CERN

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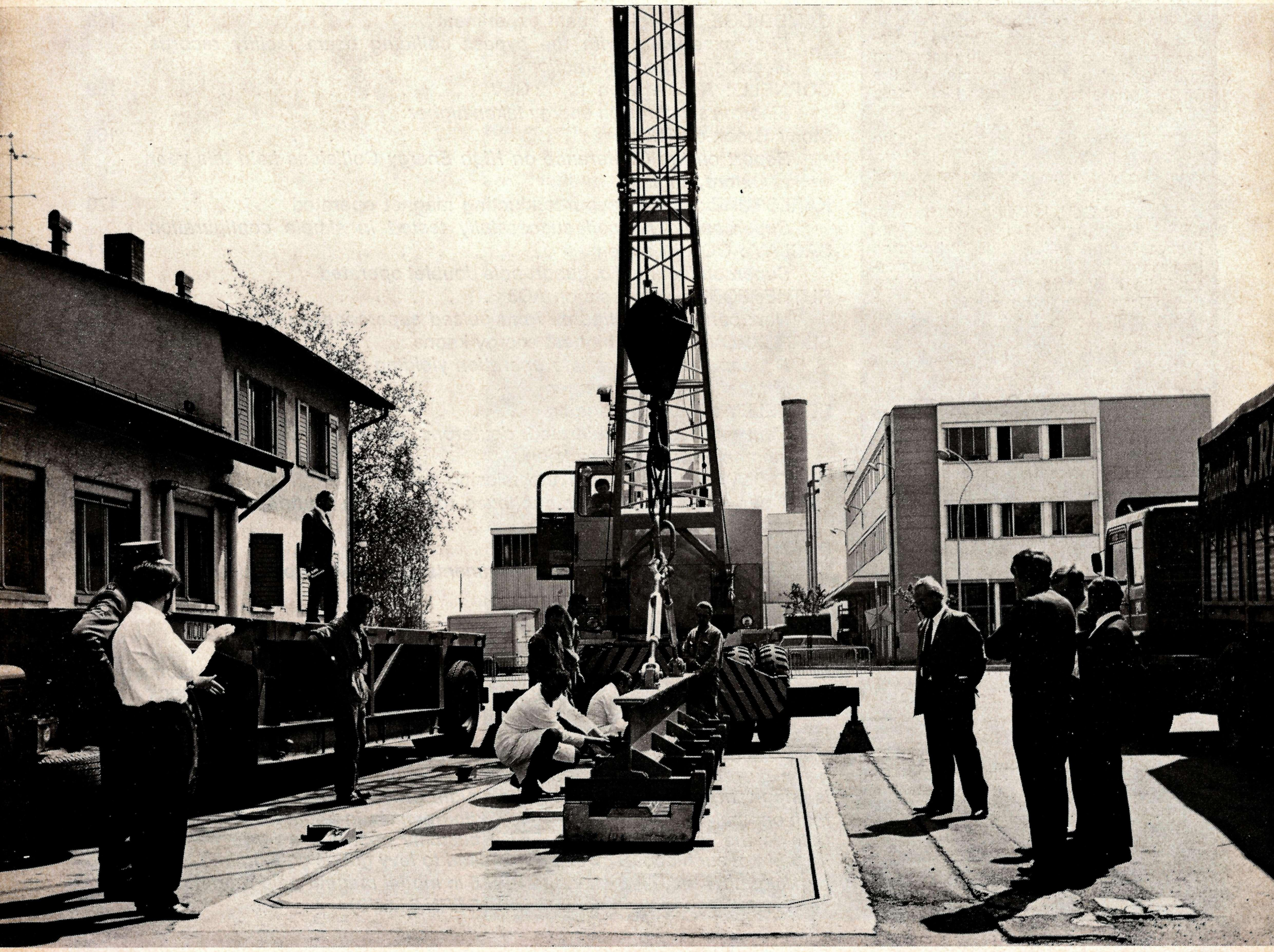

CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, 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. The Organization has its seat at Meyrin near Geneva in Switzerland. There are two adjoining Laboratories known as CERN Laboratory I and CERN Laboratory II.

CERN Laboratory I has existed since 1954. Its experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). Large intersecting storage rings (ISR), are fed with protons from the PS for experiments with colliding beams. 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 research material from CERN.

The CERN Laboratory I site covers about 80 hectares almost equally divided on either side of the frontier between France and Switzerland. The staff totals about 3000 people and, in addition, there are about 850 Fellows and Visiting Scientists. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 371.4 million Swiss francs in 1972.

CERN Laboratory II came into being in 1971. It is supported by eleven countries. A 'super proton synchrotron' (SPS), capable of a peak energy of hundreds of GeV, is being constructed. CERN Laboratory II also spans the Franco-Swiss frontier with 412 hectares in France and 68 hectares in Switzerland. Its budget for 1972 is 95 million Swiss francs and the staff will total about 300 people by the end of the year.

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Cover photograph : SPS model magnet weighing-in at the Swiss customs post. Models of the magnets to be used in the SPS have been built to check constructional techniques and magnetic properties ; the one in the picture is a full-sized version over 6 m long. When they are built to go to high fields (over about 1.5 T) the field level that can be achieved in a magnet with a given current depends very much on the amount of steel in the yoke. It is important, therefore, to know the weight of the model accurately (to better than one part in a thousand — a few kilogrammes in about 6 tons). Just outside the CERN gates, the Swiss customs post has a large weighbridge capable of such accuracy since it is used to levy goods coming into Switzerland by weight. Hence, on 8 May, the SPS 6 m model magnet paid a brief, and successful, visit to the outside world. (CERN 85.5.72)

Progress of telescope project

In 1970 the European Organization for Nuclear Research entered into an Agreement with the European Southern Observatory under the terms of which CERN is participating in the design and construction of a large optical telescope. At the time of the Agreement in August 1970, an article appeared in CERN COURIER (vol. 10, page 248) which described the aims and structure of ESO and the nature of the collaboration with CERN. We describe here how the telescope project is developing.

But first a refresher course on ESO. ESO is a joint enterprise of European astronomers who have come together to establish research facilities which would otherwise be beyond the reach of individual astronomical research centres. The Member States involved are Belgium, Denmark, Federal Republic of Germany, France, the Netherlands and Sweden. The aim is to study the sky in the southern hemisphere which up to now has not been subjected to such close scrutiny as the northern sky. There are particular features of great interest such as the Magellanic clouds and the central region of our galaxy which would become accessible to detailed study.

An observatory has been in action since 1967 on the mountain La Silla, 600 km north of Santiago in Chile. A large tract of desert, about 630 km², surrounding the observatory has been reserved for ESO by the Chilean government so as to prevent any other activity which might interfere with the viewing conditions from the mountain top which are among the best anywhere in the world.

ESO serves its scientific clientele in a similar way to CERN. There is a small nucleus of permanent professional staff but the majority of the research is carried out by visiting astronomers who return to their home centres. They have been using a

Aerial photograph of the ESO observatory on La Silla mountain in the Atacama desert in Chile. The buildings housing smaller telescopes which have been in action for several years can be seen and near the top right hand corner is the flattened summit where the 3.6 m telescope being constructed with the collaboration of CERN will be erected.

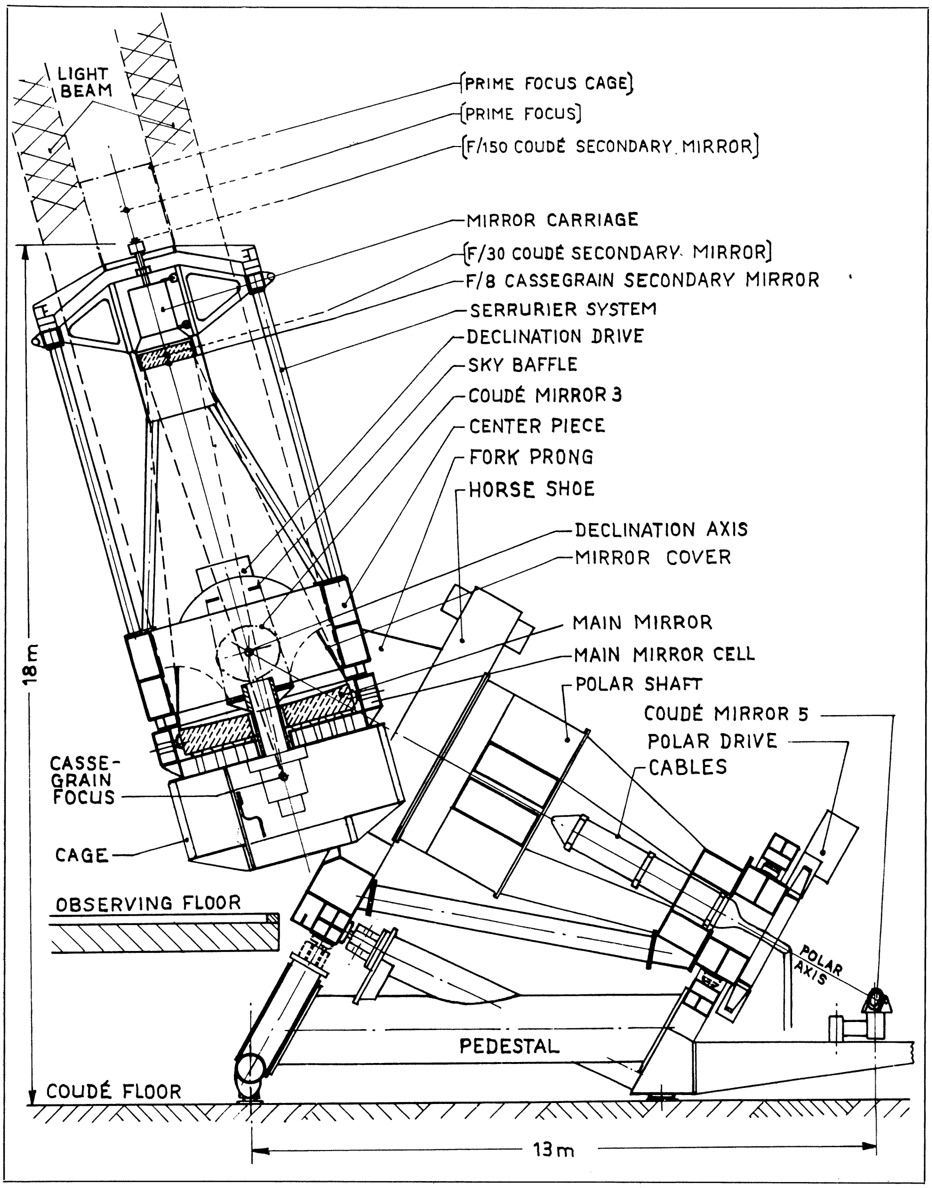


Diagram of the telescope indicating the three modes in which it can be used (using the primary, Cassegrain and/or Coudé focus). The telescope will stand about 25 m high and weigh about 200 tons. The main mirror is 3.6 m in diameter. Complex mounting and drive systems are needed to achieve the necessary high precision in orientation.

battery of small telescopes already set up at the Observatory in Chile and await the arrival of a large optical telescope with a mirror diameter of 3.6 m. This telescope will have a very high light gathering power.

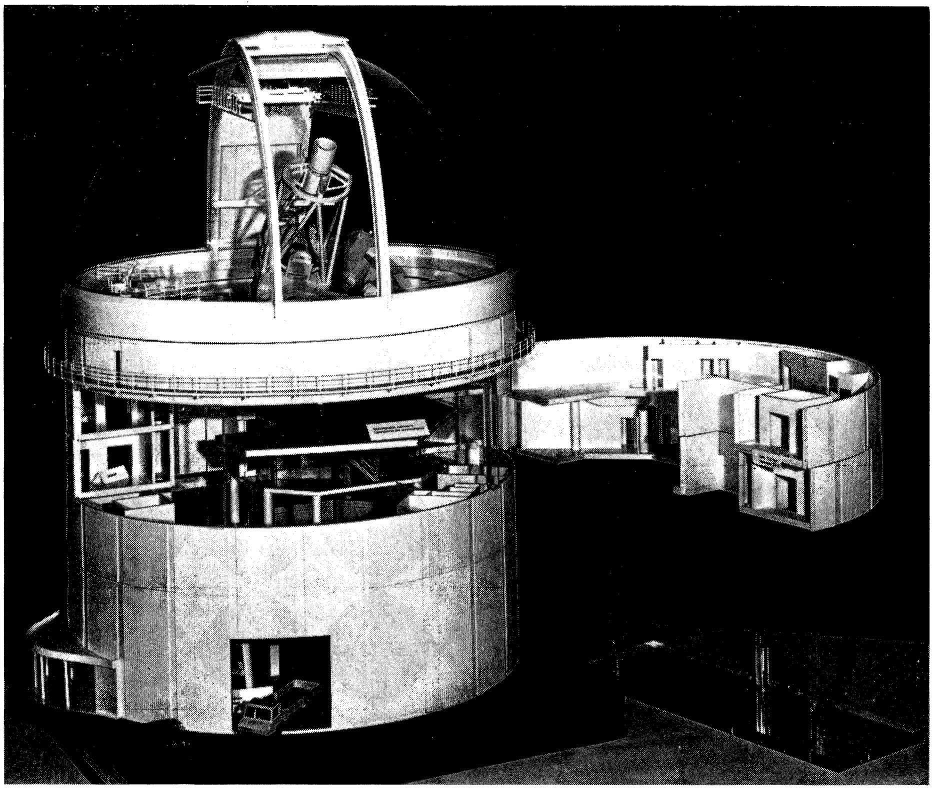
This large telescope plus its instrumentation is a project on a scale considerably larger than the small ESO organization is used to handling. It was for this reason that the ESO Council asked for CERN's help in providing engineering experience, technical know-how and the administrative apparatus for seeing such a large project through. Following the signing of the Agreement, the Telescope Project Division, led by S. Laustsen, came to CERN. It remains financially independent and pays for the CERN services which it uses.

Three CERN Divisions have been mainly involved up to now — the Proton Synchrotron Division (particularly W. Richter and with the close interest of the Department Head, C. Zilverschoon), the Technical Services and Buildings Division (particularly E. Leroy) and Data Handling Division (particularly D. Wiskott). As the stage of placing contracts is reached the Finance Division also is shouldering some responsibilities on behalf of ESO. About 15 professional staff from ESO and CERN are working on the project and there will be about 40 total staff by the time the project is completed.

The major task of the past two years has been to complete the detailed design of the telescope and its building. A design report was issued in February 1971 and received wide circulation among probable users so as to gather as much comment as possible. In addition there was a very successful conference held at CERN in March of the same year on the subject of large telescope design which brought together experts from Europe, USA, Canada and the Soviet Union. Both comment on the report and discussions at the conference led to a number of design changes.

The major features of the telescope itself were however retained. The telescope will be used in three modes — the prime focus or Newton focus (to be used mainly for observing objects of low brightness), the secondary or Cassegrain focus (where the astronomer will sit in a cage, as is also possible at the prime focus, moving with the telescope — one of the design changes was to make more space available for the observer at this focus) and/or the third focus or Coudé focus (which takes incoming light via a system of mirrors down to a separate room). The Coudé room can be used at all times, by means of a siderostat, regardless of other modes in which the telescope is used. These features are illustrated in the diagram of the telescope.

A model of the telescope and its building. Part of the side wall is swung back to show more of the internal arrangement. The dome and its shutters will move in phase with the telescope so that it always points at an aperture in the dome.



The main mirror is now finished at the firm R.E.O.S.C. in Paris. This has been an intricate piece of work for such a large size mirror — the surfaces had to be achieved with an accuracy of 0.06 μm. The secondary mirrors are also nearing completion at the same firm.

The tender documents for the large base mounting units are going out ; those for the smaller top mounting units will follow later. It is likely that the initial assembly of the telescope, which is to take place in Europe prior to dispatch to Chile, will take place in the factory where the large mounting units are manufactured since a large building with plenty of vertical height will be necessary.

The building to house the telescope has been completely redesigned, following comment from astronomers on the initial design, and a cheaper more compact version is now drawn out in detail. A model illustrating the building with the telescope in place can be seen in the photograph. The invitations to tender for construction of the building are now going out and it is hoped to place the contract by the end of the year so that work can start in Chile at the beginning of next year.

One unusual feature, which will provide maximum operational flexibility without loss of operational time, is a platform from which it will be possible to change top units. Normally these changes are done from above with the telescope held vertically. However, by mounting top units with the telescope horizontal it looks possible to change the units reasonably rapidly so that the telescope could be adapted quickly to changing atmospheric conditions and valuable research time saved.

The auxiliary instrumentation has not yet been taken very far. A major purpose of the conference on instrumentation held this month (see under CERN News) was to pool the most up-to-date ideas on this subject. Both the fluctuations of interest in the fields of research and the rapidly advancing technology in instrumentation require that these decisions be taken as late as possible.

However, the computer system has been selected and, since this is a major contract in the project (placed on 11 April), we will feed in more detail than we have for the other components where the contracts have not yet been placed. The selected computer is a Hewlett Packard 2100 which, together with the peripheral units, costs over 600 000 Swiss francs. The computer system will be used both for the control of the telescope and for acquisition of data with some on-line analysis.

Under normal circumstances control will be entirely automatic via the computer but there will be a clear interface where manual intervention is possible. The computer will control the orientation of the main telescope, the mirror and siderostat (which ensure that the Coudé focus is always fed with light), the movement of the building dome and shutters (so that the openings are always lined up with the telescope position), and the control of the exchange of top units from the horizontal platform. The driving of well over a hundred motors is involved in these control operations.

The astronomer will be able to feed to the computer, for example, a list of stars of interest. During the day the disk of the computer can thus assemble a star file (which can be modified in the course of the observations if required) ready for the night's work. It will then guide the telescope to a star (and to subsequent stars on the list), having done the sums as to where it will be at that time of night. The telescope will run quickly towards the correct orientation, slowing as it reaches the desired position.

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It will then lock onto the star and the computer will do the calculations to take account of the earth's rotation and make the adjustments to keep the star in view (and of course keep the dome, shutters, mirror and siderostat also in phase). Further complications that the computer can take care of are corrections for the bending of the mechanical parts of the telescope according to the particular orientation and corrections for the thickness of the air layer (giving atmospheric refraction) traversed by the incoming light.

During the observation period the astronomer will communicate with the telescope via the computer's cathode ray display and keyboard. Data will be collected and stored by the computer but will normally be transferred, for example to magnetic tape, to be taken away to a larger computer for analysis. However some data reduction will be possible to give samples of the quality of the information being collected.

Testing of the computer control scheme, with mock-ups of motor drive systems etc., is already underway and the computer programs are being developed.

The present schedule calls for assembly of the telescope in Europe early in 1975 and, if all goes well, the telescope should move to Chile at the end of the same year and come in to use in 1976 on La Silla mountain.

Booster commissioning

Running in of the PS Booster started on 1 May. The Booster is one of the major items of the improvement programme at the 28 GeV proton synchrotron. It will take the linac beam at an energy of 50 MeV and, in four superposed rings, accelerate the protons to 800 MeV before feeding them to the synchrotron. By injection at this higher energy the space charge limit in the PS will be raised and it should then be possible to achieve beam intensities in the 10^{13} protons per pulse region.

At the time of writing, there have been five experimental runs with the Booster. At the time of the first run it was a comparatively 'unaligned' machine — alignment of the quadrupoles was going on progressively in parallel with the first tests. On 3 May, the beam was taken 2 ½ times around Ring 3 (Ring 3 is in the same vertical plane as the linac beam and hence injection was simplified, being two-dimensional rather than three-dimensional as will be required for the other Rings). At that time about half the quadrupoles were aligned.

Two days later a circulating beam was achieved and the signal induced by the beam can be seen in the photograph. On 16 May, with the machine fully aligned, the beam circulated for 7 ms (4200 turns). The beam was lost only when steered out to the vacuum chamber wall under the influence of the rising magnetic field (no r.f. acceleration being applied).

In the next issue we hope to report further progress on the running in of the injection beam-line and the PS Booster.

Spring Study

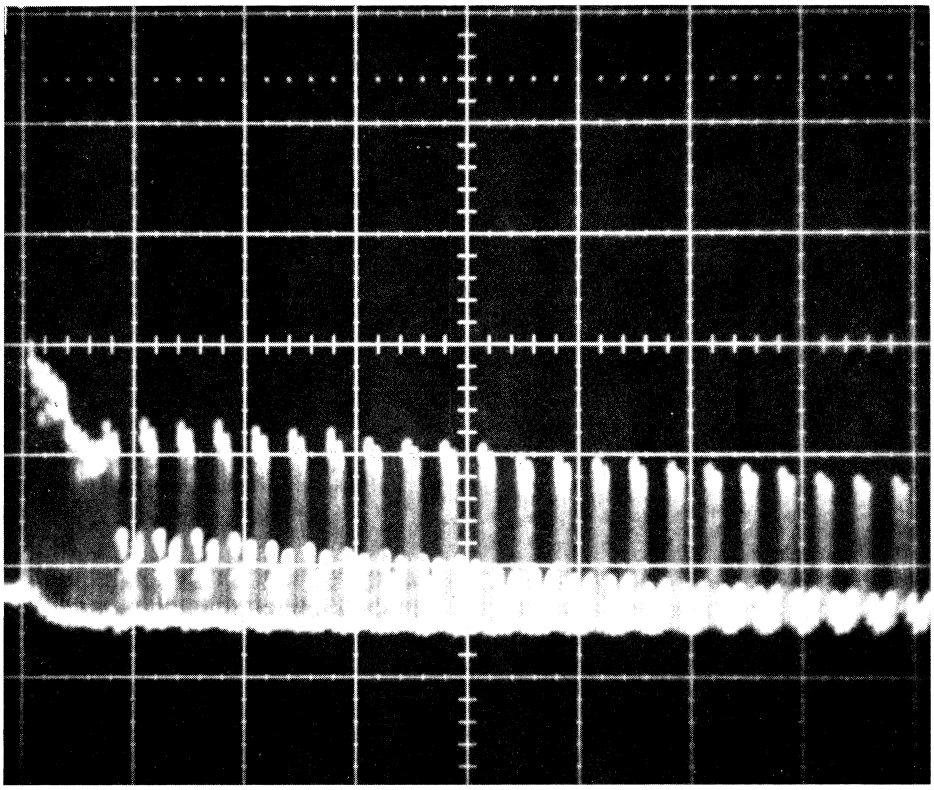
During the last two weeks of April a concerted attack on the theoretical aspects of the SPS design was held at CERN. It brought together about twenty machine theorists from other Laboratories and, when a similar number of participants from CERN itself is added, it must have been one of the largest gatherings of its type ever to be held.

The Study followed an initiative of the Advisory Machine Committee and is one of the ways in which the accelerator expertise in the other European Laboratories is being brought into the SPS project. There were people from Frascati, Orsay, Rutherford, DESY, Daresbury, Saclay and Karlsruhe, plus one participant from Brookhaven.

The exercise started in March when a series of talks by Laboratory II Group Leaders presented the machine design. With this basic information the theoreticians were able to get their teeth into refined aspects of anticipated machine behaviour. For example, they were able to tackle such topics as high intensity effects which there had not been time to go into in great detail in the course of the preparation of the design report (CERN 1050). As a result, though there were no recommendations to change any important features of the design, the machine is much better understood and some potential difficulties, which might arise when every possible bit of intensity is squeezed from the machine, have been identified and now can be steered around.

Topics included a study of the 'stop-bands' where more detailed figures were fed into such things as the resonance widths and the growth rates for instabilities. The possibilities of selecting a different working point were examined but none seemed clearly preferable to the 27.75 value previously selected. A look at instabilities and the correcting elements which would be needed to cure them did bring some minor changes. The number of correction sextupoles can be reduced but their places will need to

On the evening of 5 May a beam transformer in Ring 3 of the PS Booster recorded this signal indicating that a circulating beam had been achieved for the first time. To make monitoring of the beam easier it was chopped into five bunches at the linac input. From the third turn on, three of the bunches appear at much reduced intensity. When this was analysed later, it seemed probably due to a timing error on the fast injection kicker magnet.



be taken by octupoles required to cope with the 'resistive wall instability'. (The effect of the octupoles on ejection conditions has not yet been worked out.) Disturbance of the beam at transition seems to be no problem. Instabilities due to the presence of electrons from the ionization of the residual gas could be troublesome but the introduction of a gap in the accelerated beam would cure it. Beam-component interactions which could perturb the beam do not seem to be a worry with the possible exception of interactions with the r.f. cavity structure.

A look was also taken at possible future storage ring schemes, the aim being simply to keep options open — to avoid doing anything unnecessarily which would make the SPS accelerated beams less suitable for storage rings should this seem an appropriate development many years from now. Among the schemes examined were a superconducting conversion of the ISR for higher energies (where the SPS characteristics look good), a by-pass scheme (where potential luminosities and costs do not look encouraging) and electron-proton schemes (where physics interest is currently high).

Another study is planned for the autumn when the work will concentrate on beam diagnostic equipment for the SPS.

Leptonic decays of hyperons

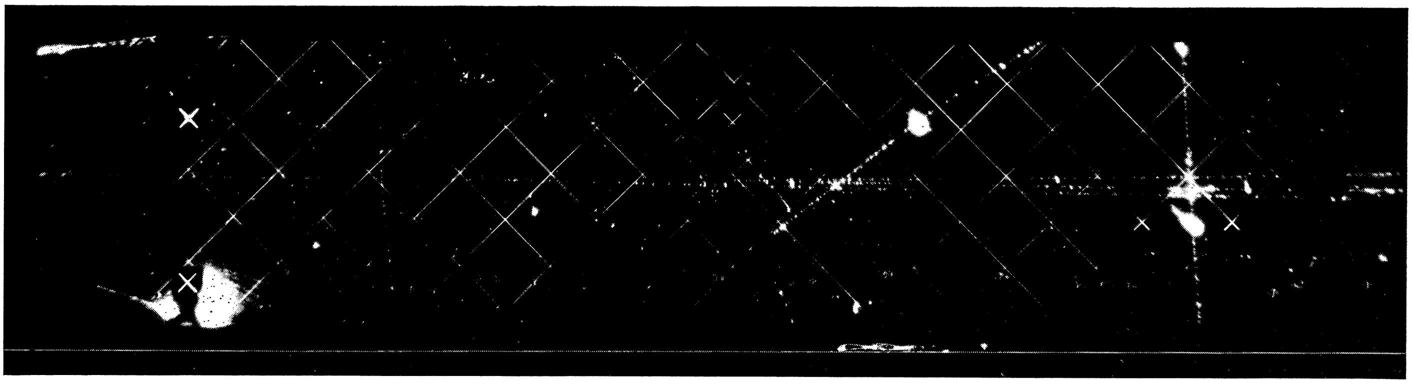
An experiment to study the leptonic decays of negative hyperons is under way in the East Hall of the 28 GeV proton synchrotron. This is another example of an experiment which was impossible prior to the recent setting up of hyperon beams at Brookhaven and at CERN.

The experiment is being carried out by a collaboration of scientists from CERN, Ecole Polytechnique and Orsay. The same team is now publishing the results of the previous experiment on the hyperon beam in which they looked at the sigma minus-proton total cross-section where the quark model predicts a relationship between this cross-section and other known cross-sections (the beam-line and the experiment were described in vol. 11, page 191). Expressing their result briefly — the quark model has stood up to the test.

The new experiment adds two streamer chambers to the collection of detectors and the sequence of equipment now reads as follows : the high energy slow ejected beam from the PS hits a target to produce the hyperons (higher energy increasing their lifetime) which are filtered out through a focusing and analysing system crowded together in only 3.7 m of beam-line to preserve as many of the short-lived hyperons as possible. The beam-line consists of two bending magnets and two short superconducting quadrupoles. A DISC (differential Cherenkov counter) at the output of the beam-line selects between the different particles. A useful flux of about 100 negative sigma hyperons is obtained from a beam of 2×10^{11} protons on the target. Multiwire proportional chambers on either side of the DISC give the direction of an incoming hyperon to a precision of ± 0.5 mrad.

A small sweeping magnet gets rid of low energy electrons just before the particles enter the first streamer chamber. This chamber is 3 m long, built by Orsay and Ecole Polytechnique, and is performing well. The leptonic decays of interest (such as negative sigma hyperon decaying into neutron, electron and antineutrino or into lambda, electron and antineutrino) take place in the streamer chamber and the charged particle tracks can be photographed. A threshold Cherenkov counter follows to identify the electrons (pions, which occur much more

A photograph taken in the 3 m streamer chamber, built by Orsay/Ecole Polytechnique, in use for an experiment on the hyperon beam. A negative psi hyperon enters from the left and decays into a negative pion and a lambda (a neutral particle which does not leave a track). About 45 cm further on the lambda itself decays into a proton and another negative pion so that three charged particle tracks can be seen emerging from the chamber.



frequently in sigma decays, do not give a signal) and there is then a second streamer chamber in a 0.8 T magnetic field 1.4 m long. This detector is used to measure the momenta of the electron and the charged decay products of the lambda. Proton counters give further handles on the lambda decay products and a neutron detector, consisting of optical spark chambers interleaved with thick iron plates, catches the neutron from the decay.

This battery of detectors ensures that the required information is collected and avoids,. as far as possible, collecting information about the many other types of event which, with a smaller array of detectors, could be mistaken for the events which are to be studied.

The physics interest lies in obtaining coupling constants for axial and vector currents with greater precision than has been achieved previously. It is predicted that only the axial vector current is involved in the sigma leptonic decay to a lambda. Also it should be possible, with the accuracy which the experiment hopes to achieve, to see the breakdown of the Cabibbo model of weak interactions. The model takes SU3 as an exact symmetry whereas in fact it should be broken within about 10 % limits. The experiment could register the effect of the symmetry breaking.

An experiment on sigma minus decays is also gathering data with the hyperon beam at Brookhaven. The experiment is carried out by a Brookhaven, NAL, Yale collaboration.

Another interesting demonstration that yesterday's hypothesis can become today's commonplace, is the fact that the Brookhaven hyperon beam is yielding on observable omega minus hyperon at the rate of about one per hour. Less than ten years ago the omega minus was just a gleam in theoretical eyes and prior to the hyperon beams only 30 of them had ever been identified.

Minnie

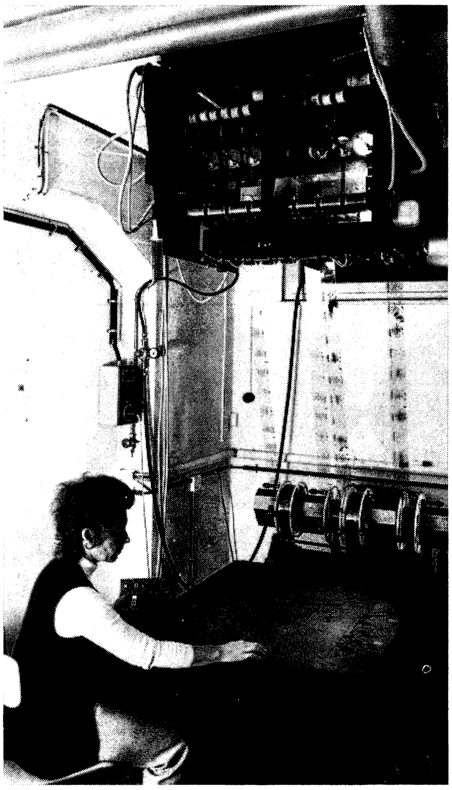
In the last issue we carried a piece on 'Bessy' a scanning and preliminary measuring machine specifically designed to cope with film from the 3.7 m European bubble chamber, BEBC. That device has proved extremely popular and has been ordered by many European research centres. Another machine, which like Bessy has been designed with economy very much in mind and with film from a particular chamber in view, is one called 'Minnie'.

'Minnie' is used for scanning and for measurement in the image plane of film from the heavy liquid bubble chamber Gargamelle. The efficient analysis of experiments in Gargamelle requires apparatus with rather complicated features in general but a good portion of the analysis can be done without them. 'Minnie' supplements the existing apparatus when these features are not required. It was designed and built at CERN very rapidly (about six months having elapsed between the first tests and the appearance, in September 1971, of the prototype which has been in uninterrupted production since then).

The machine could be manufactured in the workshops of most physics laboratories. The prototype without the measurement device cost about 10 000 Swiss francs for materials and about 800 hours work. At the moment, twelve are planned or are being built in various European research centres.

Many of the simplifications used in 'Minnie' are the same as those used by 'Bessy' (see last issue page 127). But it was also necessary to find a simple way of handling the complicated film format of Gargamelle which takes eight views spread out on two films for each photo. Views of the same photo are separated by sixteen other views of other photos. Instead of each film undulating like a Loch Ness monster between separate film gates it is wound in a spiral so that the views of the same photo are adjacent and all 8 can be held in a single film gate 675 mm long and 70 mm wide. The eight lenses are also on a single plate.

With a magnification of 12 × this compact arrangement makes it possible to hang the projector from the roof in a room of normal height without



'Minnie', the scanning and measuring machine which is used on film from the heavy liquid bubble chamber, Gargamelle. The use of a mirror is avoided in a very compact machine which can be accommodated in a room of normal height.

exceeding a projection angle of 26°, thus dispensing with the mirror. This is an important saving and also avoids the distortions inherent in reflection. The precision is 100 μm in the image or 8 μm in the film plane. The film reels are at table height and all manipulation of the films takes place at this level.

Although 'Minnie' is designed as an image plane device for Gargamelle it would be possible to make it into a simple film plane measurement system and also to adapt it to film from other chambers.

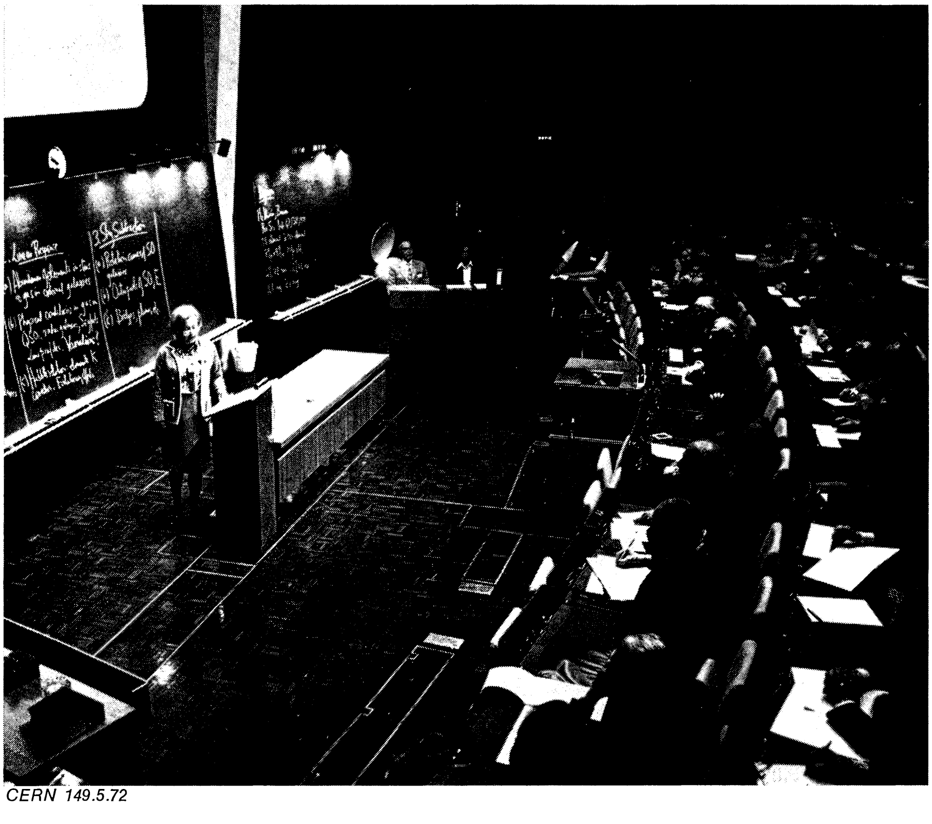
Telescope Conference

From 2 to 5 May about 180 scientists, predominantly astronomers, came together at CERN to take part in the ESO/CERN Conference on Auxiliary Instrumentation for Large Telescopes. The Conference was organized jointly by the European Southern Observatory, CERN and the large telescope projects of France (INAG) and the Federal Republic of Germany (MPIA).

Many of the telescope projects in the 3 to 4 m range have matured to the point where attention needs to turn to the question of instrumentation. It is necessary to foresee what the research programmes are likely to require in a few years' time and what developments in instrumentation techniques can be absorbed to meet the requirements.

Most of the Conference concentrated on spectrographs and spectrographic methods (grating spectrographs and spectrometers, interferometric spectrometers) and there was a session on electronographic photometry. It is obvious that, to make good observations on many of the astronomical features which are currently of interest, detectors with much higher efficiencies than the photographic plate are going to be needed. There are already devices such as image tubes (where the phosphor can be scanned in less than the decay time of the effect of the incoming light and where integration over long times is possible) and tiny diode arrays (converting light input directly to electronic information) which are under development in Europe and the USA. It seems inevitable, though in many ways sad, that even the astronomer will soon be observing the Universe via computer output.

The exchange of up-to-date information on progress in this field proved very stimulating and is likely to have considerable impact on the large telescope projects just as did the Conference one year ago on telescope design.



Professor Margaret Burbidge, Director of the Royal Greenwich Observatory, giving the introductory lecture at the Conference on Auxiliary Instrumentation for Large Telescopes. Professor Burbidge reviewed some major areas of research, where large optical telescopes are likely to play an important part in a few years' time, picking out instrumentation problems that will have to be overcome in order that full advantage can be taken of the new telescopes.

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In the beginning was the Linac

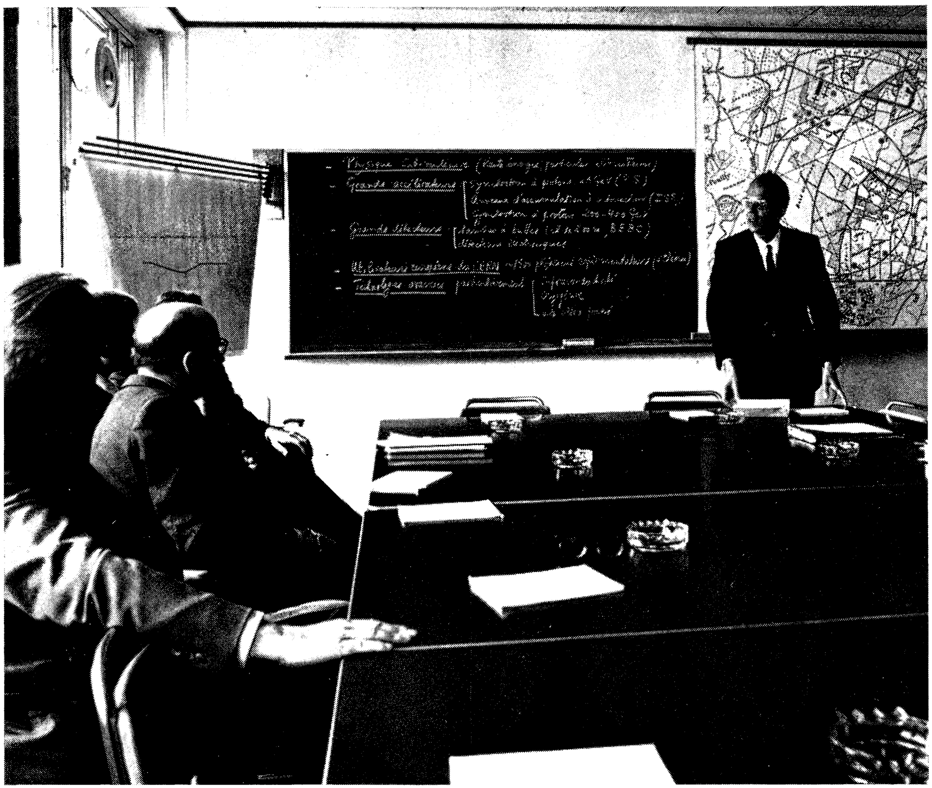
In today's high energy physics environment, the concept of an experiment is of such complexity that the man who carries out his own experiment is different enought to merit being assigned to a separate subspecies. Aside from the complexity, there is an additional difference in that *homo sapiens solus* has only himself to blame when things go wrong. *Homo sapiens collegium* on the other hand has a rich choice of target for his ire when data collection ceases, particularly if he is sitting at the end of a long secondary beam.

At the other end of the works, at the source of all protons, there is a much smaller choice of target. The number of things to blame diminishes as one approaches the source but the number of people who can assign blame increases alarmingly. It is not surprising, then, that Linac people, foreseeing the day when the Booster, PS, ISR, and SPS and their experimenters will all be breathing down their necks, are talking of fault down-time of less than 1 %. They are talking in fact of transforming the present ageing machine into an efficient proton factory which will pump out standard 50 MeV protons around the clock for many years to come, with rarely a missed pulse.

Most of the ancilliary electronics has been replaced over the past few years, and sparking weak points in the r.f. circuits are being removed by installing rigid co-axial lines in place of flexible cables. There remains the 15-year old accelerating structure and vacuum system...

Nevertheless, even assuming that the Linac could be made 99.5 % reliable, that half a percent from perfection represents 30 hours in a year, and some poor user might well draw the long odds of getting most of those 30 hours during his run. His estimate of Linac reliability will be very different. For the man who always meets rain in the mountains, it always rains in the mountains... Fortunately, *homo sapiens collegium* is usually sapiens.

On 21 April, M.T. Lefevre, the Belgian Ministre d'Etat pour la Politique et Programmation Scientifiques, visited CERN accompanied by other Belgian representatives including M. P. Levaux the delegate to the Council. They were welcomed by the CERN Directors General and by Professor L. Van Hove seen in the photograph during his introductory talk. The Minister has Professor Jentschke on his left.



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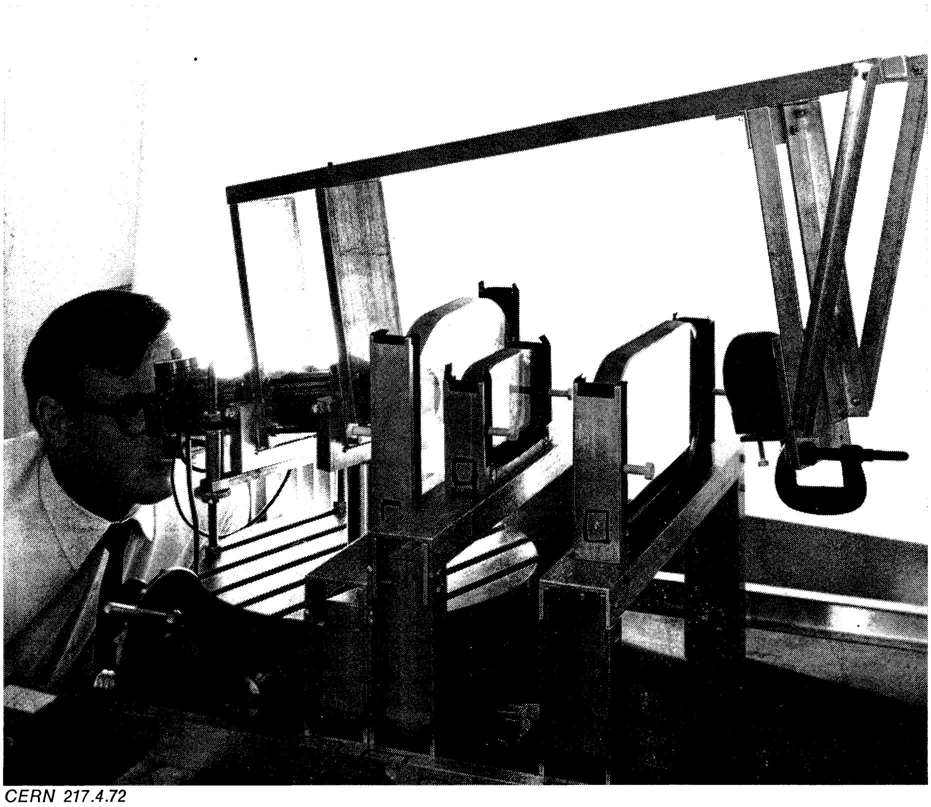
Checking the camera lenses of the 2 m hydrogen chamber using an autocollimator which measures the distortions in the complete three-lens system. The lenses, of high optical quality, will improve the precision of the photographs from the chamber. They are scheduled to be installed at the end of May and the chamber will come back into action, with a hydrogen filling, in June after a long shutdown.



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Around the Laboratories

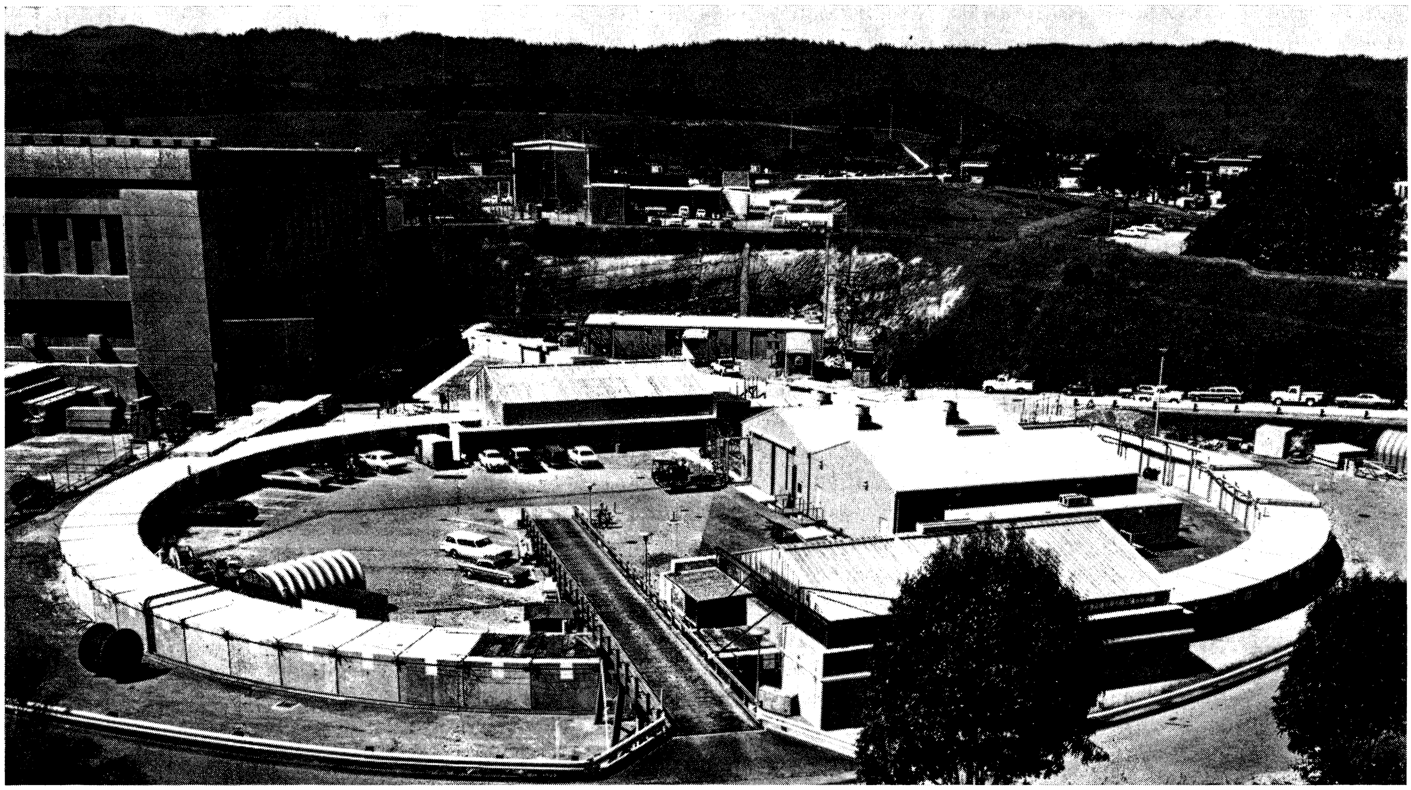
STANFORD
SPEAR gives colliding beams

On 22 April, the electron-positron storage ring, SPEAR, fed with positrons by the linear accelerator at SLAC, stored beam for the first time. The following day, the circulating currents reached as high as 30 mA average, and the lifetimes were between 15 min (low currents circulating in a vacuum of about 10^{-8} torr) and 8 min (15 mA currents circulating at higher mean pressures). A stored beam of 30 mA average corresponds to approximately 23 A peak beam current since the SPEAR beam is all packed in a single 40th harmonic (50 MHz) bunch about 1 ns long with an orbital period of 780 ns. On 27 April electron injection was tried and stored electron beams were achieved within half an hour. The following day collisions were observed.

SPEAR was described in vol. 11, page 279. It is a single ring, 31.5 m radius with two 12 m straight sections (5 m free for experiments) initially limited, by the installed r.f. power, to about 2.4 GeV peak energies for the electron and positron beams but with a magnet system capable of fields equivalent to 4.5 GeV. Development of SPEAR to 4.5 GeV levels may take place in 1973. The linac injects electrons and positrons at 1.5 GeV and stored currents of 200 mA are anticipated with lifetimes in excess of an hour. With one bunch in each ring collisions are limited to two positions (the straight sections). The maximum luminosity hoped for is about 10^{32} cm^{-2} s^{-1}.

It was intended to attempt operation on 1 April but the linac schedule brought the first injection tests back to 14 April. On the sixth day of running, 22 April, positron beam was stored and the following day currents were built up to 30 mA. The same happened with the electron beam — first stored on 27 April and built up to 30 mA the following day. Also on 28 April, 1 mA beams of both electrons and positrons were stored simultaneously at an energy of 1.5 GeV. Collisions were observed and the measured luminosity was 2.8 × 10^{28} cm^{-2} s^{-1}. Maximum currents recorded were 34.7 mA for positrons and 47.4 mA for electrons. At low circulating current mean life was as long as 50 min.

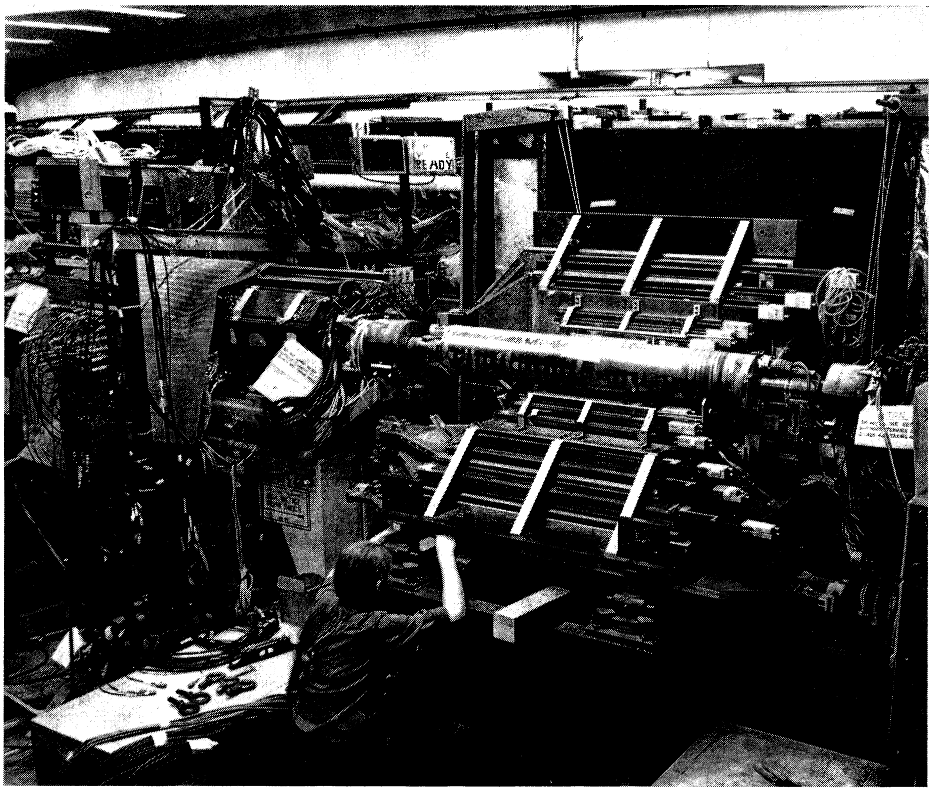
Much work remains to be done to master the storage ring and there are some rather straightforward measures still to be taken which will improve performance. For example, the initial tests were carried out with a base pressure in the 10^{-9} torr range which rose to 10^{-8} and higher in the presence of a beam ; the predominantly aluminium vacuum system will be baked



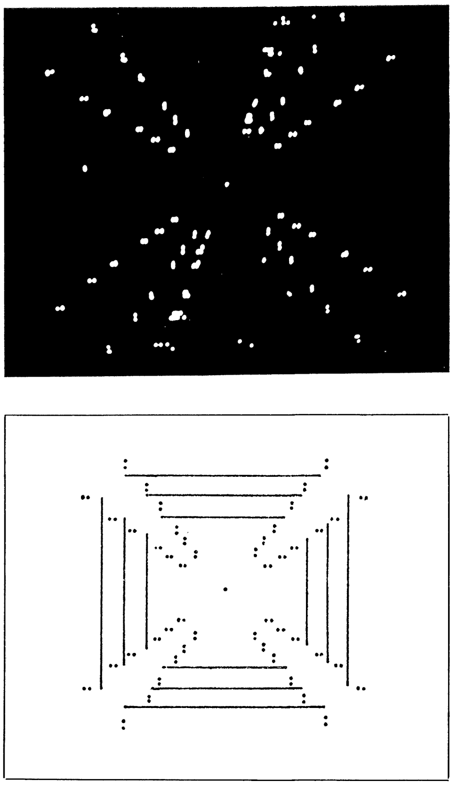
SPEAR, the electron-positron storage ring at the Stanford Linear Accelerator Centre, hides inside the concrete tunnel constructed near the end of the 20 GeV electron linac. Two larger buildings cover the straight sections where experiments can be installed. Positrons were stored for the first time on 22 April and a week later two beams were circulating and the first collisions were observed.

(Photo SLAC)

The interaction region at the centre of the CEA bypass. Two quadrants of BOLD (Bypass On-Line Detector) can be seen installed. The synchrotron ring is visible in the rear.



The first event recorded in BOLD on 8 May. Electron and positron beams of 2 GeV energy were travelling through the bypass (along the z-axis in the photograph which then shows a projection of the detector in the x-y plane). The sketch below shows the fiducial marks of six double plane spark chambers and indicates the position of the first three lead converters. The two showers in opposite quadrants coming from a large angle scatter are clearly identifiable in the photograph.



out to give lower base pressure. It is intended to have the storage ring ready for physics experiments in December and several experiments are authorized.

The SPEAR project has been led by Burton Richter and John Rees. The construction time has been just over 21 months and the project cost (at the 2.4 GeV level) about $ 5. 3 million.

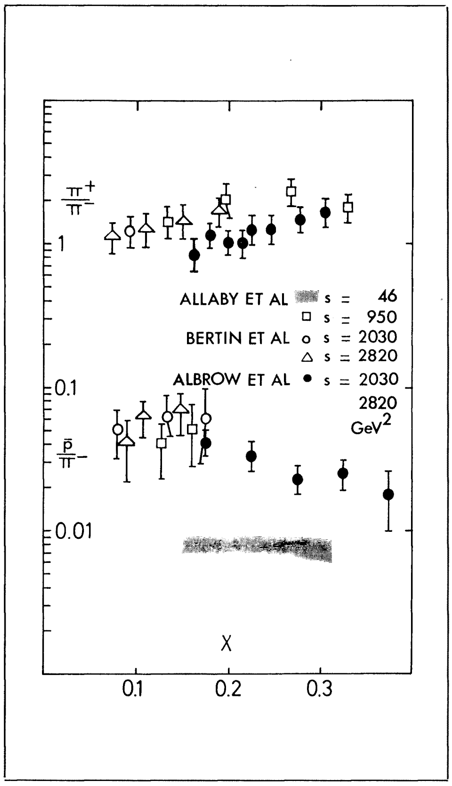
CAMBRIDGE Colliding beam experiment

The first experiment with the colliding beam facility at the Cambridge Electron Accelerator began on 8 May. The experiment consists of a survey of the relative cross-sections of q.e.d. reactions and hadron production from electron-positron collisions with a centre-of-mass energy of 4 GeV. This is currently the highest energy at which such studies are being carried out anywhere. The first event recorded was a large angle electron-positron scattering event which is shown in the Figures.

Beams are accumulated in the CEA synchrotron ring by multi-cycle injection while the magnet ring is being cycled in the normal manner. Positrons are injected at 145 MeV until an average current of 3 to 5 mA is accumulated (in three minutes) and electrons are injected at 260 MeV until a comparable current has been accumulated (in a few seconds). Magnet excitation is then converted to d.c., so that the beam energy becomes constant at 2 GeV, and the beams are then switched into a low-beta bypass about 45 m long at the centre of which the beams collide in a 2 m straight section. Each of the 100 beam bunches is 5 cm long and has a diameter of 0.01 cm at the interaction point. The beam crossing angle is 1 mrad.

The experiment began with the bypass operating at a luminosity of 1.2 × 10^{28} cm^{-2} s^{-1} and beam lifetimes of 2000 to 3000 s. Increases in the luminosity are expected with growing experience in operation of the system and from several planned improvements. At this time the bypass can handle individual beam energies of 2.5 GeV. After replacement of some of the focusing magnets in the bypass, scheduled for the summer of 1972, it will be possible to increase the beam energy to 3.5 GeV.

Enclosing the interaction region is the Bypass On-Line Detector (BOLD), developed by a CEA-Harvard group led by R. Little. The detector consists of four quadrants of spark chambers, scintillation counters, radiators, and also two flanking spark-chamber and iron-plate assemblies (hadron converters). A variety of trigger logics can be used.



Data on the rates at which particles are produced in the very high energy proton-proton collisions at the ISR. Of particular interest is the lower set of points which show the production rates for antiprotons (plotted as a ratio compared with the negative pion production rate which is itself increasing at the higher collision energies — thus the rate of increase of antiprotons with s is more rapid). The ratio at conventional accelerator energies is indicated in the shaded area. This observation on antiprotons is among the most intriguing ISR results.

CORNELL
Acceleration to 12 GeV

On 10 April the electron synchrotron at Cornell accelerated a beam to 12 GeV. The machine has held pride of place as the highest energy electron synchrotron in the world since 1968 when 10 GeV electrons were achieved and is in the midst of an improvement programme which may eventually push the peak energy to 15 GeV (much depending on experience with the 12 GeV beams).

The required increase in voltage gain per turn was accomplished by adding a single 5 m long section of r.f. accelerating waveguide. It provides as much r.f. voltage as the five existing sections combined. This is possible because of the high shunt impedance of the new bar-loaded waveguide and the use of a high power klystron (1.3 MW peak). The waveguide is operated in a travelling wave resonant ring.

The 20 % increase in the peak energy was achieved without any loss in beam intensity.

Stony Brook-on-Thames

The Fourth International Conference on High Energy Collisions (the Stony Brook series of conferences) was held at St. Catherines College, Oxford, from 5-7 April. It was sponsored by IUPAP and organized by the Rutherford Laboratory. Approximately 250 physicists from 42 countries met to discuss the physics of high energy collisions ; the programme consisted of ten invited review papers and eighteen short contributed papers — there were no parallel sessions.

Many interesting and intriguing new results were presented but it is fair to say that nothing truly 'earth-shattering' was heard. As befits a Conference on high energy collisions, some of the main talking points were the ISR results — these are presented in terms of (centre of mass energy)^2 or s ; but it should be remembered that the equivalent beam momentum for the collision of a stationary proton target is roughly between 250 to 1450 GeV/c for s values between 500 and 2900 GeV^2. The ISR is now firmly in production and the production rate is impressively high so early in the machine's life.

The following is a list of some of the outstanding new results presented :

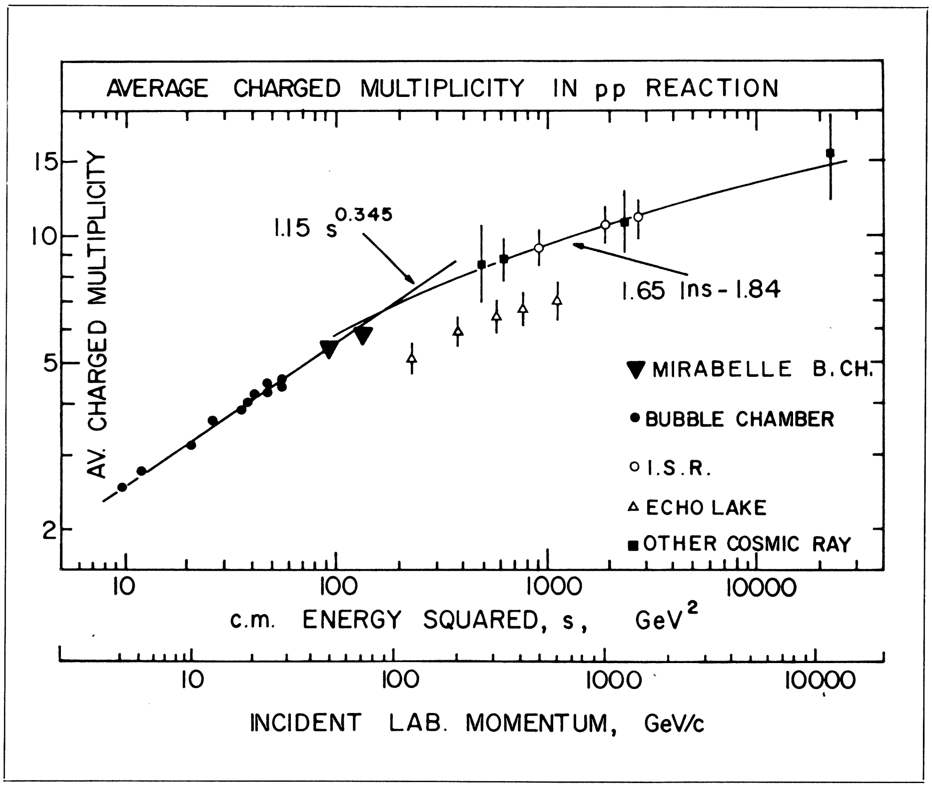
ISR and inclusive reactions — The British/Scandinavian collaboration reported the measurement of single particle $(\pi^{\pm}, p^{\pm}, K^{+})$ production at large angles and small momentum in the centre of mass. This type of experiment, studying 'inclusive' reactions, was described in vol. 11, page 242. In the ISR range of s values between 550 and 2860 GeV^2 there was no detectable energy dependence, but the striking result was the change from previous synchrotron measurements. Going from the range 5 to 50 GeV^2 up to the range 550 to 2860 GeV^2 central antiproton production increases by almost an order of magnitude, while central proton production remains essentially constant. This observation seems to be causing some difficulty for the proponents of the Mueller-Regge analysis of inclusive reactions — we can certainly expect considerable activity on this front.

ISR and pp elastic scattering and total cross-sections — Results on small angle elastic proton-proton scattering for $500 < s < 2900$ GeV^2 were reported from the Aachen-CERN-Harvard-Genova-Torino collaboration. The main points were —

(i) The proton-proton elastic differential cross-section undergoes a marked change of slope at small angles — at about $|t| = 0.1$ (GeV/c)^2. The region $|t|$ less than 0.1 and $|t|$ greater than 0.1 are well represented by a simple exponential $-e^{bt}$. Taking $b = b_0 + 2\alpha' \ln s$ the tentative values are: $b_0 = 7.0$ $\alpha' = 0.37 \pm 0.08$ GeV^{-2} (small t) $b_0 = 9.2$ $\alpha' = 0.10 \pm 0.06$ GeV^{-2} (large t).
This should generate much activity on the nature of the Pomeron — the singularity expected to control high energy elastic scattering.

(ii) The measurement of the proton-proton total cross-section gave the value 37 ± 1.5 mb at all s values between 500 and 2900. This number is consistent with Regge pole model extrapolations.

ISR and the search for the W — Results from the British collaboration experiment on high transverse momentum muons were given. These



The number of charged particles, on average, emerging from high energy interactions is indicated in the graph. Recent results from the Mirabelle chamber at Serpukhov are included and reinforce other observations extrapolating to significantly higher values thant the Echo Lake results from cosmic rays.

results are relevant to the possible existence of a particle mediating the weak interactions — the intermediate vector boson or W. As the word 'search' always implies in these contexts, no evidence for the W has yet been found in this experiment.

Charged particle multiplicities at Serpukhov — Charged particle multiplicities (n) were measured by the Saclay-Serpukhov group using the Mirabelle hydrogen bubble chamber at Serpukhov with beams of 50 to 70 GeV/c. The indications are that n lies on a curve rising logarithmically with s. This curve (including the 10 to 30 GeV/c data) extrapolates to significantly higher values than the Echo Lake cosmic ray results. Charged particle multiplicities, in principle, offer a way to distinguish between different models of production — e.g. multiperipheral models require n to be proportional to log s, whereas fragmentation models prefer n proportional to the square root of s.

Hyperon-nucleon total cross-sections — Recent hyperon-nucleon total cross-section measurements from experiments at the CERN proton synchrotron were reported. They gave the lambda-proton total cross-section as 34.6 ± 0.35 mb (apparently constant from 8 to 17 GeV/c) and the sigma-proton total cross-section as 34.9 ± 1.2 mb at 19 GeV/c. For comparison the proton-proton total cross-section is 38.8 ± 0.4 mb at 19 GeV/c. These results agree with the predictions of the simple quark model.

'Cross-overs' of elastic differential cross-sections — Very precise measurements of the $\pi^{\pm}p$, $K^{\pm}p$ and $p^{\pm}p$ small angle differential cross-sections over the lab. momentum range from 3 to 6 GeV/c were reported from Argonne. The $\pi^{\pm}p$ cross-over is found to occur at an appreciably smaller t value than $K^{\pm}p$ cross-over.

Theory — None of the 'old' (pre-Amsterdam) theoretical band-wagons have suffered any major setback or achieved any great advance since last summer. The only fast developing area seems to be that of renormalizable theories of weak interactions and the unification of the weak and electromagnetic interactions. The basic notions were given by Weinberg in 1967 but recently there has been a wave of interest and optimism that major headway is being made on this subject.

G. R.

KARLSRUHE
Pulsed superconducting magnet operated

A pulsed superconducting coil has been tested for almost ten thousand cycles in a simple 'picture-frame' magnet with a rectangular aperture of 4 × 25 cm². The iron yoke has a length of 40 cm and a cross-section of 37×58 cm². The magnet was mounted vertically and cooled in a bath of liquid helium. The cool-down of the 650 kg iron yoke from 77 K to 4.2 K was obtained with a loss of only 100 l of liquid helium (0.15 l helium per kg of iron).

The coil is of a two-dimensional race-track type. It was wound on a glass-fibre epoxy form from 1000 A cable consisting of 10 strands of Niomax TC 1045 around a central copper wire soldered by In-Sn. It was insulated with glass-fibre tape. The coil was not potted so that it can be rewound in a three-dimensional shape. Effective cooling was provided via vertical channels and the coil was fixed in place by means of wedges.

With a slow rise of 0.1 T/s, fields of 4.5 T at the centre and 5.2 T at the coil edge were obtained. The peak current of 1035 A corresponds to the short

The superconducting iron core magnet, operated for a series of tests at Karlsruhe, seen outside its cryostat.

(Photo Karlsruhe)

OGA (Optique à Grande Acceptance) the d.c. superconducting quadrupole doublet which has recently undergone successful tests at Saclay. The doublet is to be installed on a pion beam-line at the Saturne synchrotron to achieve higher pion intensities.

(Photo Saclay)

sample values at these fields. No training was observed.

Triangular current pulses with different cycle times were applied to the coil. It was found that the peak magnetic field attainable was lower as the rise time decreased (for example : 4.5 T with 45 s rise time, 3.2 T with 5 s, 2.4 T with 1 s). It is assumed that these reductions in field were caused by local heating in the coil either due to eddy currents or conductor movement. The losses per cycle also depend on the rise time probably due to eddy currents either at the end regions as the iron saturates or in the cable because of electrical coupling between the central copper wire and the strands via the In-Sn solder.

The coil is being rewound into a three-dimensional shape and will subsequently be potted in epoxy. Further experiments will then be carried out, especially to study the dependence of peak field and losses on rise time.

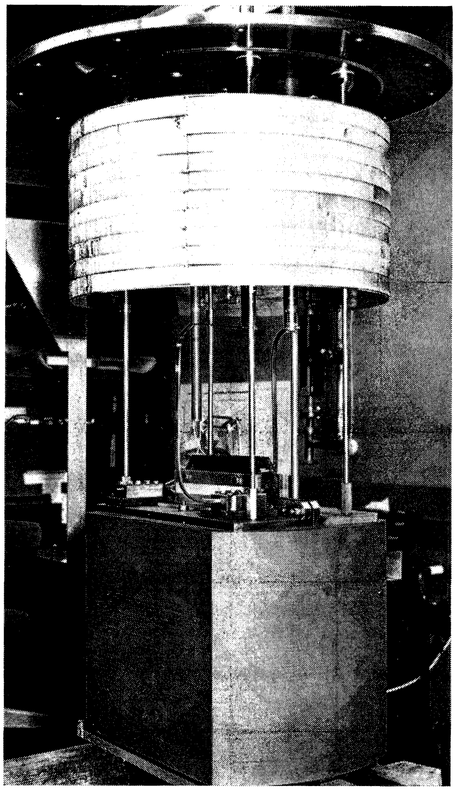
SACLAY OGA in action

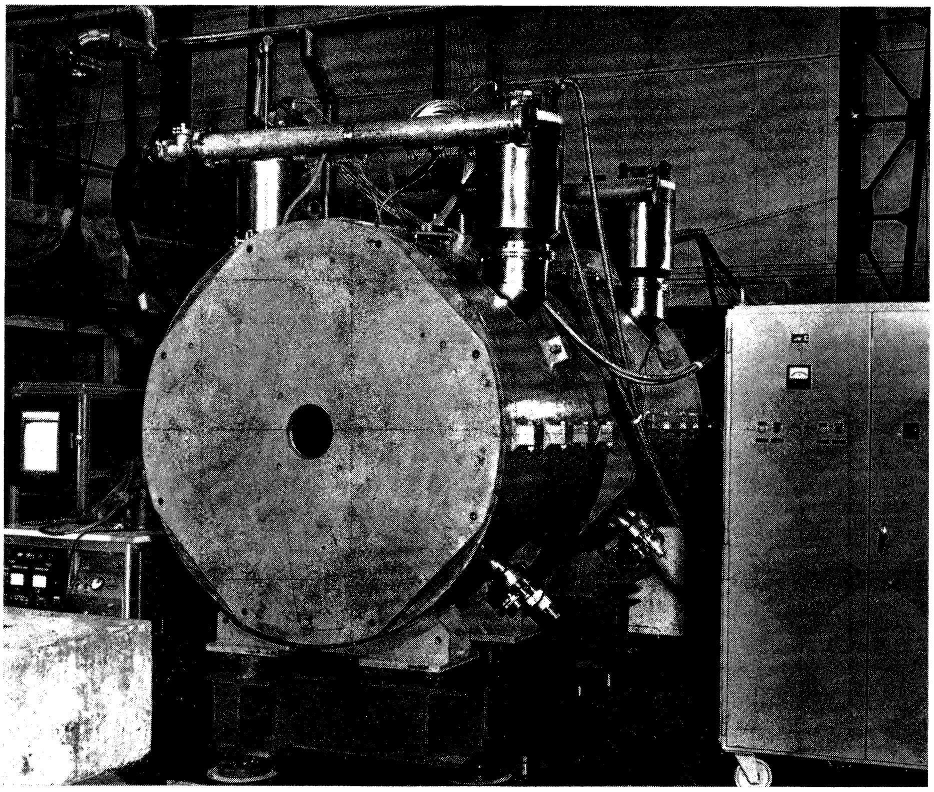
A d.c. superconducting quadrupole doublet (known as OGA — Optique à Grande Acceptance) built in the Saturne Department at Saclay has recently been successfully tested. The doublet consists of two independent quadrupoles and is intended to be installed in a pion beam-line in the experimental hall of the synchrotron, Saturne, during its next long shutdown. The large angular acceptance of the doublet should make it possible to increase the intensity of the pion beam by a factor of three to four.

The two quadrupoles were built in a similar way and externally look identical. An outside shielding cylinder 1.4 m in diameter and 1.2 m long encloses the cryostat where the quadrupole is located. The quadrupole is centred along the axis of the cylinder but the helium container is eccentric so as to provide a helium reservoir above the quadrupole which can be topped up automatically about every twelve hours.

The useful aperture for the pion beam is 20 cm in diameter for the first quadrupole and 30 cm diameter for the second. The focusing gradients are nominally designed to handle particles of momentum 1.5 GeV/c but it may be possible to push this as high as 2 GeV/c. The design field length is 68 cm in each quadrupole and the peak focusing gradients (corresponding to 2 GeV/c particles) are 35 T/m for the first and 23 T/m for the second. Similar currents are sent through the superconductor in each quadrupole to reach these field levels — 1220 A and 1180 A respectively, giving a peak field at the conductor itself of 5 T and 4.5 T with a total stored energy of 0.75 MJ.

The superconductor was supplied





by IMI and consists of twelve wires twisted around a central copper core. Each wire contains 61 niobium-titanium filaments 45 μm diameter and is twisted with a pitch of 25 mm. The complete conductor has a rectangular cross-section 2.35 × 3.27 mm² with a copper/superconductor ratio of 4.5. The short sample performance was measured as over 1900 A in a 5.7 T magnetic field. Each pole consists of 620 turns, wound following, a technique developed at Saclay to keep the length of conductor in each turn the same. Cooling is via helium channels.

During the tests a high degree of automation was achieved since the helium transfers were carried out automatically (called for by gauges in the cryostat) and the current rise and d.c. control were simply set in advance. The design values were achieved and sustained for several hours in each quadrupole, though the first (unlike the second) went through progressive training to achieve the design values. Mechanical movement in this quadrupole which, with its small aperture, was more difficult to wind, is the likely cause. The total helium loss was about 12 l per hour.

Field measurements were made and showed that the field map is centred on the axis to within 0.3 mm and is symmetric. The equivalent length of field is 70 cm and the field configuration is achieved to better than 1 %.

RUTHERFORD
New tests on AC3

The prototype superconducting pulsed dipole known as AC3 was first put through its paces at the Rutherford Laboratory in the autumn of last year (see vol. 11, page 253). It then reached field levels of 3.9 T in a 10 cm bore.

An inner winding, reducing the bore to 7.5 cm, has recently been added and on its first cooldown the new assembly repeatedly pulsed to 4.6 T central field levels (5.2 T peak field) with slow rate of rise and to 4.5 T central field with a 3 s rise time. Very little 'training' (progressive approach to peak fields) was observed and the magnet current (4500 A) was close to the short sample current for the cable used in the magnet construction.

Another encouraging feature of the latest tests is that they were preceded by a major repair to an inter-pancake connection. This involved splicing in a short length of superconducting cable and reimpregnating. No deterioration ot performance resulted from the repair which is a further indication that superconducting magnets are reaching the stage where the engineering techniques used in their construction, operation and maintenance are being confidently mastered.

SERPUKHOV
World's highest energy kaons

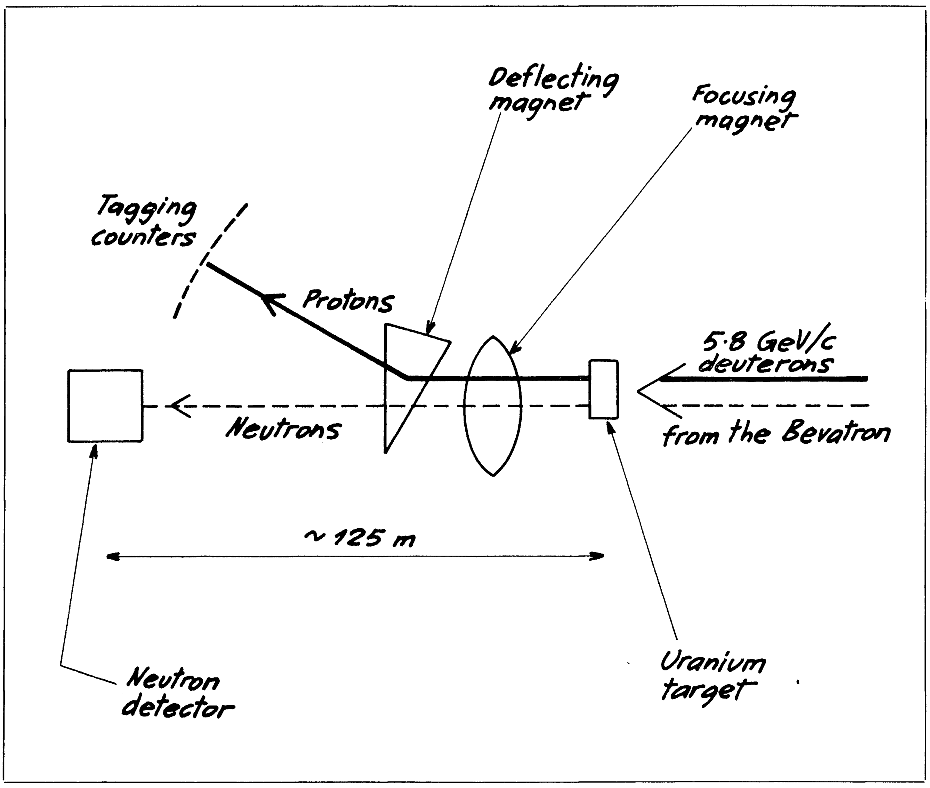
In April, the last of the major items of equipment provided by CERN to be used at the 76 GeV proton synchrotron came into operation and helped to yield the world's highest energy kaons. Separated beams of positive and negative kaons and antiprotons were achieved with a momentum of 32 GeV/c when a new section of beam-line (designed and built by a Serpukhov team under V. Kotov) and the three cavity r.f. separator (designed and built by a CERN team under H. Lengeler and Ph. Bernard) were brought into action.

In the February issue (page 38) we reported the first operation of the fast ejection system and the ejected beam transport system which extends as far as the target. The April tests were to take beam through a subsequent length of beam-line and through the separators. (Details concerning these components can be found in vol. 11 number 8). All previous tests of these components had been performed without beam and the aim was to study the beam quality and separator performance which could be achieved. The results were highly satisfactory. With the system tuning in the hands of P. Lazeyras, a peak kaon momentum of 32 GeV/c was reached with a beam contamination (the presence of unwanted particles) of less than 2 %.

There were about ten kaons per burst but this number could be considerably increased if desired. The tests used only one of the thirty bunches in the accelerated proton beam (and a low intensity bunch at that) or a 4 μs burst of residual beam after internal targets had been bombarded. The intensities along the ejected beam-line and secondary beam (channel No. 7) were deliberately kept low because some attention is needed to shielding around the target area. The separated beam was studied using Cherenkov counters provided by Yu.D. Prokoshkin's group since the Mirabelle hydrogen bubble chamber, that it will normally feed, was not then in operation.

The first physics run with the full battery of equipment, including Mirabelle, in action is scheduled to start on 25 May. Pictures using the 32 GeV/c kaons will be analysed by Soviet, French and CERN groups.

On 8 June, the Director of the Institute of High Energy Physics, A.A. Logunov, will be joined at Serpukhov by the Director General of CERN Laboratory I, W.K. Jentschke, for a ceremony to mark the successful completion of this important phase of the work being carried out in the context of the 1967 CERN-Serpukhov agreement.



Schematic representation (not to scale) of the neutron tagging system developed at the Bevatron. Protons associated with neutrons as deuterons dissociate in a uranium target are deflected by magnets and detected by counters. Corresponding neutrons can be identified with a momentum resolution of ± 0.7 %.

BERKELEY
Neutron tagging

A team from the University of California San Diego and from the Lawrence Berkeley Laboratory have succeeded in developing a system for 'tagging' neutrons at GeV energies using a method similar to that familiar at electron synchrotrons for tagging photons. The team members were : C.W. Leeman, W.A. Mehlhop, H.A. Grunder. O. Piccioni, P.H. Bowles, R.H. Thomas, D.S. Scipione and R.W. Garland.

Considerable emphasis is being given to the acceleration of deuterons and heavier ions at the Bevatron (see vol. 11, page 251). The recent work studied the secondary neutrons which emerged from a uranium target when bombarded by a 5.8 GeV/c deuteron beam. A very healthy neutron beam can be obtained — 10^9 neutrons per msteradian from 10^{11} deuterons on a uranium target about 3 cm thick, the neutron beam having a momentum spread of ± 3 %. Experiments with such beams are likely to be limited by the capabilities of the detectors rather than the beams themselves.

The tagging operation involves neutron beams of much lower intensities (in the 10^6 range). The protons accompanying the neutrons from the dissociating deuterons are deviated by magnets and detected by counters. The first data indicated that about 40 % of a 1.5×10^6 neutron beam could be identified with a tagging proton so that the neutron momentum is known to better than ± 0.7 % (measuring the proton momentum to better than 0.5 %). With a spill length of 1.5 s from the Bevatron, about 5 % of the neutrons so tagged can be estimated to be accidental coincidences with the proton counters.

Using a conventional time-of-flight method to determine the neutron momentum, with a counter in front of the uranium target and a neutron counter (scintillator preceded by 10 cm of lead convertor) at the end of a 125 m flight path, the precision was of the order of ± 3 %. Using the tagging system the precision, as mentioned above, is improved to ± 0.7 %. The added precision can be very useful in some types of experiment (such as missing mass experiments) and the method is an additional refinement in the use of neutron beams which could also be applied at other accelerators. It is possible also that tagged antineutrons could be obtained in view of the findings at Serpukhov where substantial numbers of antideuterons have been identified in secondary beams.

BROOKHAVEN
Mystery of the missing neutrinos

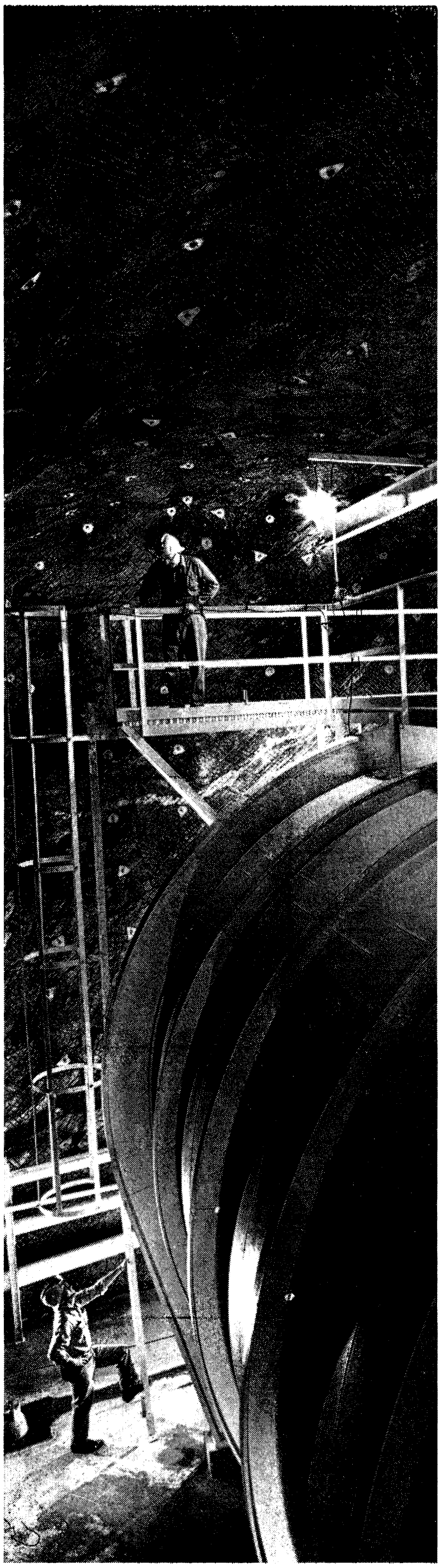
The latest results from the Brookhaven solar neutrino experiment were reported by R. Davis at the Washington meeting of the American Physical Society on 26 April. The experiment began in 1968 (see vol. 8, page 54) and involves an imaginative alliance of physics and chemistry in an attempt to get hold of neutrinos coming from the fusion reactions which power the sun. A measure of the neutrino rate is an indication as to whether our ideas about the nuclear interactions going on in the heart of the sun are correct. The results so far suggest that our ideas are wrong.

The neutrino detector is a huge tank of perchloroethylene (a common dry cleaning solvent that is 80 % chlorine) hidden about 1.5 km down Homestake Gold Mine is South Dakota where only neutrinos can be expected to penetrate. When a neutrino interacts with a chlorine nucleus it converts it to argon-37

$$Cl^{37} + \nu \rightarrow A^{37} + e$$

One end of the huge tank of perchloroethylene located 1.5 km below ground to catch neutrinos from the sun. This Brookhaven experiment has observed neutrinos at a rate ten times lower than predicted by the accepted theories about what is happening in the sun.

(Photo BNL)



which is radioactive with a half-life of 35 days. The liquid is allowed to sit collecting neutrinos for about 100 days and then it is purged with helium gas to pick up the argon atoms whose decays are counted with a small proportional counter.

The detection sensitivity has been improved since the early days of the experiment but the measured neutrino flux is still a factor of ten below what is theoretically expected. It is possible to calculate that if our ideas on the source of the neutrinos in the sun are correct, the tank should capture two neutrinos per day — the measured rate is less than 0.2 neutrinos per day. No convincing explanation of this observation has been put forward.

DUBNA Experimental results

Muon capture

A meson beam of the Dubna 680 MeV synchro-cyclotron, has been used to study the charged particles emitted when muons are absorbed by nuclei. Targets of ^{28}Si, ^{32}S, ^{40}Ca and ^{64}Cu were exposed to a stopping muon beam and the emerging particles were identified in terms of their mass by measuring both the ionization losses in a thin semiconducting silicon detector and the total energy in a cesium iodide spectrometer.

The energy spectra (up to about 50 MeV) and the probability of the production of protons of over 15 MeV and deuterons of over 18 MeV from the capture were measured. The probability of the production of tritium nuclei of over 24 MeV could also be estimated.

The number of protons emerging depends on the charge of the nucleus and is at a maximum in the region of nuclear charge number 20 and, for protons of over 15 MeV, is about 13×10^{-3} per capture (measured on ^{40}Ca). When the charge of the nucleus is lower, the proportion of deuterons in the total number of charged particles increases from about 17% for ^{64}Cu to about 34% for ^{28}Si. These results may be explained in terms of the absorption of muons by clusters of nuclei in the surface layer of the nucleus.

In recent years, there has been great interest in the interaction of particles with nuclei and negatively charged mesons provide a convenient way of obtaining information on nuclear structure. They are captured by nuclei after first forming a mesic atom. The data obtained from the Dubna experiment adds to the knowledge of the muon capture process obtained from experiments on muon capture accompanied by neutron emission.

Rare muon decays

Experiments are continuing at the synchro-cyclotron, using a spectrometer with spark chambers in the magnetic field, to search for rare pion and muon decays. In order to check the law of lepton charge conservation the decay of the positive muon into two positrons and one electron was looked for. It was found that the branching ratio of this decay compared with the decay into a positron and two neutrinos is less than, or equal to, 6.2×10^{-9} (with 90% confidence limits). This is approximately twenty times less than the upper probability limit previously established for the decay.

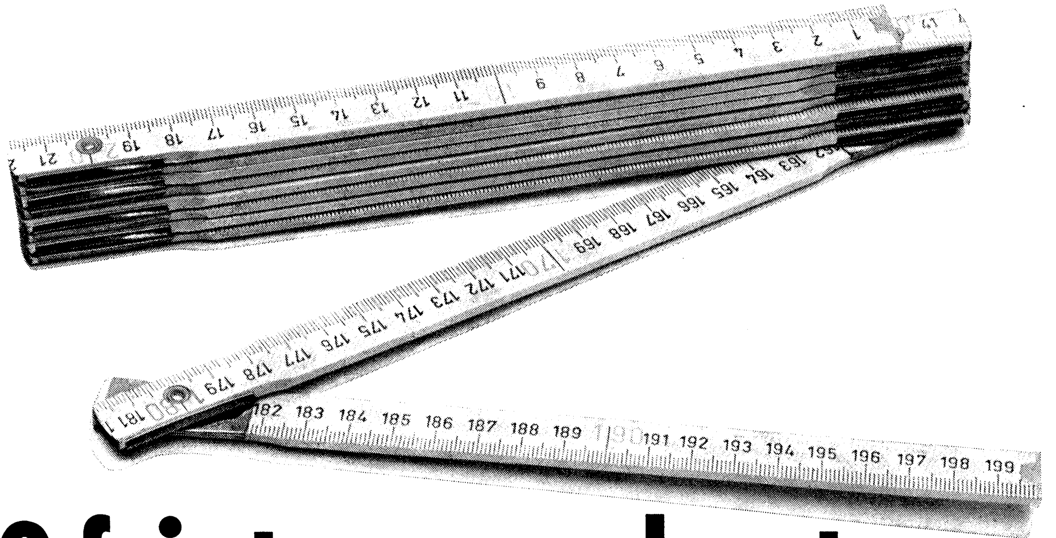
Backward pion electro-production

The reactions for backward pion electro-production where the negative pion interacts with a proton to give a positron, an electron and a neutron, was investigated at 275 MeV at the synchro-cyclotron. A study of this process could yield information on the mechanism for backward pion photo-production, which has a virtual photon with time-like 4-momentum. Moreover, a knowledge of the differential cross-sections of the process should, in theory, make it easier to study the electromagnetic structure of the pion and nucleon in the time-like momentum transfer region.

The nucleon's form factor at $q^2 > 0$ has not been studied. Moreover, in future experiments with colliding beams, the region $0 < q^2 < 4\ M^2$ (M being the nucleon's mass) will be kinematically inaccessible. Therefore, the reactions for backward electro-production is virtually the only source of experimental data on the structure of the nucleon in this momentum transfer range. The same applies to data on pion structure.

The reaction was detected in the experiment by means of a device consisting of scintillation and Cherenkov counters, total absorption Cherenkov spectrometers and spark chambers. Electrons and positrons were recorded at an angle close to 90° to the negative pion beam. The energies and emission angles of the electrons and positrons were measured.

When the data were analyzed, 55 events were identifield with an effective mass of the electron-positron pair ranging from 1 to 3 f^{-2} and the differential cross-section for the process at an electron (positron) energy of over 40 MeV was determined as $(3.0 \pm 0.8) \times 10^{-33}$ cm^2/steradian^2.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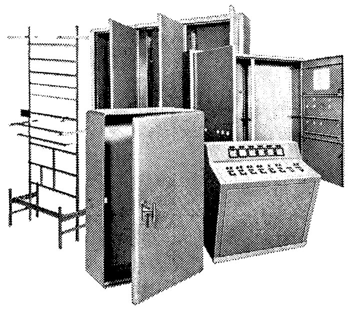

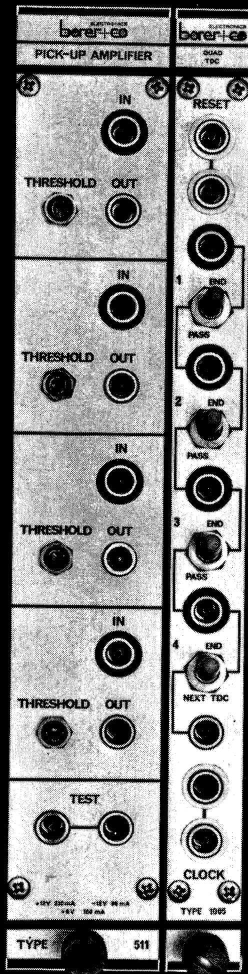
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FREQ 5 MHz
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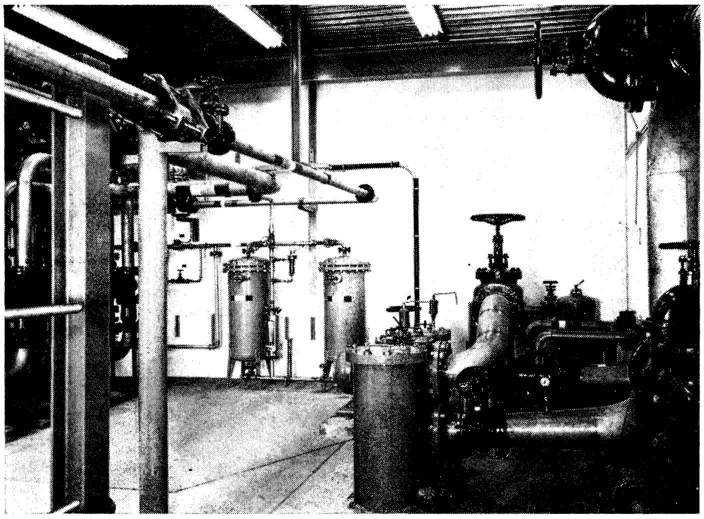
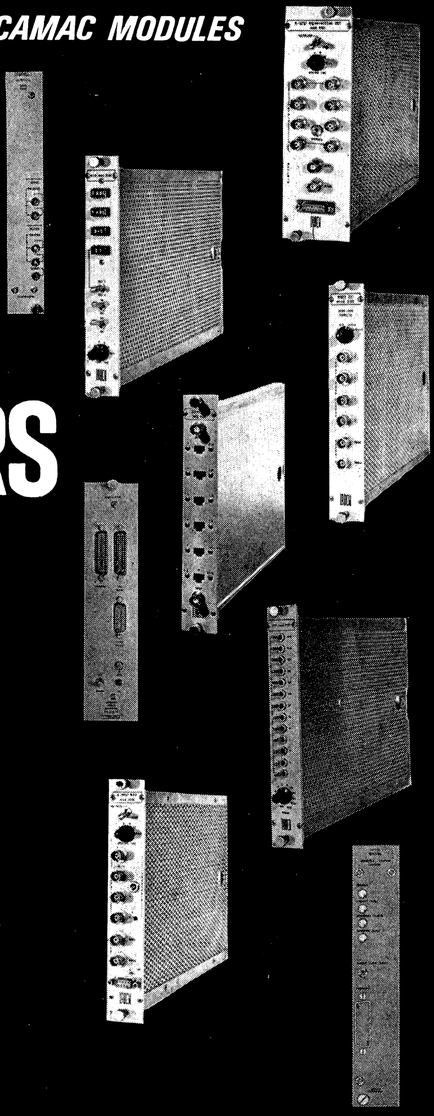
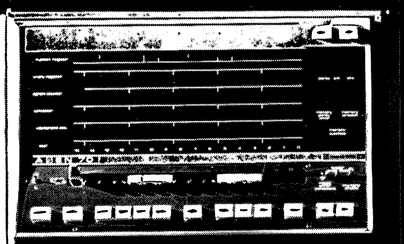
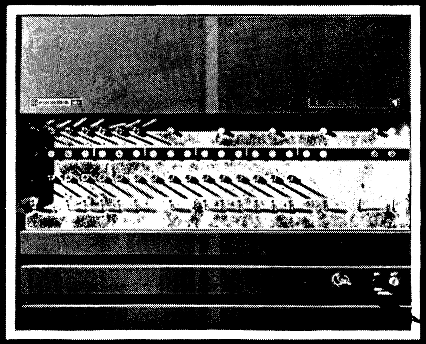
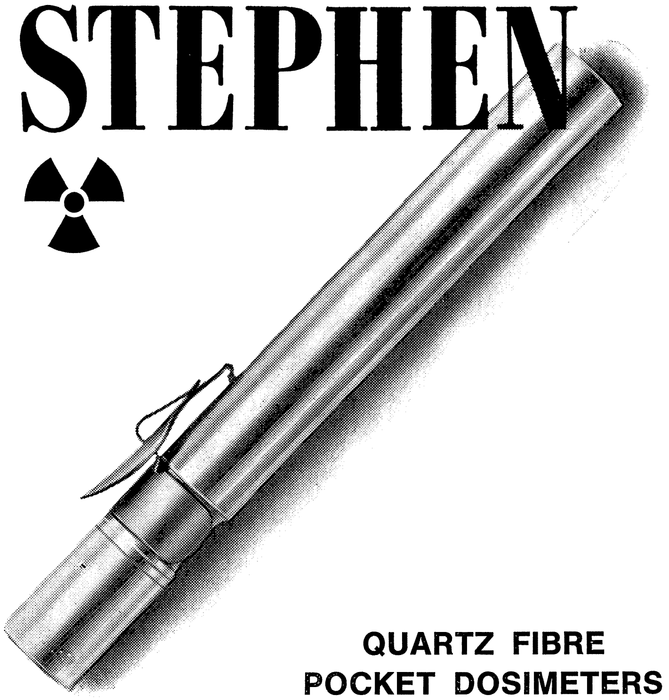
CONNOR-WINFIELD CORP

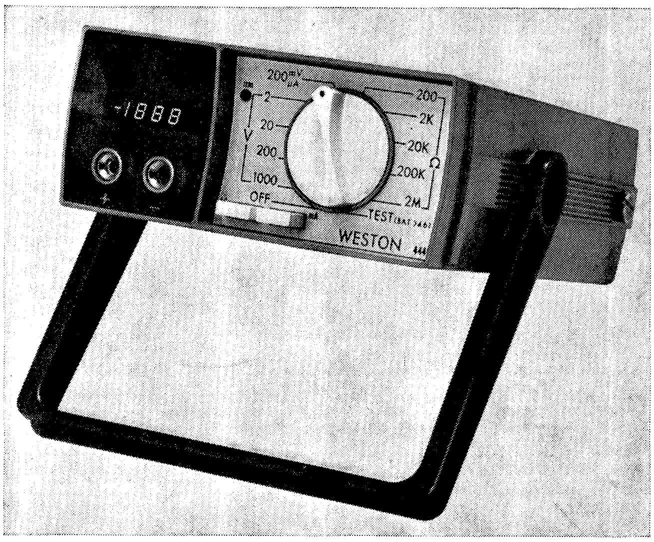








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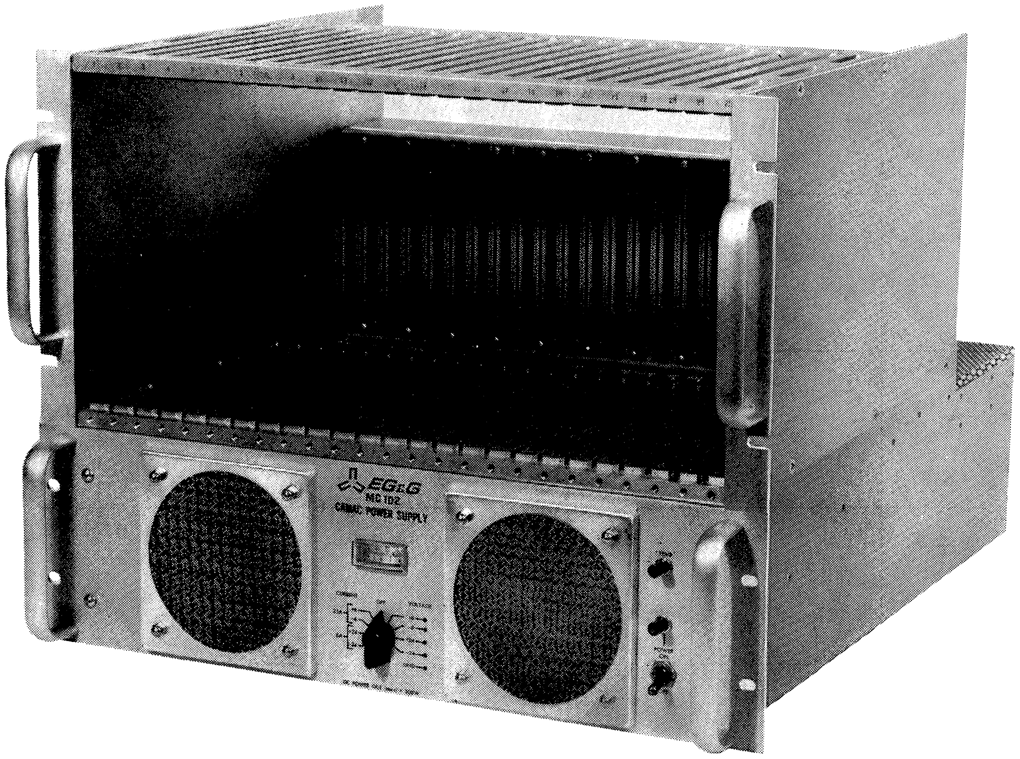

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DO YOU KNOW HOW FLEXIBLE A NOVA - CAMAC SYSTEM IS?

- Systems with virtually **any number of crates** can be assembled using only model CC 2023 Crate Controllers.
- Each crate has its **own command register** where a Camac command can be left for subsequent use. This means greatly reduced overheads.
- Each crate has its **own 24 bit data Register.** Data transfers from one module to another one within the same crate without disturbing any accumulator.
- Each crate is **uniquely identified** as a LAM-source by a **single instruction**. Complete L-patterns (one bit for every station in the system) can be fetched with two more instructions.
- **Direct memory channel is standard.** Fast data transfers can be effected at no additional cost and with minimum program sequences.
- While one crate is set up for direct channel, the others are accessible to the program to do useful work. It is even possible to have several crates stealing memory cycles in a concurrent manner.
- **Automatic Camac address modification**, usable both with the direct channel and with the programmed dialog, allows efficient and fast readout or loading of strings of similar modules.

* Trade name for computers made by DATA GEN. CORP.

DO YOU KNOW HOW FAST A NOVA - CAMAC SYSTEM IS?

The times given here assume a NOVA 1200 computer, the least expensive member of the line. They apply to single and to multi-crate environment.

9 μs	to read a 16 bit word from a module into a NOVA accumulator. This figure **includes** fetching the command from memory, loading the command into the controller and getting the data.
9 μs	to write a 16 bit word into a module from an accumulator, same conditions as above. Only 3 instructions are required.
5.7 μs	to effect a non-Read/non-Write Camac command, all **overheads included.**
12 μs	to read a **24 bit word** into a pair of accumulators.
11.4 μs	to read a 24 bit word from module A and write it back into module B, overheads included.
23 μs	to get the LAM pattern into a pair of accumulators as a response to an interrupt request. This time includes the saving of the machine's state while entering interrupt service and interrupt source identification.

The above looks nice but single commands are not particulary favorable; now something more impressive:

1.9 μs	per 16 bit word to readout 10 four-fold scalers and **store the data into memory**. This figure includes the necessary overheads and the program sequence has only 4 instructions and 2 constants !
1.2 μs	only per 16 bit words successively read-in through the direct memory channel.

If you meet time problems in planning Camac data taking equipments, it is worth considering a NOVA-CAMAC system.

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Digital Equipment's new family of big computers, DECsystem-10. Each of the five systems (2nd shown) is a price/performance giant.

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All five systems run all four functions using the same operating system with the same job control commands. All are serviced by the same language processors COBOL, ALGOL, FORTRAN, BASIC, MACRO, and many others. The only thing that changes is speed and capacity.

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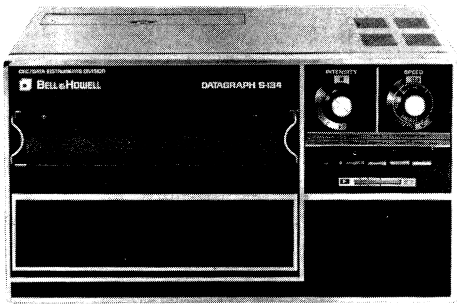
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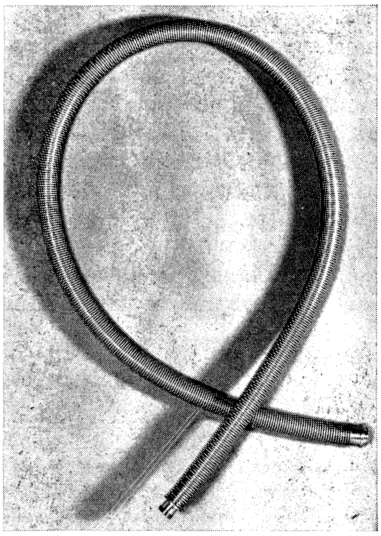
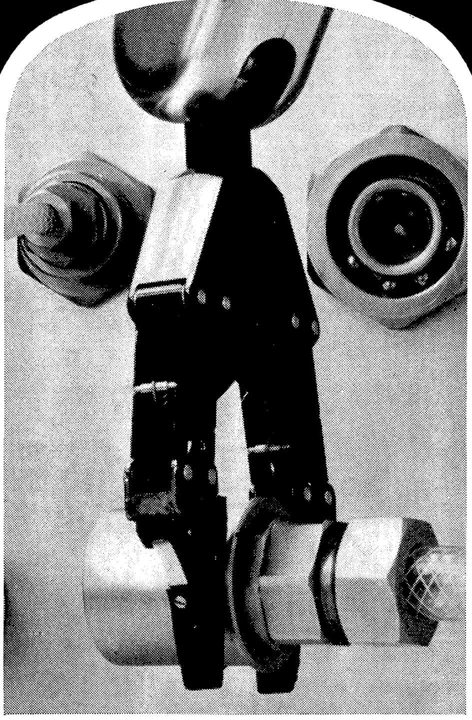
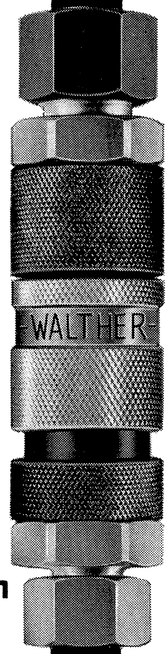
DATAGRAPH 5-134
INTENSITY
SPEED



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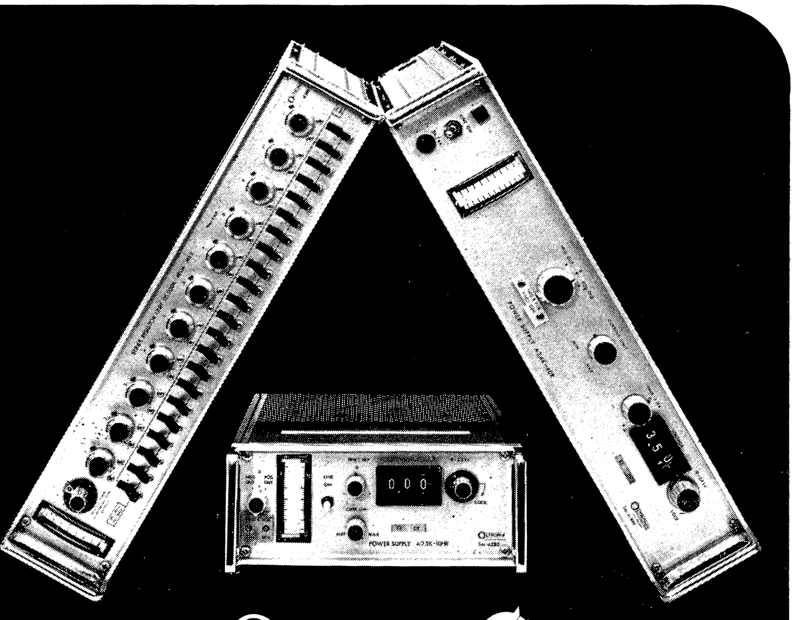

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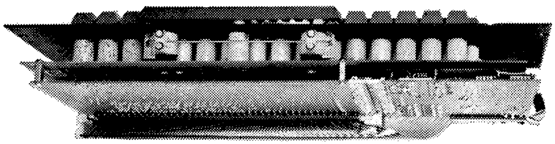
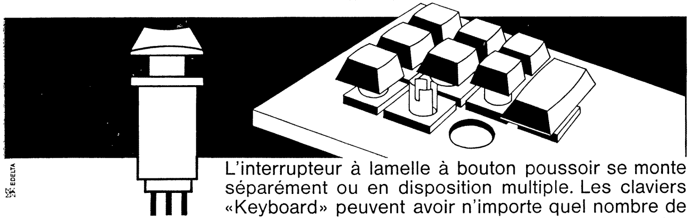
interrupteur à lamelle à bouton poussoir pushbutton reed switch





L'interrupteur à lamelle à bouton poussoir se monte séparément ou en disposition multiple. Les claviers «Keyboard» peuvent avoir n'importe quel nombre de touches. Les montages incorporés ont un système de code «diode-matrix» avec circuit intégré qui donne la suite logique de deux touches, «strobe», etc. Existe en version «CHANGE OVER» réf 2 RB1. Les types 1 RB1 et 2 RB1 sont livrables avec voyant lumineux.

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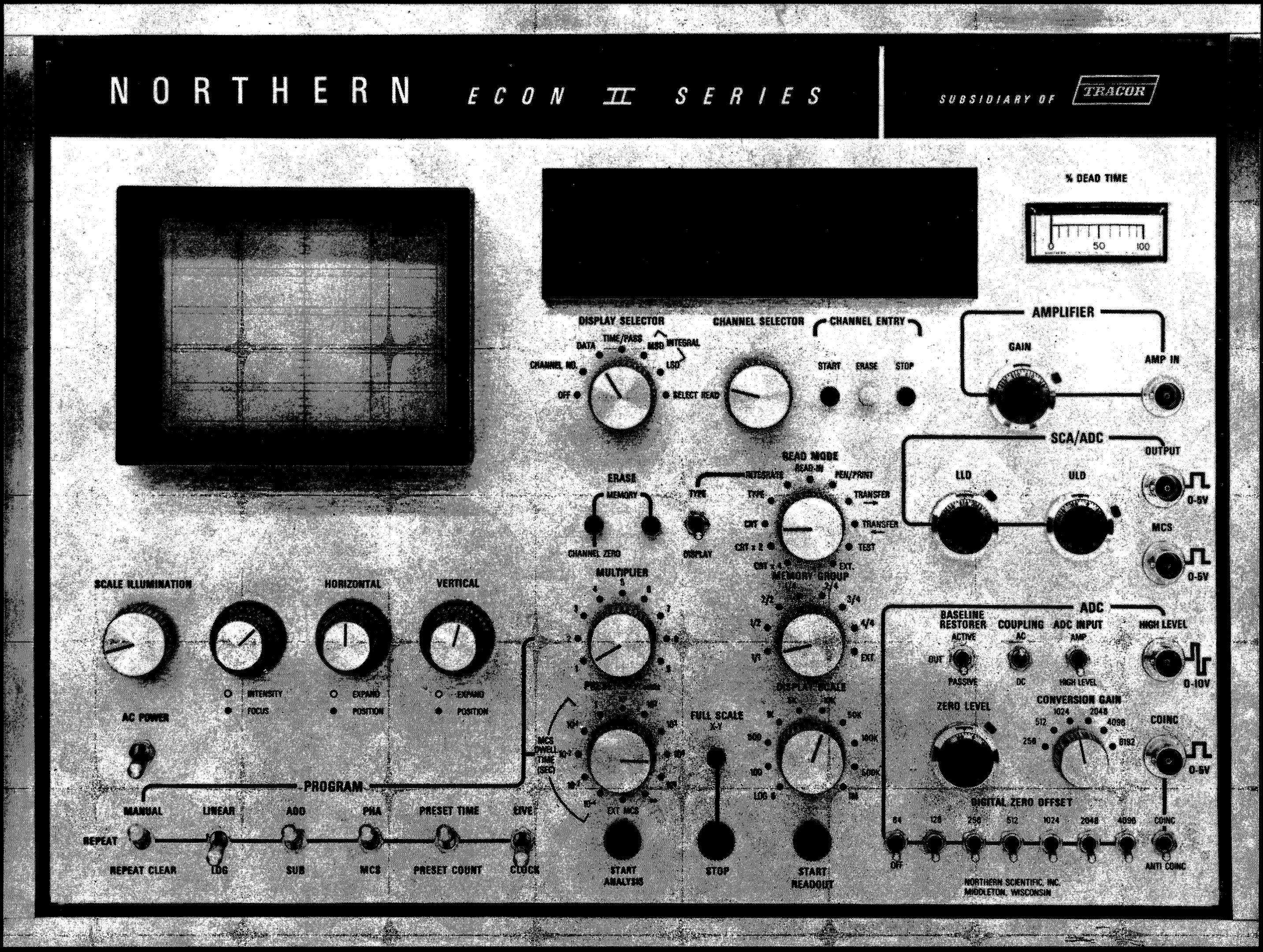
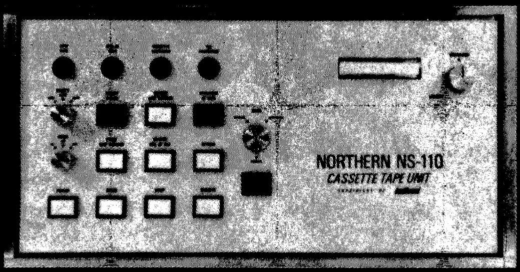
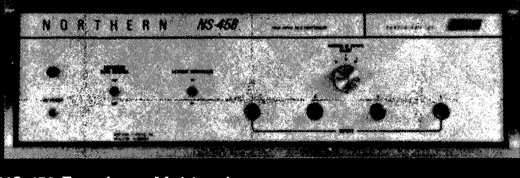
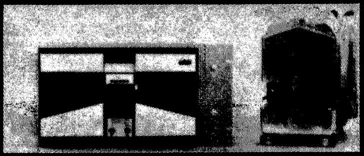




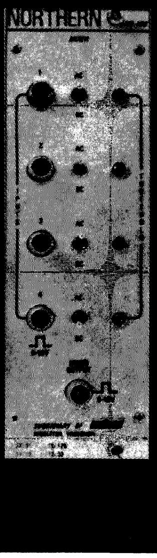
NS-110 Cassette Tape Unit



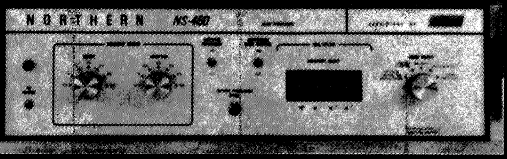
NS-458 Four Input Multiscaler



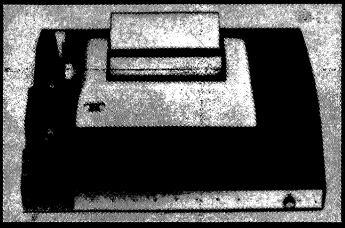
High Speed Paper Tape Punch and Reader



NS-459 Mixer/Router



NS-450 Data Processor (Spectrum Stripper)



Model 33-ASR Teletype

Wang Magnetic Tape System with
NS-406M Magnetic Tape Controller

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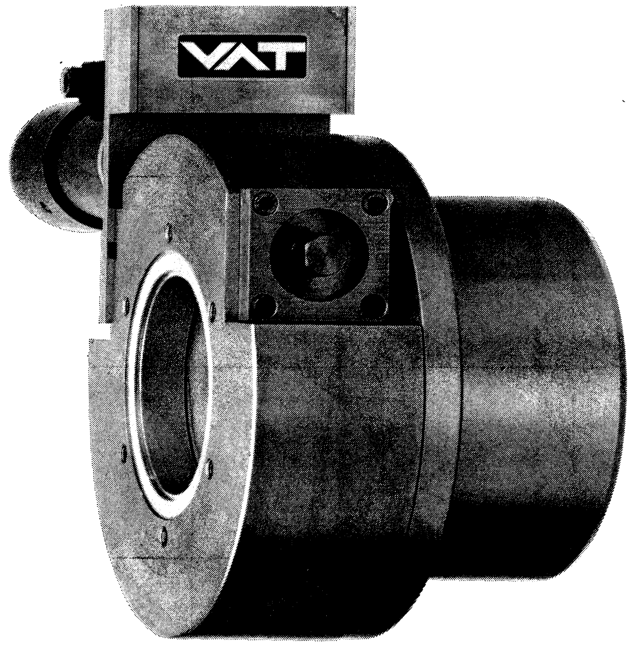

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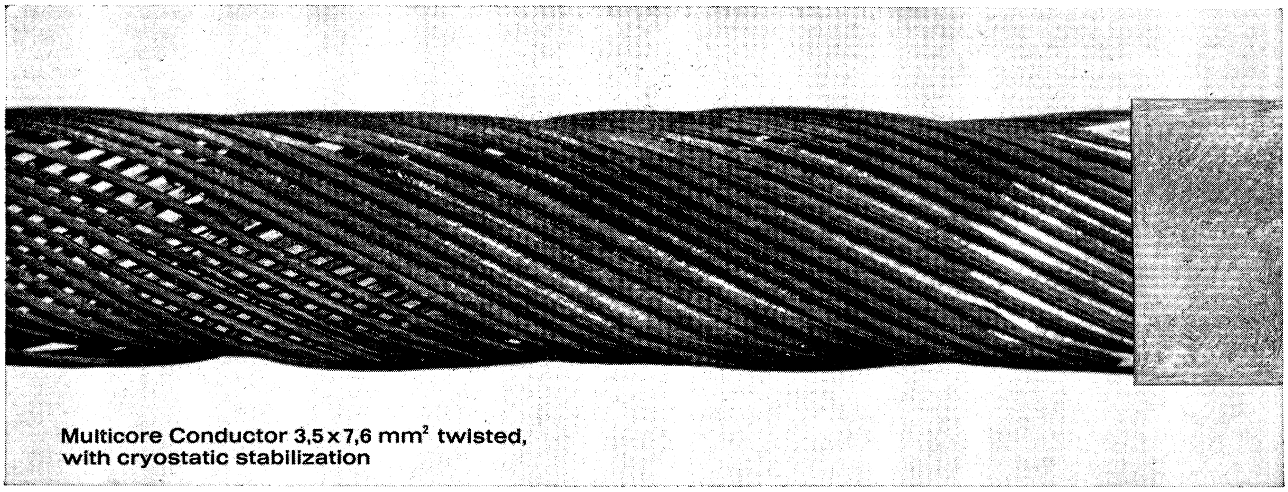

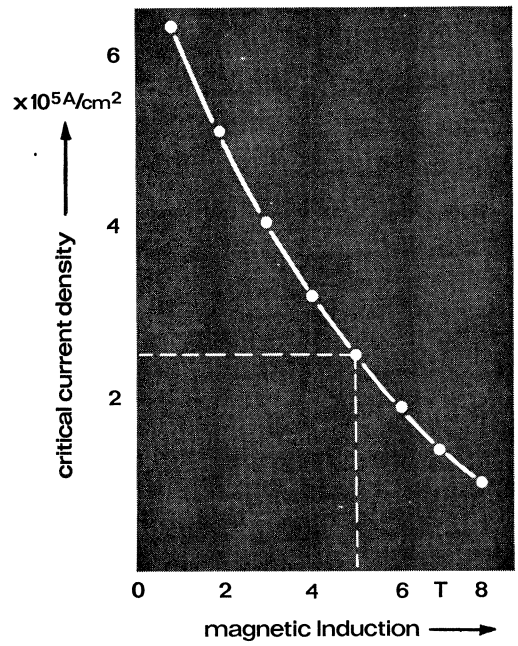
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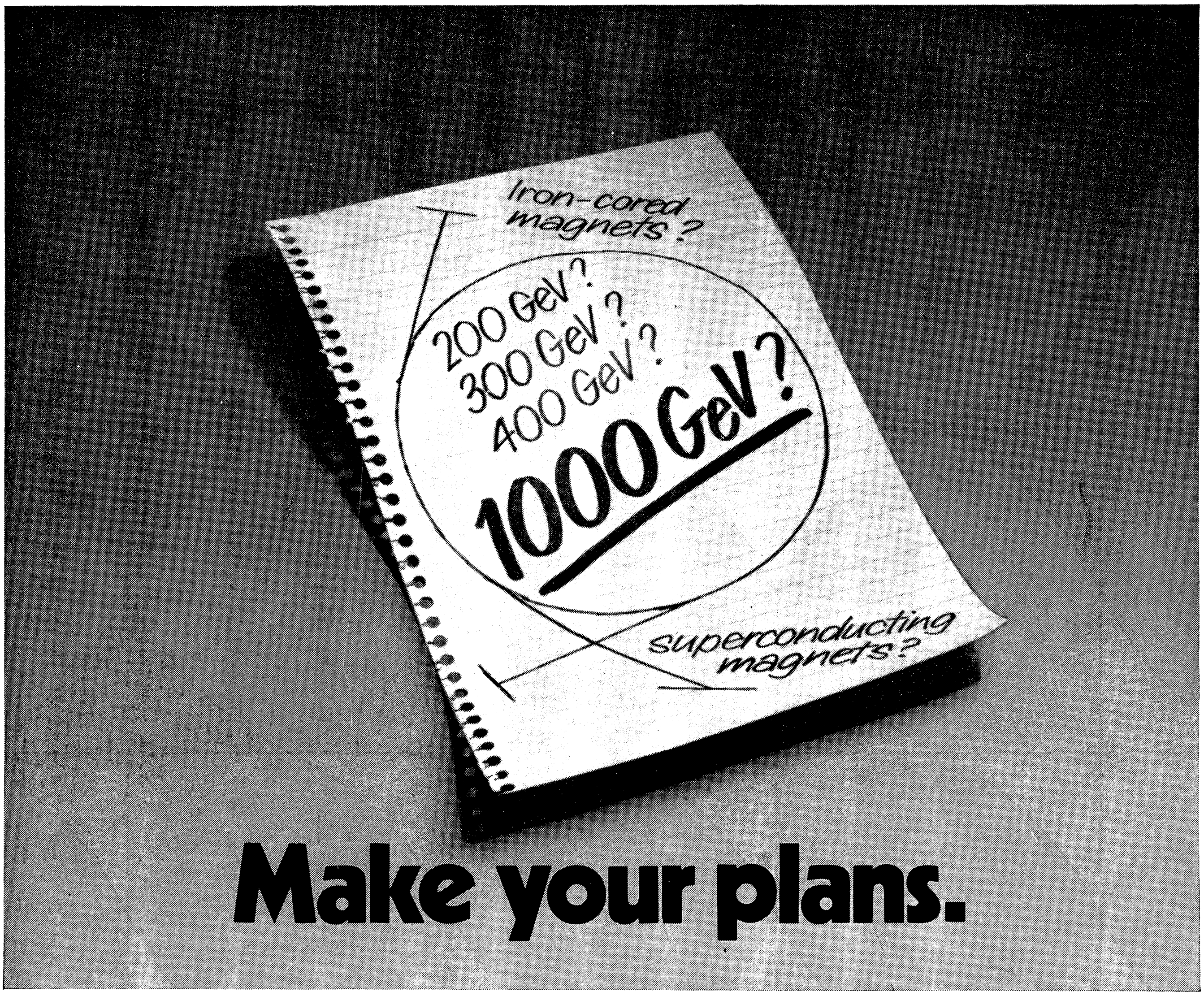

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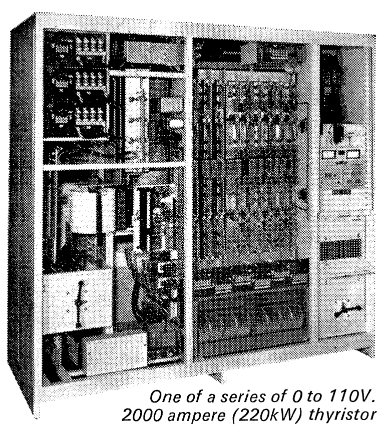

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