) refer to the conditions when the current and thus the magnetic field is held virtually constant for a time, as is required when particles are being ejected from the machine. To be able to produce a variety of tops and porches means to be able to produce, in one machine cycle, ejected beams of a variety of energies lasting for a variety of times.



1.



2.

In the previous method of operation, one of the two Bevatron alternators was inverted at the start of flat-top, the other remaining in the rectification mode. Consequently, power was exchanged between the two machines during flat-top. The roles of the two alternators were reversed every other pulse so that the average speeds of the two machines remained the same.

In the new scheme, the alternators and the power converters habe been connected in a different way so that power is not exchanged between the two machines. The advantages are a substantial reduction in the cyclic stress on the rotating parts of the generator (a very desirable advantage in view of the troubles experienced in the past at many Laboratories with these heavily burdened machines) and a greatly improved flexibility in the pulse programme.

In February, an on-line computer control system was brought into operation on a dual-channel ejected proton beam (EPB) which has 16 pulsed magnets. It provides continuous up-dating (every 3 ms) of the currents in each of the magnets and allows independent operator control of the slope and magnitude of the current within each of the beam spill zones (front-porch, flat-top, back-porch). Perturbations in the magnet currents make it possible to have several modes of operation, such as fast spill for bubble chambers and beam switching between the two EPB channels.

The automatic control system has worked very well and with this success behind them the Bevatron team intend in the near future to apply the techniques of computer control to the main magnet power supply. It will then be possible for the accelerator guide field programme to be readily adjusted and optimized for each desired operating condition.

Further plans for computer control involve an extension of the present ejected beam control to include the d.c. magnets of the dual channel system, and ten pulsed magnets of a new EPB (septum channel) which is now being developed from the second focus of EPB channel I.

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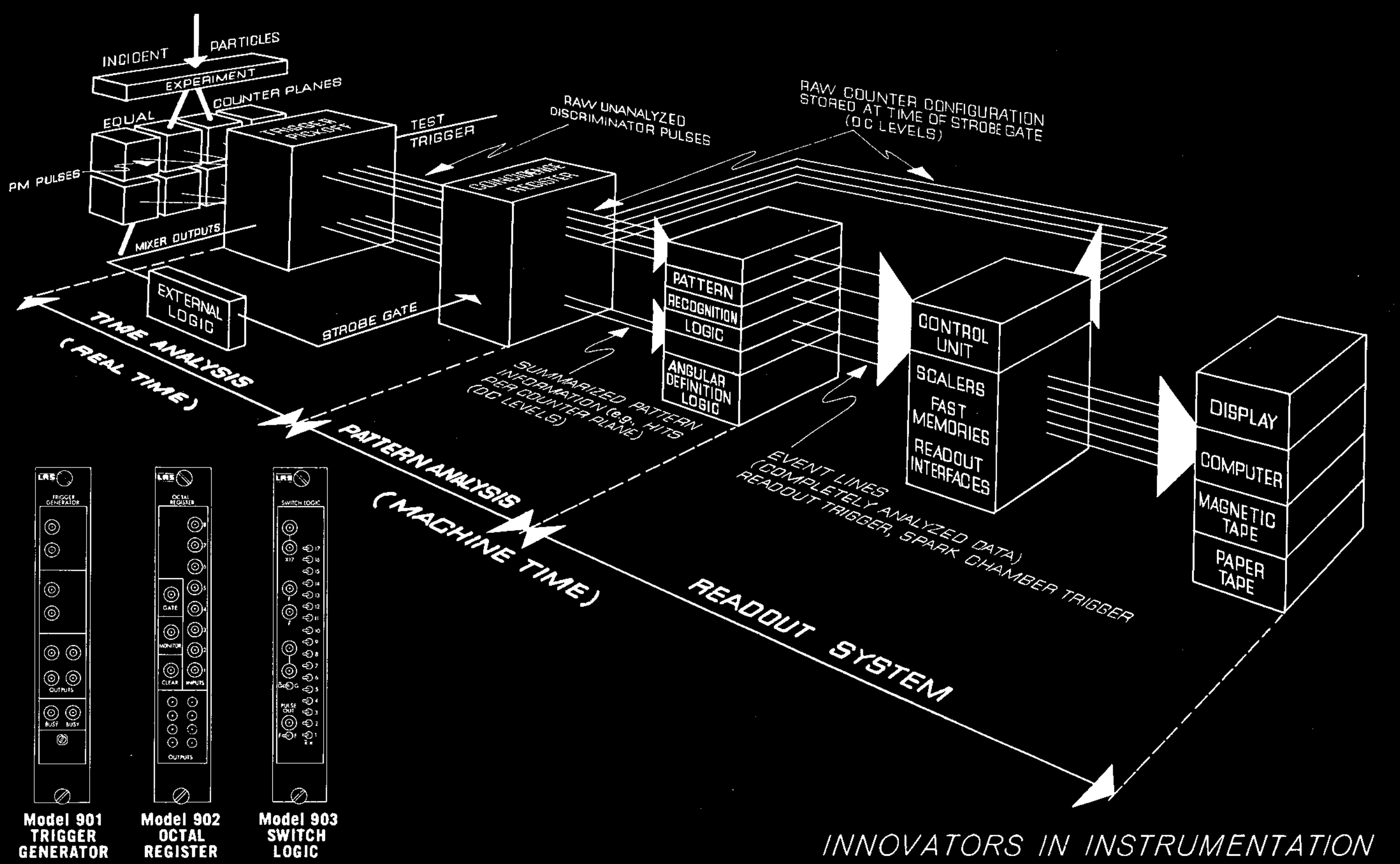
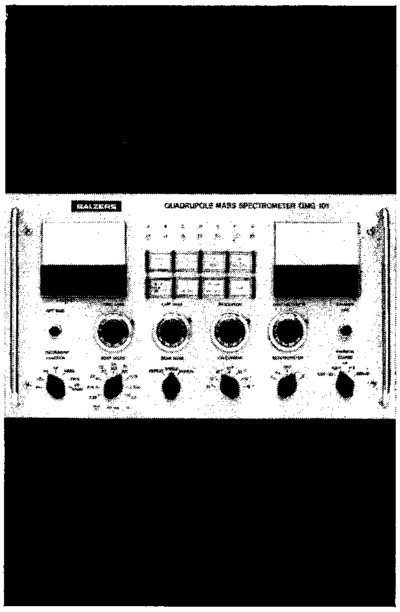
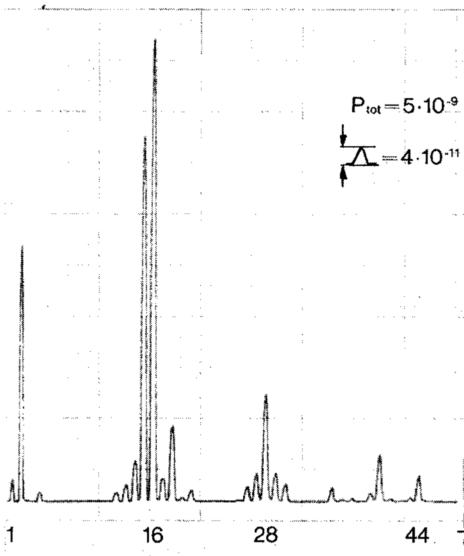


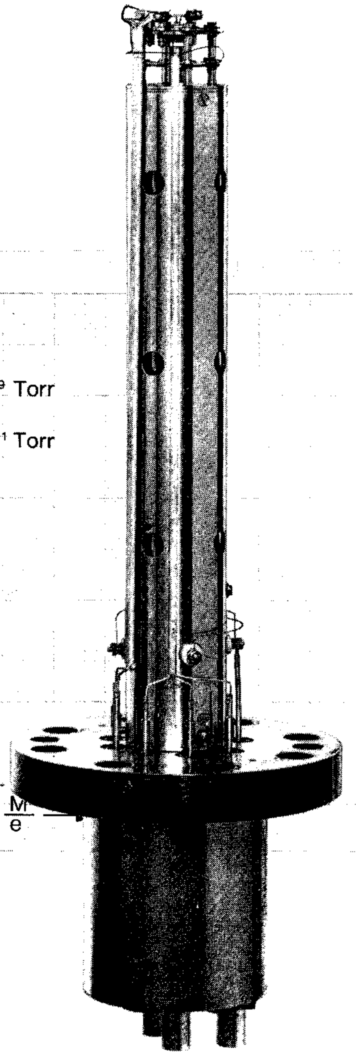
INNOVATORS IN INSTRUMENTATION

Partial Pressure Measuring Instrument QMG 101

Sensitivity 10^{-13} – 10^{-14} Torr
Mass range 1—400







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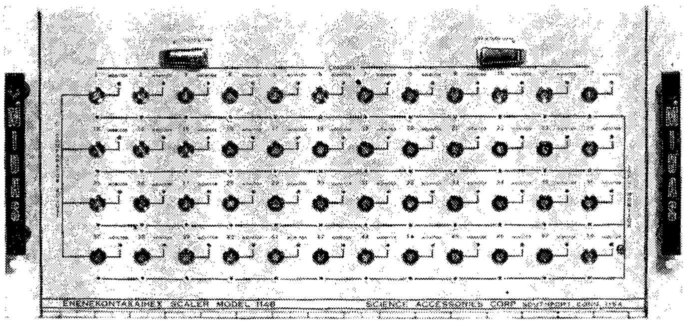

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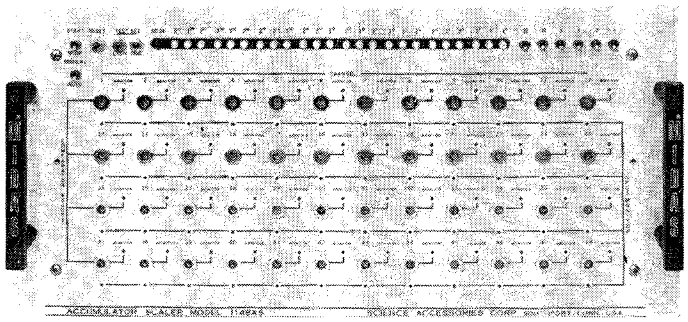

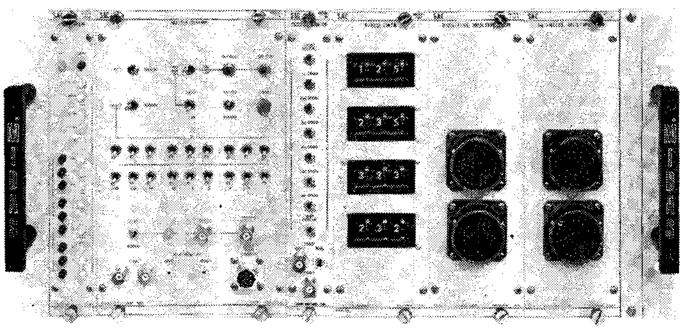

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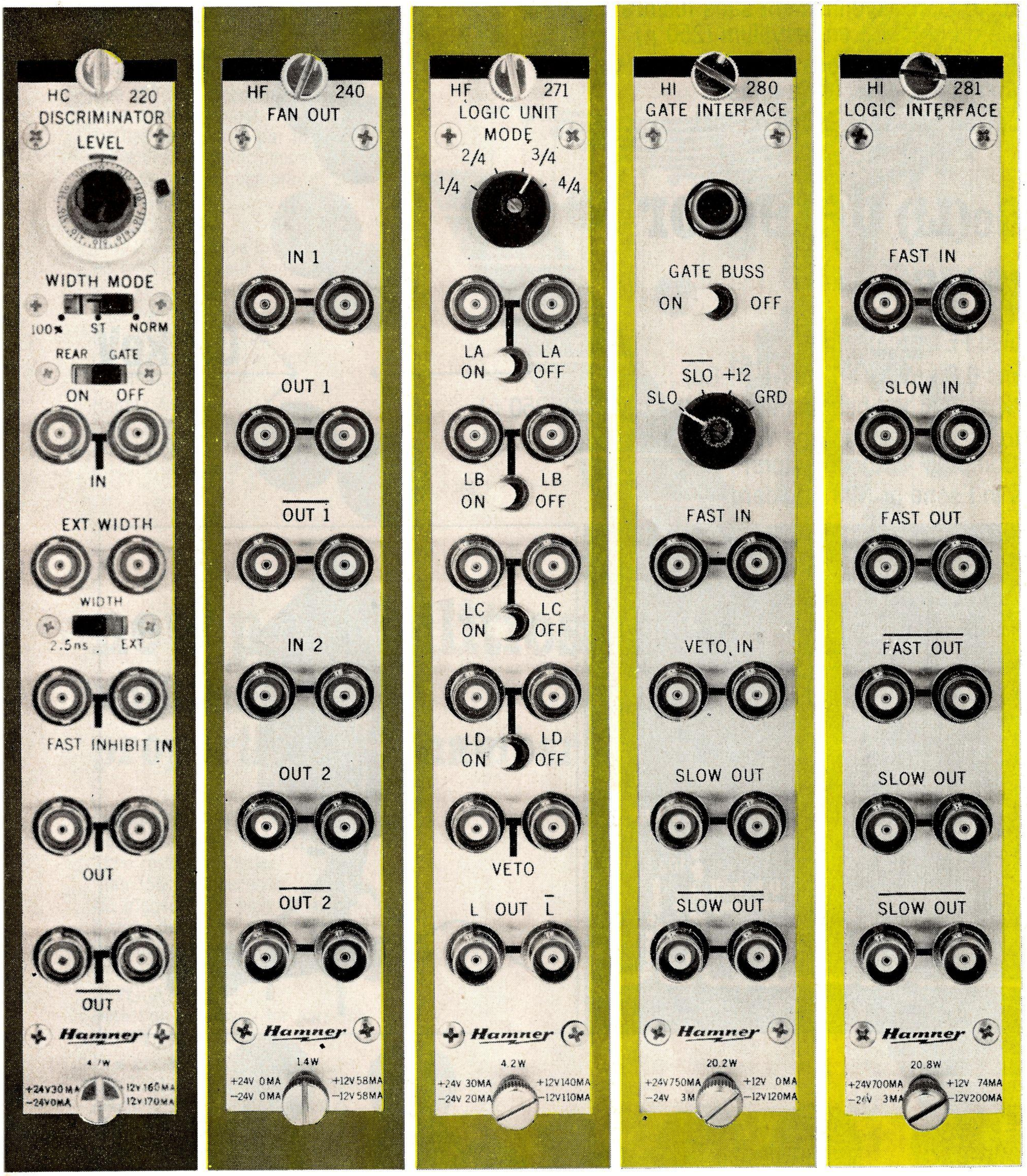

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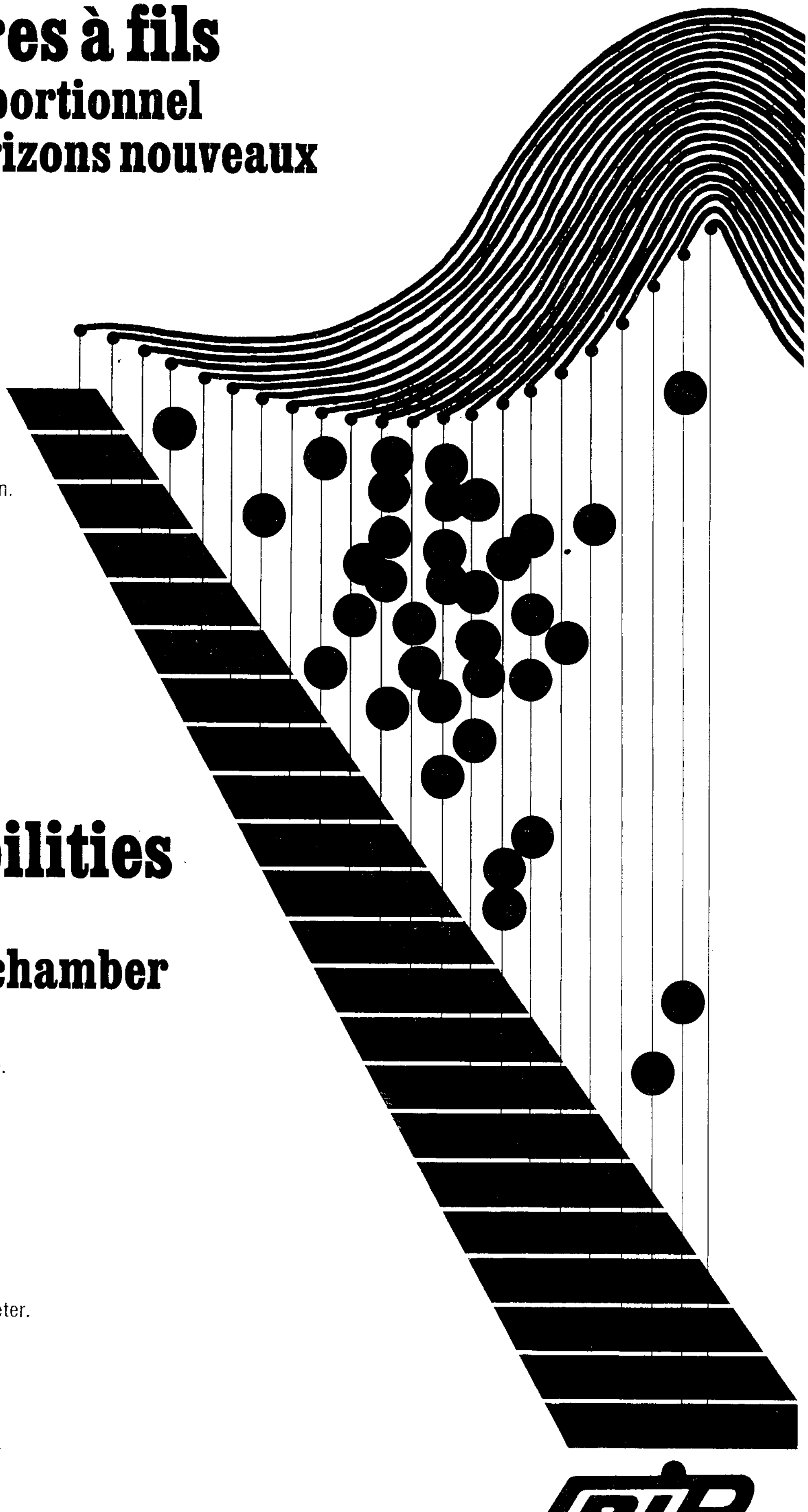

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High energy physics :
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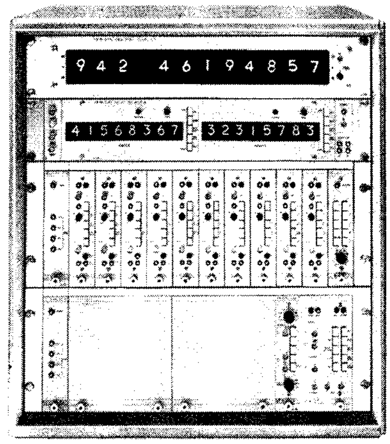

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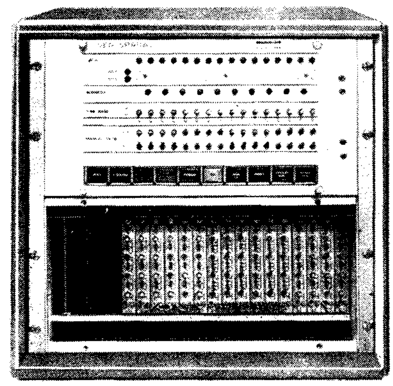

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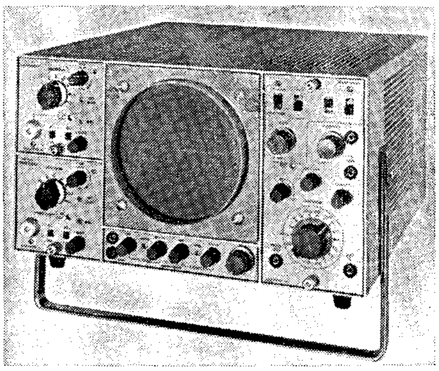

Oscilloscope double trace mod. CD 1400

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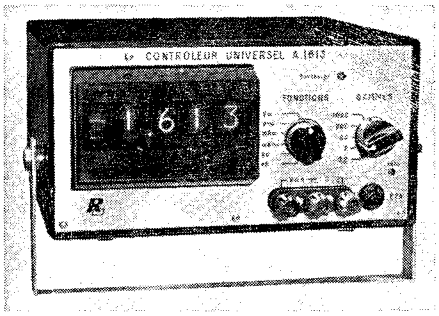

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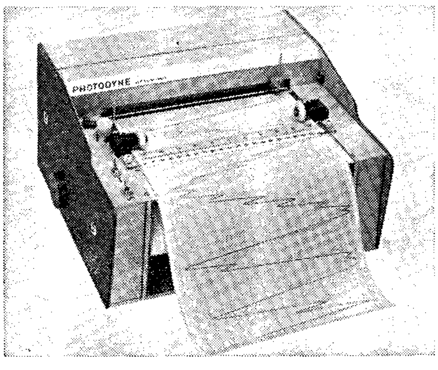

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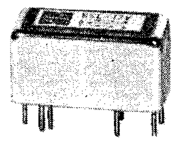
Relais «Reed», conception nouvelle, REL R-10



- ☐ Relais miniature polarisé
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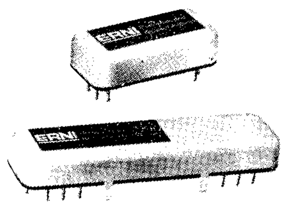
Relais «Reed», types ARID et ERID



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- ☐ Jusqu'à 6 contacts de travail ou inverseurs
- ☐ Commutation très rapide
- ☐ Haute sensibilité
- ☐ Connexions pour circuits imprimés

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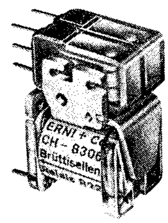

- ☐ Pour courant continu ou alternatif
- ☐ Faible encombrement 20×20×24 mm
- ☐ 1 ou 2 contacts inverseurs 6 A 250 V ∿
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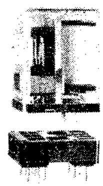

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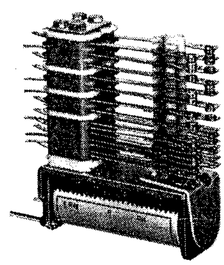

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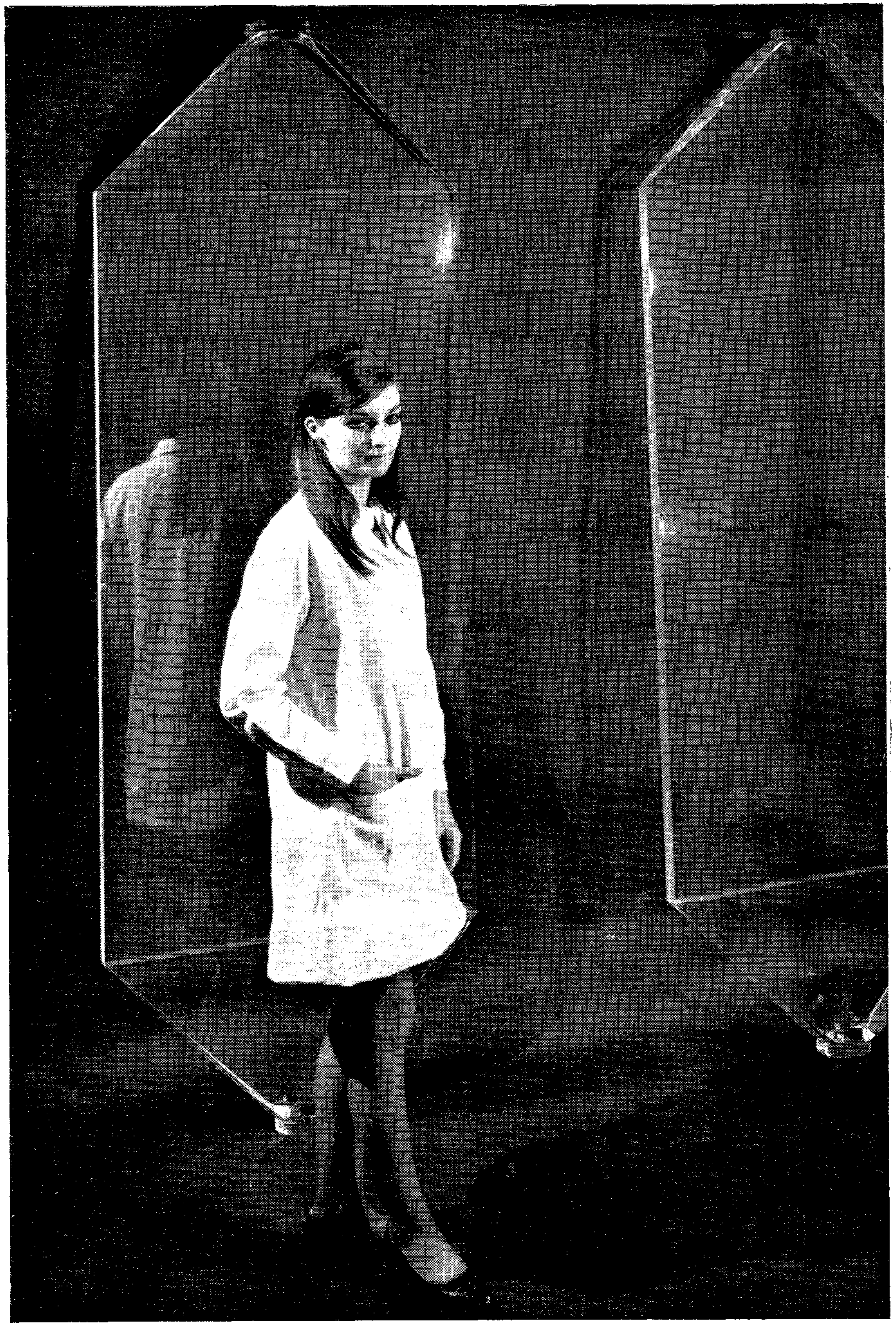

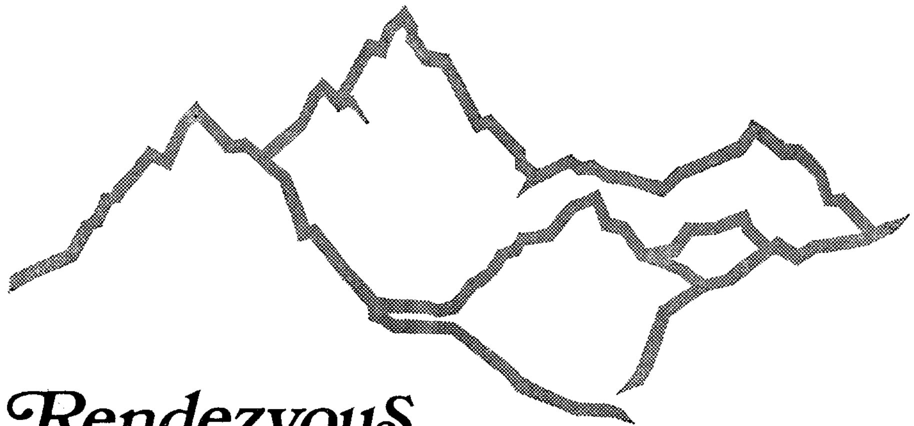

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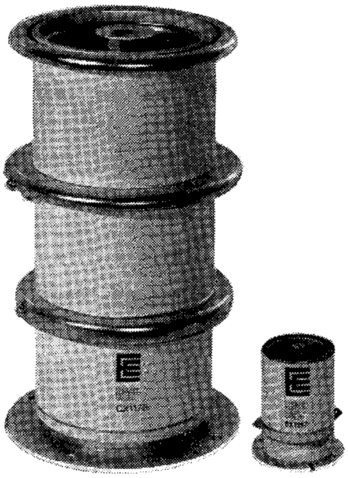
EEV thyratrons-for better high speed switching



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1 Their short anode delay time of between 20 and 120 nanoseconds depending on triggering method.

2 Low jitter generally of 1 to 2 nanoseconds but down to less than $\frac{1}{2}$ nanosecond depending on heater supply.

3 The negligible change in anode delay time—typically only 10 nanoseconds over a long period of use.

4 A high peak inverse voltage capability of 20kV immediately following pulse.

5 The low trigger power required.

6 The wide operating voltage range of 1kV-120kV with four tubes.

7 The ability to control anode delay time and rise time of current, using reservoir.

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Particle linear accelerators with RF accelerating powers up to 50MW. They may also be used in first-stage particle beam choppers.

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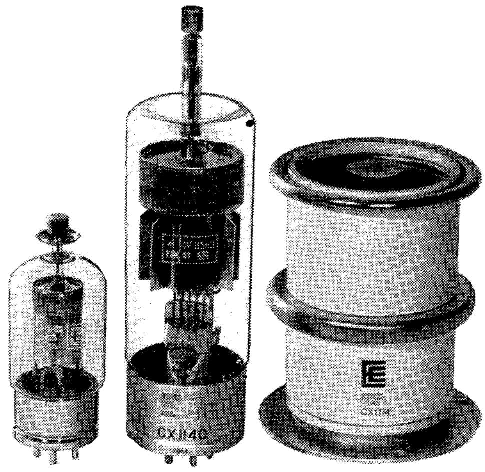

Brief data on some of the ceramic types available.

Type	Peak power output max (MW)	Heating Factor (V.A.p.p.s.)	Peak forward voltage max (kV)	Peak anode current max (A)	Mean anode current max (A)
CX1154	50.0	30 x 10^9	40	2500	3.0
CX1157	3.5	7 x 10^9	20	350	0.35
CX1168	100.0	70 x 10^9	80	2500	2.5
CX1171	150	70 x 10^9	120	2500	2.5
CX1174	120	60 x 10^9	40	6000	6.0
CX1175	200	140 x 10^9	80	5000	6.0
CX1180	12.5	9 x 10^9	25	1000	1.25

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Peak forward voltage

Peak anode current

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Direct-coupled limiting VETO input with buffered VETO output.

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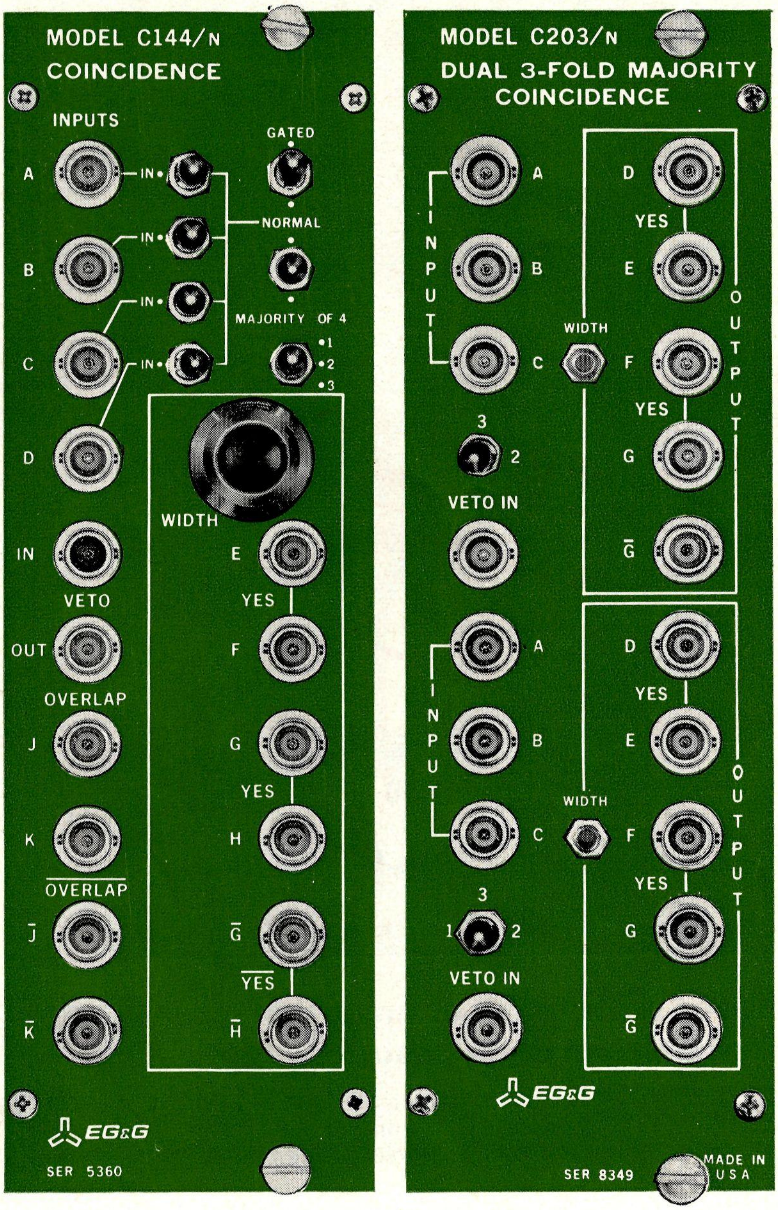
Dual OVERLAP (AND) and dual OVERLAP (NAND) NIM standard fast logic outputs. Full output 2 nsec FWHM or greater. Output pulse pair resolution typically 4.5 nsec.



Three direct-coupled inputs accept NIM standard normal or complementary fast logic signals of 2 nsec duration or greater.

Resolution of 6 nsec for full NIM standard output pulses. Updating resolution of 5 nsec.

Direct-coupled VETO input.

MAJORITY level selected by locking toggle switch; all inputs participate.

Two dual YES and one YES regenerated NIM standard fast logic outputs. Output pulse width continuously adjustable between 4 and 200 nsec.

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