CERN COURIER

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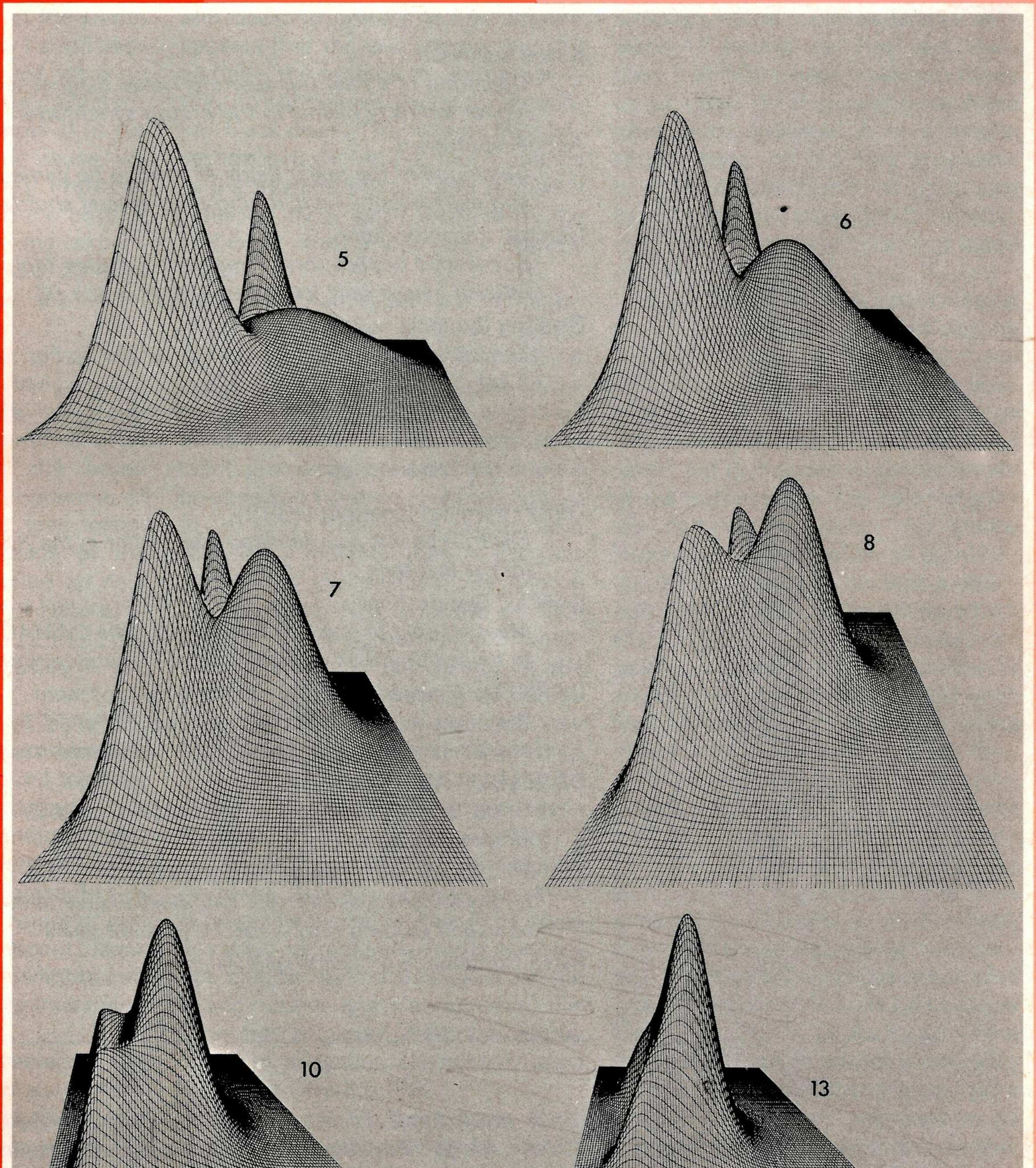

CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, 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 1500 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 3100 people and, in addition, there are about 1000 Fellows and Scientific Associates. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 391.1 million Swiss francs in 1974.

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 400 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 1974 is 227.1 million Swiss francs and the staff totals about 350 plus 10 Scientific Associates.

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Cover photograph: Mountain ranges from experiments with the Intersecting Storage Rings. They are a three dimensional representation of the source of particles emerging from a high energy collision between two protons. When only five particles emerge (top left) it is usually the result of 'fragmentation' — two distinct peaks are seen, corresponding to fragmentation of one or other proton. As the number of particles emerging increases, fragmentation becomes less dominant and it is production of particles from the 'central region' which grows in importance. This can be seen in going through the sequence of peaks corresponding to 6, 7, 8, 10 particles emerging. When as many as 13 particles emerge they are almost always due to collisions involving emission from the central region.

51st Session of CERN Council

The Council met on 19, 20 December under the Presidency of Professor W. Gentner

The Council Session opened, as usual, with progress reports from the Director Generals of Laboratory I and Laboratory II. Since we covered work on construction of the 400 GeV synchrotron, the SPS, at Laboratory II in the November and December issues, we will give here the report of Professor W. Jentschke concerning the physics which has come from the experimental programmes at the 28 GeV Proton Synchrotron and the Intersecting Storage Rings.

Progress in particle and nuclear physics is taking place on many different frontiers and most of them are represented within the broad range of the research programme at CERN. In 1973 CERN lead major advances in the knowledge of the behaviour of matter opening up new perspectives in our view of Nature.

The strong interaction and the nucleons

The nucleus of the atom contains protons and neutrons bound together by a force we call the strong interaction. Although an enormous amount of data exists, a real understanding of this force still eludes our grasp. In this field the ISR holds a unique and dominant position and recent experiments have given fresh insights into the character of the strong interaction at very high energies.

In the ISR range of energies the total proton-proton cross-section, which measures the probability that two protons will interact, increases with energy instead of remaining constant at the plateau value observed in experiments at the previous highest energies — up to 70 GeV at Serpukhov.

The ISR experiments carry the energy up to that equivalent to 2000 GeV for a proton incident on a stationary proton target. Although at these high energies the total number of possible absorptive reactions for two colliding protons is very large, it appears that the two protons are still partially 'transparent' to each other — they do not behave like totally absorbing 'black discs'. The increase in cross-section occurs without much change in the average opacity and is mainly achieved by a small increase in the radius — the proton gets slightly fatter.

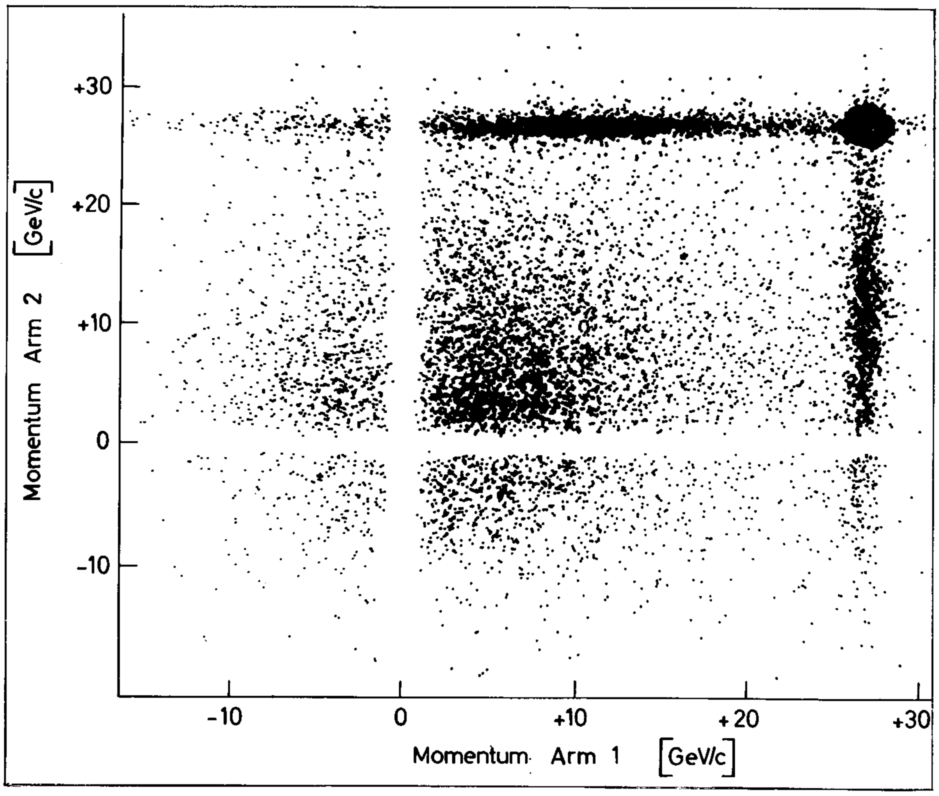
It is important to see how the cross-sections for other particles (pions, kaons and antiprotons) behave, in collisions with the proton. One of the first experiments carried out at Serpukhov by a joint CERN-Serpukhov team discovered a slow rise in the positive kaon-proton cross-section up to 70 GeV. Preliminary results from NAL also indicate that a rise has started for the positive pion-proton cross-section. NAL will also be able to study the antiproton-proton cross-section which is still falling at the highest energies investigated so far. The ISR would be able to add very high energy data on this cross-section if it proved feasible to store antiprotons in the machine. Further experiments at NAL and at the CERN SPS are needed to see how the picture develops, but the unexpected result is now established — very large steps in energy are required in order to measure change in the behaviour of the strong interaction; asymptopia lies even further away than the energy region — sixty times the nucleon mass — reached by the ISR.

It is a fundamental law of physics that to probe smaller distances we must go to higher energies. Here also the ISR has yielded results of great significance — the discovery of a process which must be related to very small scale structure of some kind. Collisions are observed in which particles carrying high momentum are emitted at large angles to the direction of the incoming protons; although these 'high transverse momentum' events are very rare (less than 1 in 100 million collisions) they occur about ten thousand times more often than expected from a simple extrapolation of the low transverse momentum behaviour. It has also been shown that the higher the energy, the higher the probability that these events will occur.

High transverse momentum (over 4 GeV/c) implies a sensitivity to structure in the region of 5.10^{-15} cm and observation of this new phenomenon is reminiscent of the large angle scattering of alpha particles which led Rutherford to the discovery of the nucleus. We may be seeing for the first time, through the strong interaction, an indication of granularity of the nucleon — perhaps a structure of point-like constituents which are also conjectured to account for similar behaviour in experiments in which nucleons are bombarded with high energy electrons (at the Stanford accelerator) or neutrinos (at CERN).

In terms of the simplest parton model the emission of particles with high transverse momentum can be imagined as the result of a rare collision between two partons, one from each proton. The picture predicts that, if a high transverse momentum particle is emitted, the number of particles created at the same time will be larger than usual. This is indeed found — the number of charged particles emerging in the same general direction as a pion of large transverse momentum is nearly twice the average number observed in the much more common events with small transverse momentum; in the opposite direction the number of particles (the multiplicity) rises to about four times the average value.

However, many puzzles still confront advocates of the parton picture. The most naive version is not correct



A 'scatter diagram' where points represent the measured momenta of particles emerging from proton-proton collisions in the ISR. 'Elastic' events where the protons brush against one another and emerge retaining their incoming momenta appear as the black blob in the top right-hand corner. The two well populated horizontal and vertical bands correspond to the situation where one proton or the other was not significantly disturbed.

and it is not yet clear whether it is useful to proceed on the basis of this attractively simple model or to follow other explanations derived from the familiar strong interaction mechanisms extended to an extreme short range form.

At the ISR, matter can be studied under conditions so extraordinary as to be met elsewhere only in the extreme astrophysical domain. One way of representing the situation is to use energy density, rather than energy, as a characteristic parameter. The interaction between two protons is confined to a region whose dimensions are of the order 10^{-13} cm (the range of the strong interaction); the total energy in a collision can be 60 GeV and so the energy density reached during the collision (for the brief interval of less than 10^{-23} seconds) is about 10^{40} GeV/cm^3, or about 10^{17} gm/cm^3. This is about a hundred times the density inside an atomic nucleus and is only otherwise attained within objects like neutron stars or 'black holes'. It is remarkable to contemplate that such situations can be created, if only very briefly, in the laboratory.

The most obvious result of this violent encounter between two energetic concentrations of matter is well known. Numerous particles (on average about eighteen) are created by the transformation of energy into mass during the collision.

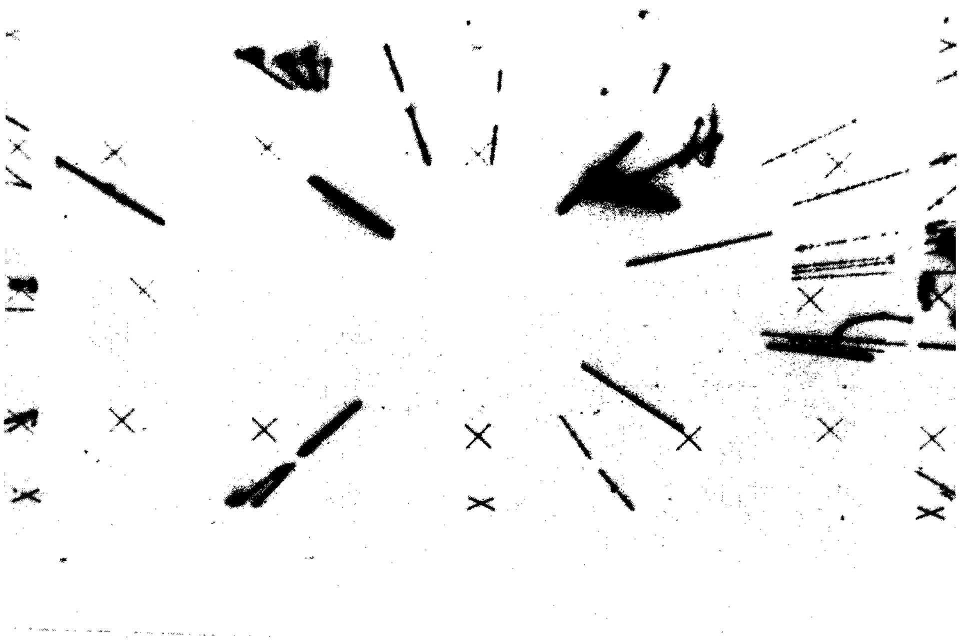
Recent experiments at the ISR and at NAL suggest that the creation of new matter in high energy collisions is a two-stage process. In the first stage, matter appears to be produced in the form of heavy but very short-lived objects (often called fireballs or clusters). In the second stage, each of these splits up into several 'ordinary' particles. Only the latter particles are detected by the experimental equipment but, by the presence of certain correlations between them, we may infer the existence of the heavier clusters from which they emerged.

The ISR observations also suggest two dominant mechanisms of cluster formation. One is called fragmentation in which the particles emitted retain a strong memory of the parent nucleon motion; the other is called production from the central region in which, particles (mainly mesons) are emitted more or less equally in all directions. The relative importance of the fragmentation and central regions as sources of particles has been studied at the ISR in a variety of ways.

First, there is an important class of events, about 20% of the total, in which only one proton is significantly disturbed by the collision and the other continues with just a slight change in energy and direction. There is no contribution of particles emitted at large angles, from the central region, and the only particles created appear as a low multiplicity narrow cone, or jet, of particles lying close to the trajectory of one of the protons. This is a special case of fragmentation of one proton. Similar processes (called proton diffraction dissociation) have been observed in experiments at the PS but the striking result seen at the ISR is that this mechanism can result in excitation of a proton to conditions of much higher mass than was expected. The production of states of up to ten times the nucleon mass has been demonstrated and the further investigation of these states is of great interest in our quest to understand nucleon structure.

The most common interactions are those in which both protons are excited and the central region also plays a role. A suitable choice of parameters allows a very clear demonstration of the contributions arising from these different sources of par-

A photograph taken in the streamer chamber surrounding intersection I-7 in the ISR. It records a proton-proton collision in which many particles are detected emerging from the interaction. A story on the streamer chamber will appear in the next issue.



ticles. The striking feature as we move to the class of events with high multiplicity is the growth of particle emission from the central region. Events of small total multiplicity are dominantly due to fragmentation while collisions in which the central region is dominant lead to higher multiplicities.

Some experiments have looked in more detail at production from the central region and have found evidence that events of high multiplicity correspond to the formation of several clusters which later break up.

This concept of a two step process — formation of a cluster and then, after a time of about 10^{-23} seconds, break-up into three or four particles observed in the detecting apparatus — may be given additional support by a very different sort of experiment. The production of three pions by a collision of an incident pion with a large nucleus has been studied at the PS, and elsewhere, in both bubble chamber and electronic experiments. The results show the surprising result that, under certain conditions, the three pion system seems to propagate through the nucleus with less attenuation than would be expected for three separate pions. With the three pion system, the probability for interaction in the nucleus is no bigger than for a single pion. The attractively simple explanation which now seems possible is that the first step is the formation of a cluster; the cluster would be moving with almost the velocity of light and its apparent lifetime would thus be extended by a factor of about ten — which gives it a chance to escape from the nucleus before breaking up into the three pions eventually observed.

Although the detailed interpretation is probably not as simple as this, there seems no doubt that such experiments in nuclei offer a possibility of studying the behaviour of very highly excited states of matter which exist for only very short times.

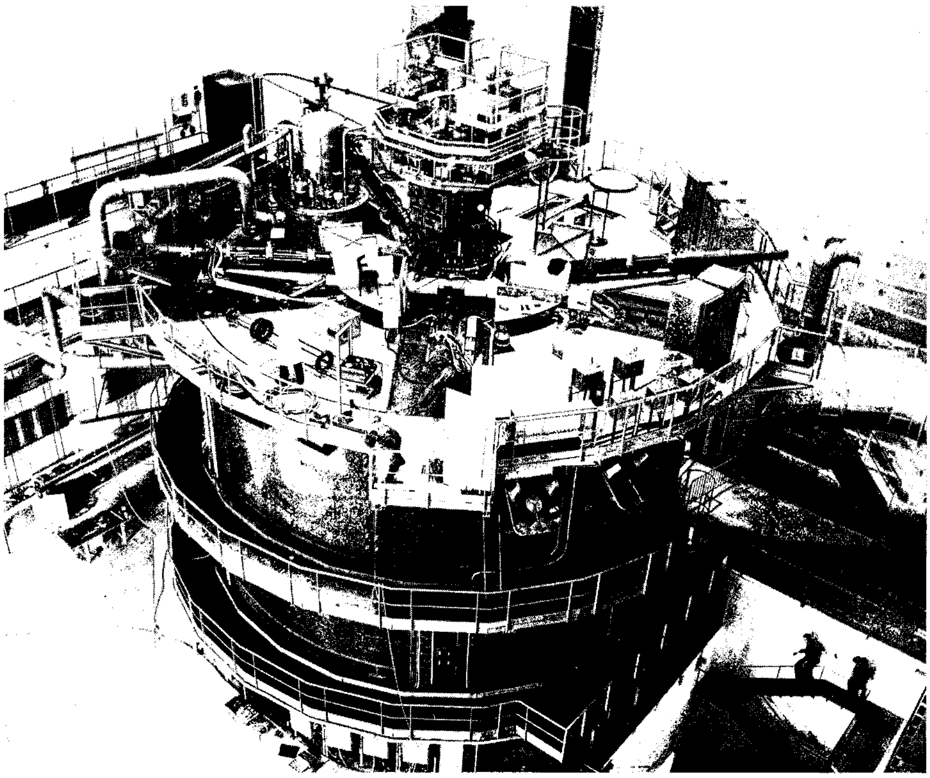
The weak interaction

It is rather easy to relate the strong and electromagnetic interactions to the appearance of the every-day world — the strong force keeps nucleons together in nuclei, the electromagnetic force keeps electrons around nuclei to form atoms and keeps atoms together to form molecules, and is thus responsible for the pyhsical properties and appearance of matter in the large. The weak interaction plays a less obvious but equally fundamental role in determining the character of our world. It is one of the determining factors in the chemistry of nuclear reactions. For example, the sun releases its enormous store of nuclear energy slowly, with a lifetime of about ten thousand million years but if the weak interaction were not so weak, the sun could have burnt out long before life developed on the earth. The weak interaction is not without interest.

CERN has made many important contributions to the study of weak interactions and the results of an experiment in 1973 have captured the interest of the whole physics community. The experiment studies the weak interaction due to a beam of neutrinos passing through the large heavy liquid bubble chamber, Gargamelle, at the PS. The neutrino can only interact with matter through the weak interaction and, as an illustration of the meaning of weak, most of the pictures taken in the bubble chamber are blank even though a thousand million neutrinos are passing through ten tons of liquid freon each time a photograph is taken.

An event has been seen in Gargamelle which could be an example of elastic scattering of an antineutrino

One of the elements of the CERN improvement programme which came into action during 1973 — the 3.7 m European bubble chamber. The chamber is surrounded by a large cylindrical iron shield which retains the stray field of the superconducting magnet. The camera system looks in from the top.



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by an electron. This process is quite unlike the familiar form of the weak interaction, called a charged-current interaction, in which the neutrino would have changed into a muon (involving a change of electric charge between the neutrino which is always neutral and the muon which is always charged). This sort of interaction clearly forbids the elastic scattering process which can only take place if the so-called neutral-current interaction also exists. The event observed in Gargamelle was the first indication that this form of weak interaction might be present in Nature.

The question of the existence of neutral currents has assumed great importance because it is required by certain theoretical attempts to find a unified theory of the weak and electromagnetic interactions. The search for further examples of neutrino-electron scattering has very high priority and Gargamelle has embarked on another 1 million picture experiment, in which the PS Booster is being used for the first time to increase the neutrino yield.

Another type of event was observed in the Gargamelle neutrino experiment which is also evidence for the neutral current interaction. The normal charged current interaction between a muon-neutrino and a nucleon leads to the emission of a muon. The Gargamelle experiment has observed 165 events in which the muon is absent. A background of energetic neutrons could cause such events and neutrino interactions occurring in the magnet and other material surrounding the visible region of the bubble chamber provide a source for such neutrons but the number of muon-less events observed is about six times greater than the estimated neutron background. The muon-less events could be produced by neutrinos — a process which again requires a neutral current.

For many years the study of the nucleus has been concentrated at the 600 MeV synchro-cyclotron but in the last three years we have seen a rapid increase in the use of the PS for such experiments — out of the thirteen beam-lines at the PS, two are permanently in use for nuclear structure experiments.

In one experiment the PS is used as a source of high energy protons to bombard a uranium target and a most ingenious technique has allowed rare isotopes to be identified among the fragments even though their lifetimes are as short as about 1 ms. This experiment has observed and measured the masses of such extraordinarily neutron-rich nuclei as ^{11}Li (with four excess neutrons), ^{27}Na to ^{32}Na (with up to nine excess neutrons) and ^{48}K to ^{50}K (with up to eleven excess neutrons). The study of nuclei, with such extreme composition imposes severe tests on models of the nucleus.

The absorption of negative kaons by nuclei can also lead to the formation of an extraordinary sort of nucleus, called a hypernucleus in which, for a brief period of about 10^{-10} s, a lambda particle joins the protons and neutrons as a nuclear constituent. Experiments at CERN were the first to detect excited states of such nuclei by direct observation of the radiation emitted from them. There is now an active programme of such experiments which will be a fruitful source of information on the interaction between lambda particles and nucleons at low energy.

Professor Jentschke concluded by paying tribute to the quality of the accelerators and detection systems which have been built up at CERN. The strength of the experimental programme depends upon this quality.

During 1973, the 800 MeV Booster came into action at the proton synchrotron and high energy beam intensities of over 5×10^{12} can be achieved.

CERN News

The ISR exceeded its design luminosity of 4×10^{30} cm^{-2} s^{-1} reaching 5.5×10^{30} in a physics run with good background conditions. The Split Field Magnet and its detection system is installed and operating at the ISR. The 3.7 m European bubble chamber began its experimental programme. The Omega spectrometer is performing well.

Agreement on budgets for coming years

There have been long discussions concerning the CERN budgets for coming years. They have considered the evolution of CERN's overall programme as preparations for use of the 400 GeV SPS begin to take an important part of the resources and have also been influenced by the internal difficulties of science funding in the Member States. (For a full explanation of the problems see vol. 13, page 212). It was therefore very gratifying that, at the December Council meeting, the discussion culminated in agreement on the CERN budgets for the next four years.

Following the 'Bannier procedure' the budget for 1974, a firm estimate for 1975 and provisional determinations for 1976 and 1977 were voted. For CERN Laboratory I, a plateau figure of 367.6 million Swiss francs was agreed for all four years; for CERN Laboratory II the figures were 212.8 MSF (1974), 206.9 MSF (1975), 195.1 MSF (1976), 195.1 MSF (1977). All these budgets are given at 1973 prices to which a cost variation index is applied each year. The index for 1974 was set at 6.4 %, compared with the 7.19 % given by the usual formula, the reduction being achieved by awarding a lower salary increase to CERN staff than that given by the salary index. The result of these decisions is that the actual budgets for 1974 are — 391.1 MSF for CERN Laboratory I and 227.1 MSF for CERN Laboratory II.

Elections and Appointments

The Council re-elected Professor W. Gentner (Federal Republic of Germany) as its President for 1974 and also re-elected the two Vice-Presidents — Professor Th. Kouyoumzelis (Greece) and Dr. G.H. Stafford (UK). Three new delegates were welcomed — Professor M. Pihl, Ambassador A. Farace di Villaforesta and Ambassador E. Hambro representing Denmark, Italy and Norway respectively.

M. Lemne succeeds P. Levaux who, as Chairman, has guided the work of the Finance Committee excellently during the very difficult discussions of the past three years. Professor A.G. Ekspong remains Chairman of the Scientific Policy Committee. The Chairmen of the Experiments Committees also remain the same (Electronics Experiments Committee — I. Mannelli, Physics III Committee — D.H. Wilkinson, Intersecting Storage Rings Committee — H. Schopper, SPS Experiments Committee — P. Lehmann) with the exception of the Track Chamber Experiments Committee where D.C. Colley succeeds M. Cresti.

Within CERN itself the appointment of Professor W.K. Jentschke as Director General of CERN Laboratory I was extended for a year until December 1975. S. Fubini will succeed L. Van Hove as Director of the Theoretical Physics Department as from 1 July 1974. E. Michaelis continues as Leader of the Synchro-cyclotron Division for a further two years, also from 1 July 1974. W. Schnell was appointed Leader of the ISR Division for one year as from 1 January 1974.

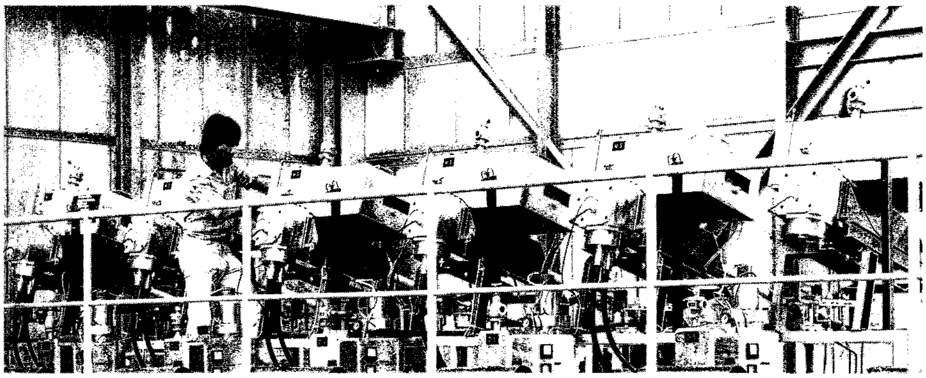
Kicker success

Another satisfying outcome of the pre-shutdown run at the proton synchrotron was the performance of a new full aperture kicker magnet, pressed into service before its scheduled time in order to cope with the high beam intensities. With the 800 MeV Booster giving beams of 5×10^{12} protons orbiting the PS ring, the usual small aperture kicker in straight section 97 was receiving an overdose of radiation. The full aperture kicker (FAK), installed in straight section 71, was therefore brought into action and did all that was asked of it.

Kicker magnets are powered by short high voltage pulses to induce oscillations in the orbits of high energy particles circulating in bunches in accelerator rings. Ideally they should be able to kick chosen bunches with full power without influencing any other bunches. This means that they must come on in the brief time between the passage of one bunch of particles and the arrival of the next bunch. They can then kick this bunch and subsequent bunches before being switched off. The switching off may again need to be done in the inter-bunch interval so as to leave other bunches still orbiting the ring.

At the PS, small aperture kicker magnets, plunged into position as the accelerated beam shrinks in cross-section, have been used up to now. These smaller-scale magnets are less complex than the FAK variety but, with the coming of high intensity beams, the danger of radiation damage became serious. The construction of a kicker magnet to sit in a fixed position with an aperture large enough to accommodate the injected beam has therefore been one of the necessary subsidiary elements of the PS improvement programme.

There was an abortive attempt at a full aperture kicker magnet in 1968



Part of the pulse generator system which powers the FAK. Six of the generators (each feeding a different module) can be seen. They are located in a building at the centre of the PS ring and are connected to the FAK via high quality cable. Each generator is capable of supplying a 100 MW pulse for up to 2.2 μs.

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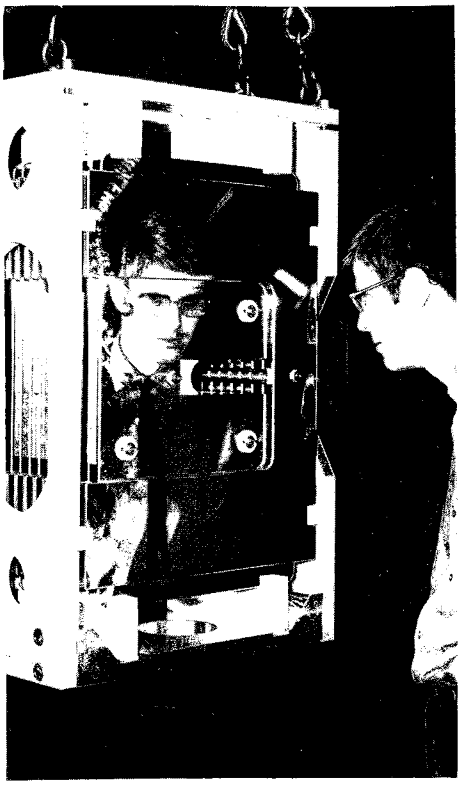

One of the nine modules of the Full Aperture Kicker. The capacitor plates, which determine the characteristic impedance of the module, are polished to a mirror finish. They hide the ferrite around the magnet aperture.

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(see vol. 8, page 26) but it was not successful mainly because of attempting to use araldite impregnated ferrite to serve as the vacuum chamber and high voltage dielectric as well as the magnetic circuit. The new kicker has a separate vacuum chamber surrounding the ferrite. It is built in nine modules each fed by its own pulse generator. The aperture available to the beam is 147×53.5 mm and the total length is about 2.4 m. Each module has a characteristic impedance of 15 ohms.

The reason for the division into many modules is the need to fill the FAK with field (and empty it) in the 0.1 μs interval between the passage of successive bunches at full energy in the PS. The pulse is derived from a cable pulse forming network charged to 80 kV. Thyratrons are used at each end of the network — one to switch power to the kicker, bringing on the required field in about 75 ns, and the other to switch the power to a dump to bring the field off in the same time interval. By adjusting the firing times of the thyratrons the pulse length at the FAK can be varied to eject from one to twenty (i.e. all) bunches in the PS. The pulse forming network can be recharged in 4 ms and the kicker can be powered to perform up to four ejections per machine cycle.

The most difficult aspects of the FAK design and construction have been connected with the ferrite. The magnet has about 500 kg of ferrite inside the vacuum vessel. To lessen the outgassing problem the ferrite was immersed for two months in boiling demineralized water to remove hygroscopic salts and then vacuum baked. With nine ion pumps on the vessel, a pressure of better than 10^{-7} torr is achieved. The remanent field of the ferrite was measured using an electron beam and some of the material proved to be a little outside the specified limit. This caused no noticeable disturbance to the beam in the proton synchrotron.

Another lengthy pre-operation procedure concerned the thyratrons. High reliability is needed and has been well achieved — six tubes withstood a life-test of a hundred million pulses.

The FAK is intended to take over all the fast ejection system operations from the present small aperture kickers. During the PS run, the FAK was used for ejection from straight section 74 towards the heavy liquid bubble chamber Gargamelle and for high intensity filling of the ISR. This involved manually changing the magnet polarity in the accelerator ring.

The kicker operated reliably throughout the run and achieved ejection with no discernible beam loss. Its abilities were particularly noticeable when it was required to eject nineteen bunches; it was able to leave a single clean bunch orbiting quietly in the proton synchrotron ring.

Annual shutdown

As usual at this time of the year, the PS and ISR are shut down for maintenance and modifications. This means the interruption of all experiments while the equipment of the PS, ISR and experimental halls is inspected and overhauled methodically.

There are more than 500 jobs to be carried out at the PS and we pick out only the major tasks: At the linac, in addition to the maintenance work, the flexible power supply cables for the r.f. cavities have been replaced by rigid one. This will improve the reliability which is crucial to the whole CERN accelerator complex.

At the Booster the tasks include:
- replacing a defective vacuum chamber in a bending magnet unit
- replacing a vacuum vessel and its four septum magnets for injection by septum magnets of an improved type
- installing four wide-band radial pick-up stations
- re-aligning the injection system
- surveying magnet positions and alignment of the quadrupoles.

At the PS ring, as is the case every year, the work to be carried out on the magnets is considerable because of radiation damage. Of the 100 magnets in the ring, two will be replaced by reconditioned units and eight others will be repaired by strapping the end blocks on which the adhesive has suffered damage. Another stage of the installation of the auxiliary correction magnets has now been completed and this work will be reported in next month's issue.

A new large-aperture septum magnet (vertical aperture measuring 30 mm instead of 20 mm) for the ejection of a high intensity beam has been installed for the neutrino area, necessitating modifications to the vacuum chambers in the upstream and downstream magnets. New power lines have been installed for this magnet.

Special attention is being paid to the vacuum systems since 75 out of the 100 straight sections must be opened up. Fifteen of these straight sections are being modified. Special attention is also devoted to the control room where 25 racks will be converted in order to change from manual to automatic control. New consoles are being installed for this purpose and the equipment is being modernized.

For the main magnet power supply a system has been installed enabling one of the two rectifier units to be bypassed. During the flat top of the acceleration cycle, the second unit will operate at double voltage, thereby reducing blow-up of the beam. This will improve the power factor and the increase in reactive power will result in flat tops between 20 and 30% longer, depending on the cycle used. This system should be operational for Easter.

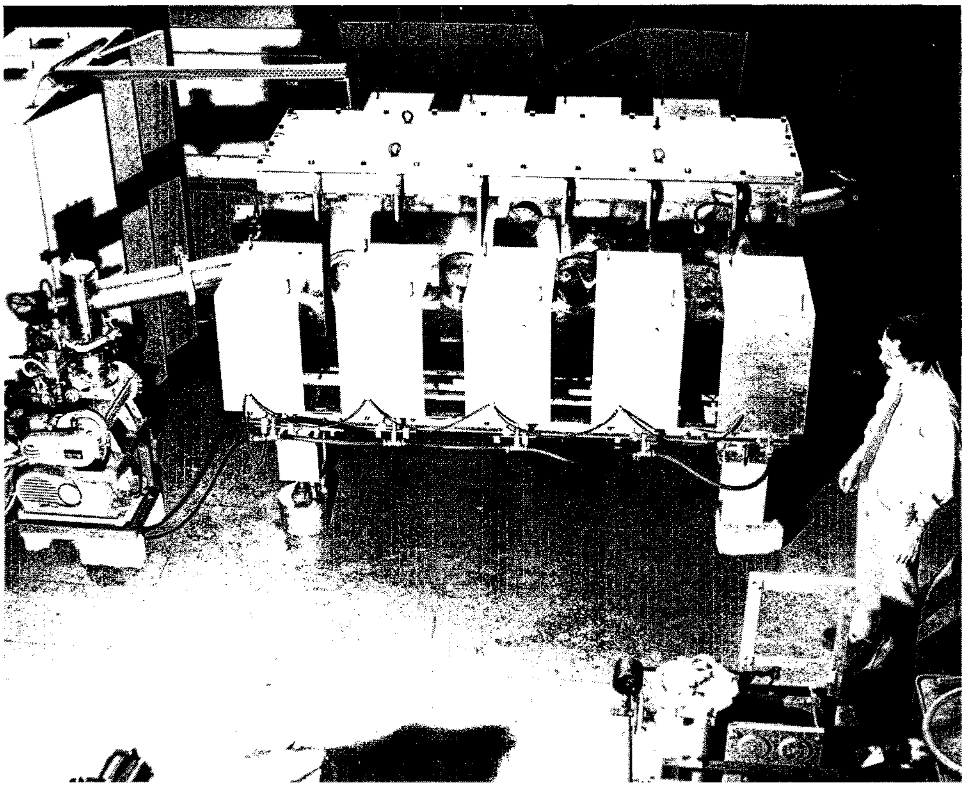
At the experimental halls: In the West Hall, the only modification is the installation of a d.c. superconducting lens in the u7 beam for tests. In the North Hall, the main job is to dismantle the k16 beam to the Hybuc bubble chamber which has finished its experiment on the magnetic moment of the sigma hyperon. In the South Hall, to allow access to the PS ring, nearby beam-line components must be moved and some separators, which have not been operating well, are being taken out and reconditioned. In the East Hall, certain beam-line magnets which have been exposed to radiation are being removed for overhaul and replaced by reconditioned components.

In addition, some reorganization of the East Hall beam-lines is under way. The medium energy p8 pion beam is being replaced by a b20 neutral particle beam for an experiment to study neutral kaon-proton interactions. The p13 beam is being modified and will be known as p14. Its particle production angle will be smaller thus increasing the beam intensity. At the end of the u5 beam-line, bending magnets are being replaced by more powerful versions in order to separate neutral particles which will feed the 2 m bubble chamber. It is estimated that the operations in the East Hall will involve moving and re-positioning more than 3000 tons of equipment (iron, concrete shielding and beam transport components).

At the ISR, the shutdown began on a note of satisfaction because the high intensity run using the Booster resulted in a better feed to the ISR than had been anticipated. On 7 December, 20.6 A were stored in Ring 2 and 22.1 A in Ring I with high luminosities also being achieved. The average pressure over the two kilometers of vacuum chamber is less than 2×10^{-11} torr, with even lower values of 10^{-12} torr in certain regions. This followed the installation of 500 titanium sublimation pumps and 47 bake-out operations in 31 different sectors.

In order to confirm this performance and continue improvements during 1974, a programme has been carefully worked out to take full advantage of this third major shutdown of the ISR. In view of the wide range of possibilities, a list of priorities was drawn up as a compromise between work

The vacuum tank of the FAK being tested prior to installation in the PS ring. Nine ion pumps are distributed either side of the tank.



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devoted to development, installation, experiments and maintenance.

New apparatus is being installed to make possible better studies of the beam behaviour. A number of lenses (sextupoles and octupoles) are being introduced around the two rings to compensate non-linear beam resonances. A special observation station will be used for monitoring the horizontal beam profile. A damping magnet will correct vertical errors in the injection system. Titanium jackets are being installed in the vacuum chamber to prevent pressure bumps and it is planned to use several gas discharges in an argon atmosphere to clean out certain chambers in twelve sectors, which will be baked out during the machine shutdown.

Most activity will, however, centre around the intersection regions where certain experiments are being replaced by new ones.

In intersection 2, the programme of experiment R203 using a wide-angle spectrometer has been completed and it will be converted to experiment R205 by the addition of a central hodoscope composed of 120 scintillators around the intersection.

In intersection 4, the detectors used for five experiments have been dismantled for inspection of the Split Field Magnet and baked out of this intersection region. It is hoped that all the detectors can be re-installed before the end of the shutdown period.

In intersection 5, chamber modifications are being carried out which should help to improve performance and be particularly useful for the measurement of beam luminosity.

In intersection 6, experiment R603 has been dismantled and a new vacuum chamber is being installed to continue studies on small-angle elastic diffraction scattering with experiment R602. New detectors are also being installed by this group.

In intersection 8, the vacuum chamber is being modified for experiment R801 in order to be able to check the total cross-section by simultaneous measurement of the overall number of interactions and the small-angle elastic diffraction scattering rate. The vacuum chamber for experiment R802 is being completed by the installation of a special chamber known as the 'flying bedstead'. Finally installation of a new experiment, R803, should also begin.

Gamma-transition jump

The 'gamma-transition jump' system used in the 28 GeV proton synchrotron proved to be particularly effective in coping with the increase in intensity recorded before the machine shutdown.

In a synchrotron, the principle of phase stability, discovered by V. Veksler and E. McMillan, makes it possible to achieve stable acceleration of many particles because of synchrotron oscillations. A synchronous particle orbits the ring exactly in rhythm with the accelerating fields while a bunch of other particles oscillate around it sometimes arriving at the r.f. accelerating station sooner, sometimes later.

A particle which has a higher energy than the synchronous particle acquires a higher tangential velocity resulting in two conflicting effects — an increase in its angular velocity around the ring and an increase in its orbit radius. In a strong-focusing synchrotron, the former effect is the more important at low energies. It cuts down the time taken to travel around the ring and the particle arrives ahead of the synchronous particle at the r.f. accelerating field and must therefore receive less energy from that field than the synchronous particle in order to keep it in the bunch.

At high energies, on the other hand, the latter effect is predominant — the proton has further to travel in going around the ring and this increases the revolution time. A particle arriving later than the synchronous particle has then to receive less energy from the r.f. field in order to remain in the bunch.

Between this low energy and high energy behaviour, there is an energy at which the increase in angular velocity exactly counters the elongation of the orbit. The time taken to orbit the ring is independent of the momentum of the particle and the corresponding energy is known as the transition energy. The r.f. accelerating voltage has to change phase when the transition energy is reached to adapt to the changing particle behaviour.

Space charge phenomena also undergo radical changes when the transition energy is crossed since the behaviour of the particle bunch is completely different below and above this energy. Below transition energy, the forces of repulsion between particles cause the bunches to lengthen. Above it, these forces cause the bunches to shorten. This results in oscillations in the shape of the bunches and can lead to dilution or even considerable losses. Moreover, just after transition, the slight statistical fluctuations in the bunches increase and cause them to expand laterally (negative mass effect).

The transition region must be crossed fairly rapidly in order to avoid damaging effects from these two phenomena. The solution consists in abruptly changing the transition energy just before crossing the transition region, by acting directly on the focusing forces which dictate the transition energy.

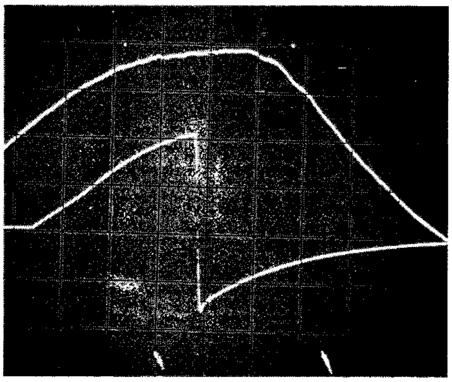
Since 1969, the transition region has been crossed by provoking a 'jump' in the number of horizontal betatron oscillations per turn, Q_H, (controlled by the focusing forces). Using the correction quadrupoles installed in the machine, a pulse was transmitted which adjusted the focusing fields so that the value of Q_H rose slowly at first and then dropped sharply, subsequently returning to its normal value. The rate at which the transition region was crossed was limited because Q_H could be varied only within a restricted range to avoid running into resonant phenomena (stop bands).

The method used since August of last year consists in varying the transition energy, again using quadrupoles to adjust focusing fields but this time without changing the value of Q_H. This is called the gamma-transition jump.

Two quadrupoles with opposite polarities are placed half a betatron wavelength apart; such a doublet does not affect the value of Q_H. This arrangement is possible in the PS ring because of a special feature of the CERN accelerator: the ring has fifty periods and, since the normal value of Q_H is 6.25, the two quadrupoles of a doublet can be positioned in straight sections four periods apart. The ring layout now includes four doublets of this kind together with two triplets, which can be regarded as consisting of two adjacent doublets.

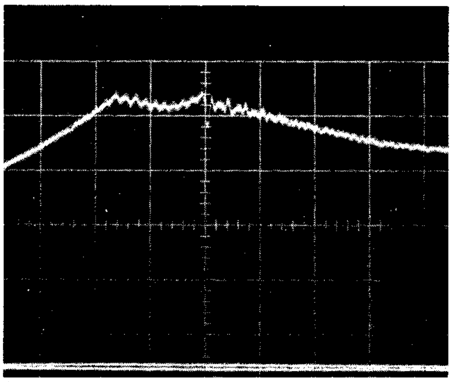
The important parameters of the gamma-transition jump are its speed, its magnitude, and its shape, and they have all been closely studied at the PS. With the old Q_H jump system the transition region was crossed about five times faster than without a Q_H jump. With the gamma-transition jump system the transition region is crossed fifty times faster than without it. A new power supply is now being built for the quadrupoles and will make it possible to double this speed during 1974.

With the intensity of 5×10^{12} protons per pulse obtained in November, the gamma-transition jump system made it possible to maintain the beam emittance (10 mrad) throughout acceleration. With an intensity of 10^{13} ppp which is expected to be reached during the next few years, the space charge phenomena will be even more important at transition and it is intended to enlarge the bunches artificially before transition in order to eliminate transverse expansion. The longitudinal emittance of the beam is then not expected to exceed 14 mrad.



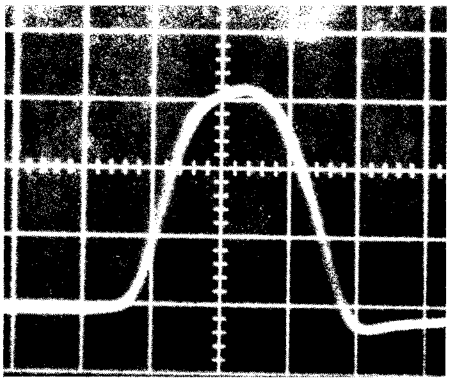
1.

1. The upper trace shows the current rise in the triplets (about 500 A), while the lower one shows the current in the doublets (about 700 A peak-to-peak). The sweep rate is 5 ms per division.



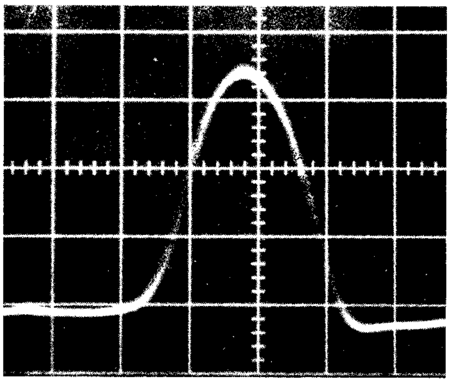
2.

2. The signal from the wide-band pick-up station which is inversely proportional to the length of the bunches. The first peak corresponds to the beginning of the current rise in the doublets, and the second to the passage through transition. A few rapidly damped oscillations can be seen. The beam intensity is 5.5×10^{12} protons and the sweep rate is 10 ms per division.



3.

3. The instantaneous particle density in a bunch before transition at 3.4 GeV. The sweep rate is 5 ns per division.



4.

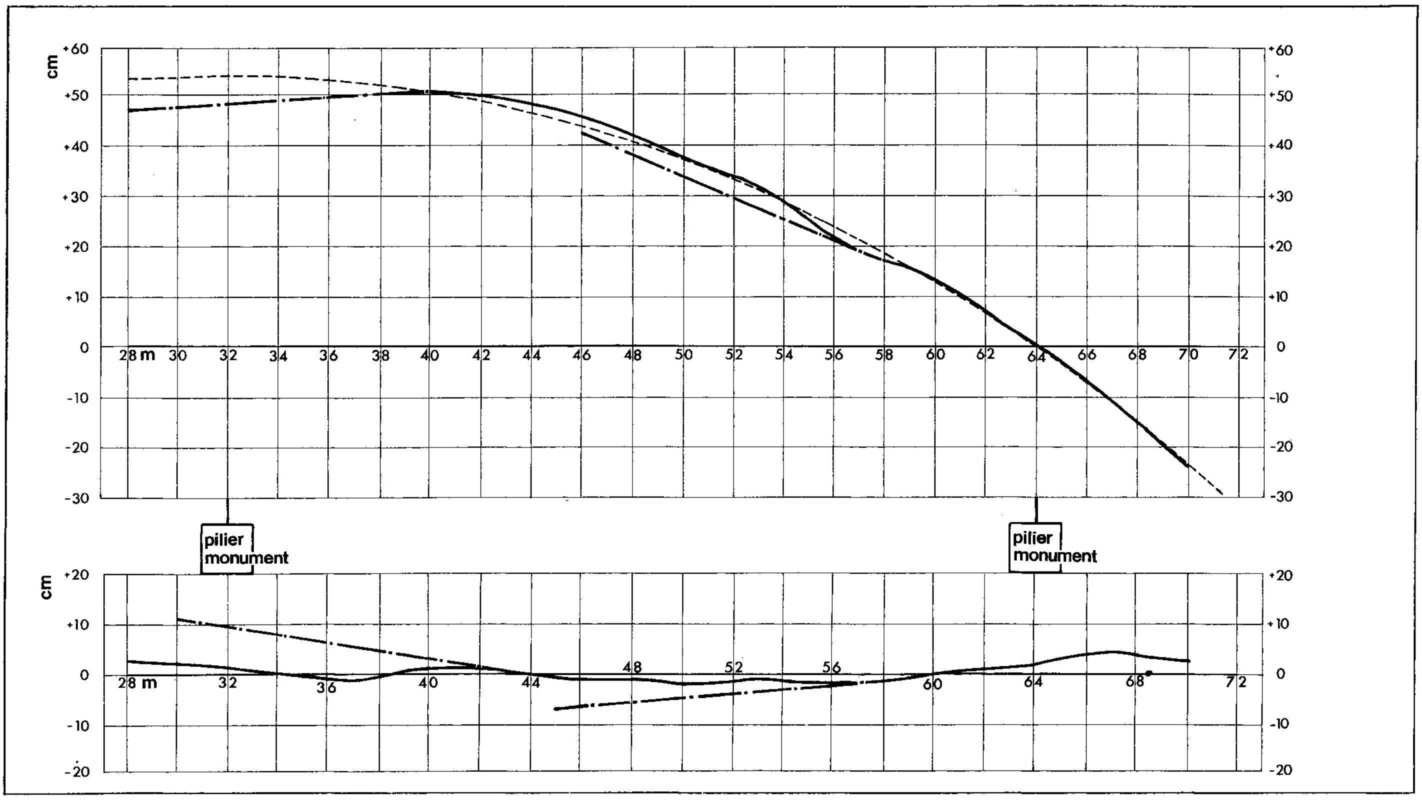
4. The instantaneous particle density in the bunch after transition at 9 GeV. The transition energy has dropped to 5.2 GeV using the gamma-transition jump device. The photograph shows that the bunch has successfully passed transition since there are no 'tails' to the trace.

Steering the mole

On 12 December, the Robbins boring machine reached shaft PP4 half-way around the 6900 m circumference of the SPS tunnel. Adding the 200 m length of the access tunnel between the Civil Engineering Shaft (PGC) and PP1, the total distance covered in the ten months since the machine descended into the depths is 3650 m.

In accordance with the programme (see vol. 13, p. 70), PP4 is now being used as the servicing shaft instead of PGC — it is from here that the spoil is being removed to the surface and tunnel lining components taken down.

How does the 'mole' know where to go while working several tens of metres underground? First of all, the co-ordinates of the axes of the various shafts had to be determined on the surface, using the CERN survey grid. This was the prime purpose of a surface geodetic network drawn up to an accuracy of 2 mm by triangulation-trilateration. The next step was to mark out the centre of each of the first three shafts (PGC, PP1 and PA2) on the ground. After these shafts had been sunk, the surface co-ordinates were transferred to tunnel level. In this way it was possible to set up 'monuments', accurately sited at the bottom of each of these first three shafts.



Example of a guide chart for the Robbins boring machine. Top: the Direction diagram (horizontal plane). The X axis, representing the laser beam, carries the longitudinal scale from 28 to 72 m of the monument on which the laser is fitted. On the Y axis are the displacements corresponding to the tunnel curvature. Long and short dashes: theoretical excavation curve; chain dotted line: segments fixing the position of the head in relation to the recorded displacements; unbroken line: real excavation curve in the horizontal plane.
Below: the Level diagram (vertical plane). The X axis is both the theoretical excavation curve and the representation of the laser beam. The broken line: segments fixing the position of the head in relation to the recorded displacements; unbroken line: real excavation curve in the vertical plane.

In going from the monument at the bottom of the first shaft to that at the bottom of the second, on the curve laid down in the plans, the following technique was followed: An instrument had to be used which would give a direction in relation to a physical constant and the method employed had to make it possible to position the tunnel in accordance with the requirements of the civil engineering specifications as regards accuracy.

A compass is far from being precise enough. The only possible instrument is a gyro-theodolite, which gives the geographical north to an accuracy of 30 centisimal seconds, obtained at the surface from the datum points of the network. The desired direction, with reference to the geographical north, is measured by the gyro-theodolite on the monument at the bottom of the first shaft. The plotting method consists in setting up a monument every 32 m in the tunnel, gyroscopic measurements being taken at each one.

A straight tunnel some 200 m long was needed for the assembly of the 'mole'. For this reason, the first shaft (PGC) was sunk outside the ring on the axis of the future injection tunnel. An Alpine boring machine began work from there towards PP1 along the line dictated by the gyroscope. When the machine arrived at PP1, it was found that the displacement in relation to the co-ordinates plotted at the surface was 2.3 mm. The 'mole', also guided by the gyroscope, was started off from the co-ordinates of monument PP1.

The Robbins machine is fitted with two grid targets in known positions with reference to the axis of the machine. The guide datum is a laser beam coming from the monument which gives, in visible form, the direction obtained by gyroscopic measurements. The operator has a guide chart prepared by the CERN Survey Group which has two diagrams relating to a 44 m stretch for excavation. The horizontal plane diagram consists of the track of the laser beam and the theoretical boring curve. The vertical plane diagram is simply a straight line giving both the track of the laser beam and the theoretical excavation curve.

After the first stroke of 1.2 m, the operator checks the position of the head of the Robbins machine. He notes the direction and level displacements of the axes of each target in relation to the point illuminated by the laser beam, transfers them to the two diagrams on the guide chart and deduces the position of the head of the machine. If the location of the head on the diagram lies outside the theoretical curve, the boring axis is corrected.

After it has advanced 44 m, the next survey monument is set up and the 'mole' is given a new direction, dictated by the gyro-theodolite and rendered visible by the laser fitted on this monument. On its arrival at PA2, the machine entered an enlarged section previously excavated from the shaft. The polygonal track formed by the 36 monuments set up between PP1 and PA2 had then to be 'closed'. This merely involved relating the PA2 monument, whose exact co-ordinates have been determined from the surface, to all the preceding ones.

The transverse displacement thus found was only 25 mm at PA2, within the limit of 30 mm required in the specification, after a total distance covered of the order of 1150 m. At the next shaft (PA3), the displacement was as little as 20 mm. This accuracy relates only to the direction as given by the surveyor; obviously, the actual tolerances on excavation are less strict but even they do not exceed 7 cm.

Around the Laboratories

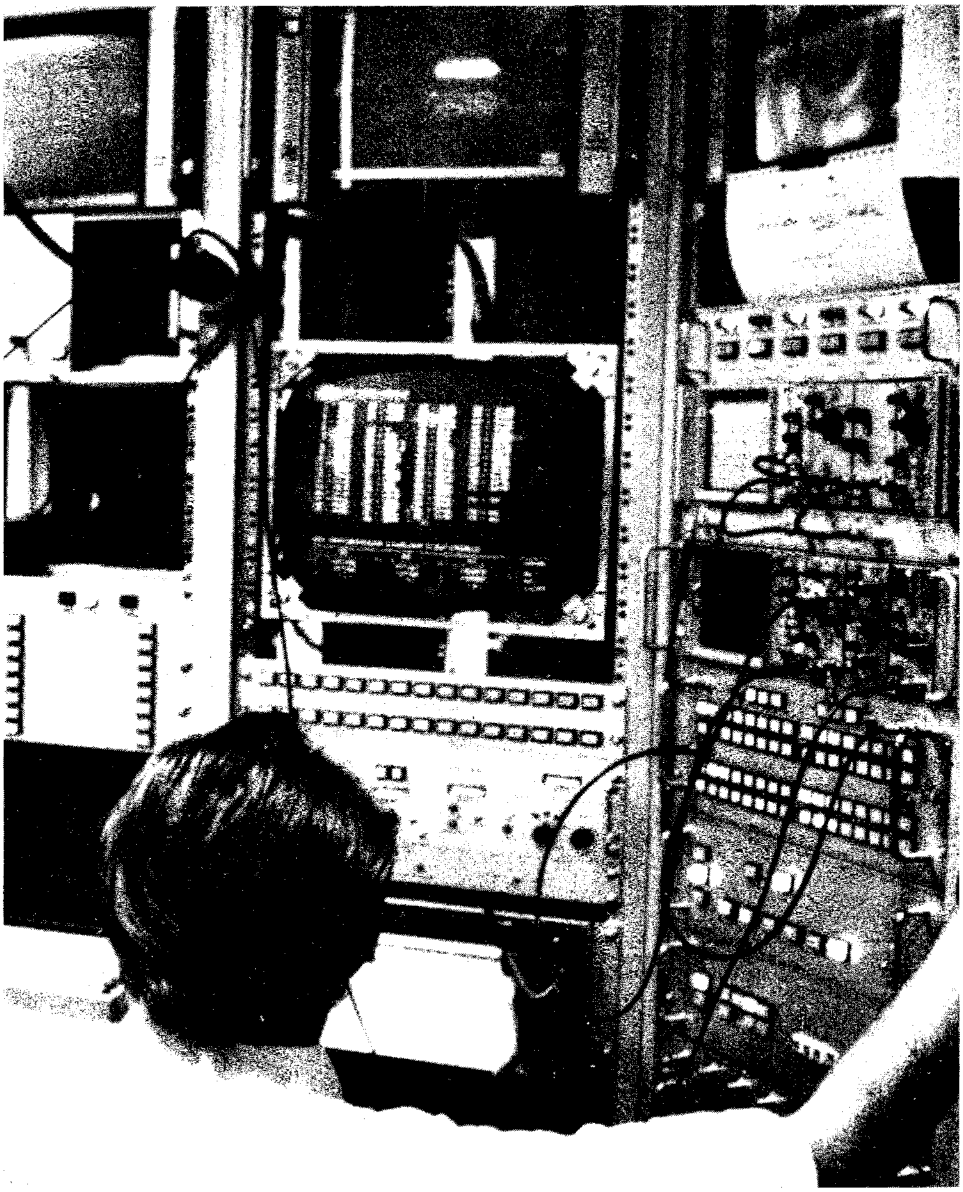
DESY
Particles stored in DORIS

On 21 December, for the first time, an electron beam of the order of one milliampere was accumulated and stored in DORIS and survived with a lifetime of a couple of hours. Starting on 17 December the first attempts were made to inject electrons from the DESY synchrotron into DORIS. It took about a day to achieve a beam circulating for many thousands of turns. The lifetime however was only some ten milliseconds and it was obvious that the beam was being scraped off because of large orbit distortions. The following days were devoted to improving the orbit and the optics of the storage ring and this resulted finally in the accumulation of an electron beam with a good lifetime.

The first few months of this year will be devoted to improving the injection conditions, the betatron functions in the storage ring and the machine tunes. Sextupoles will be brought into action to correct for chromaticity in order to be able to store higher beam currents. To finally achieve colliding beams, the same work has to be carried out with positrons in the second ring. (Latest news from DESY, 18 January, is that 130 mA of electrons and a positron beam have been stored.)

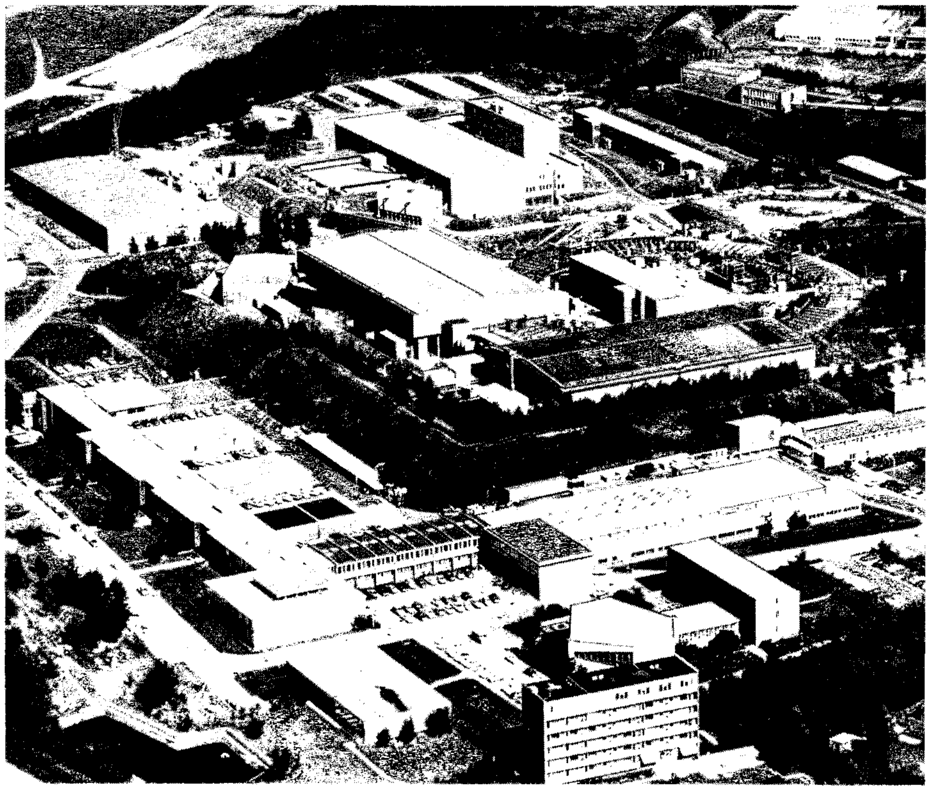
DORIS is a double storage ring to store electrons and positrons in different rings so as to achieve better control of the beams. The rings are built one on top of the other and vertical bending magnets are used to bring the two beams together at two interaction regions with a crossing angle of 24 mrad. The circumference of the storage rings is 288 m with a 12.4 m bending radius. The magnets are designed for a maximum energy of 5 GeV, but the magnet power supplies presently installed will not allow higher energies than 3.5 GeV. A programme to raise the energy to the peak possible value has already started. The r.f. system comprises six modulators giving 1.5 MW of d.c. power for both rings into twelve cavities per ring with an r.f. frequency of 500 MHz. The r.f. system is capable of handling beam currents of the order of a few amperes at energies below 2.5 GeV if no other limits come into play. The design maximum luminosity is computed to be 3×10^{32} cm^{-2}s^{-1} at 1.6 GeV dropping off to 2×10^{30} cm^{-2} sec^{-1} at 3 GeV.

Having two separate rings gives unique possibilities not only for the individual control of the electron and positron beams but also because it makes it possible to store two electron beams and bring them into collision. Experiments are envisaged with colliding electron-electron beams as well as electron-positron beams. Still another possibility is to store protons and



In the control room on 21 December when the storage rings, DORIS, stored an electron beam with a healthy lifetime for the first time. At the top of the control panels can be seen a television screen recording the synchrotron light emerging from the orbiting electrons.

(Photo Desy)



Recent aerial view of the DESY Laboratory. Top centre is the large experimental hall which spans over both interaction regions in the straight sections of the oval shaped storage rings. The long low building of the injector is to its right and a little below to the right it is possible to distinguish the circular shape of the electron synchrotron.

(Photo DESY)

collide them with an electron beam. It has been shown that very interesting electron-proton scattering and photoproduction experiments can be done even at the comparatively low energies of 3.5 GeV or, later, 5 GeV. A programme to accelerate protons at DESY is under way and is expected to result in a proton beam ready to be injected into DORIS by the end of 1974. In addition to high energy physics experiments, it is intended to do a series of machine physics experiments to understand more about the behaviour of a proton beam colliding with an intense electron beam. Those studies are essential for the design of large electron-proton storage rings which are now being studied on both sides of the Atlantic.

CAMAC Symposium

From 4-6 December 1973, an International Symposium on 'Camac in real-time computer applications' was held at Luxembourg. It was organized by the Commission of the European Communities in collaboration with the ESONE (European Standard for Nuclear Electronics) Committee on which CERN is represented.

CAMAC is the set of rules for the design and use of modular electronic data-handling equipment which was evolved some five years ago by ESONE (see vol. 8, page 314). It has brought standardization into the electronics of data-handling in nuclear and high energy physics Laboratories in a way which has proved very beneficial both to users of electronic equipment and to manufacturers.

The CEC are seriously considering extending use of the system into other fields and a major aim of the Symposium was to spread knowledge of CAMAC to other disciplines. The opening lectures were therefore an introduction to CAMAC followed by papers on its use in a variety of situations.

Applications have already been found in medical and health services and in industry (for measurement and control). There were papers given on these subjects. Many other areas of application can be envisaged — telecommunications, traffic control, environmental monitoring, astronomy, chemical industry, etc. — and it is hoped that, via some of the 500 participants at the Symposium, knowledge of the CAMAC system will reach such fields which have not yet standardised their electronic equipment.

A General Assembly of the ESONE Committee was held following the Symposium and took further decisions on the extension of CAMAC. A description of a serial CAMAC system (resulting from a NIM/ESONE study) was accepted and the detailed specification will now be worked out. A further report on analog signals was also accepted and a related study on signals for industrial and control use will be implemented. The use of CAMAC in industry is a topic of growing importance and raises some practical liaison problems and the question of ESONE's range of activities in the future.

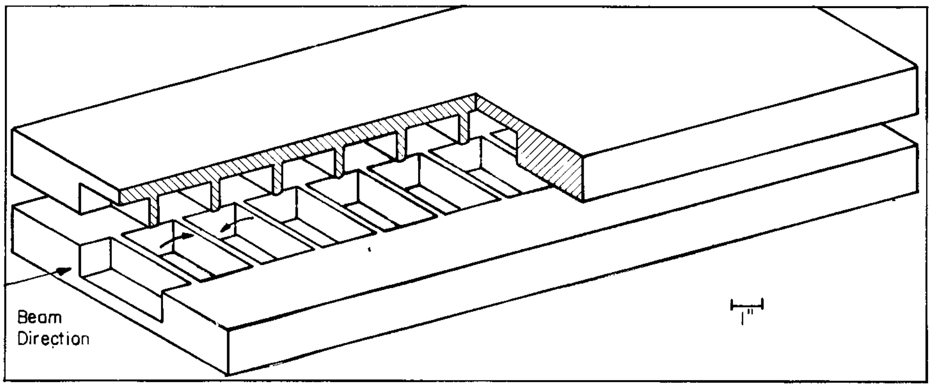
Dr. H. Meyer of Euratom was elected Chairman of the ESONE Committee for 1973-74 and will preside over the next General Assembly in Warsaw in September. Any repeat of the Symposium awaits the results of a survey carried out during the Luxembourg meeting.

CORNELL Superconducting r. f. cavity development

In raising the energy of an electron synchrotron, account has to be taken of the severe radiation loss which increases with the fourth power of the beam energy. Making up this loss by r.f. cavities can be a very expensive business. This is why the staff of the Cornell 12 GeV synchrotron are attempting to develop superconducting accelerating cavities that will be suitable for use in an electron synchrotron environment.

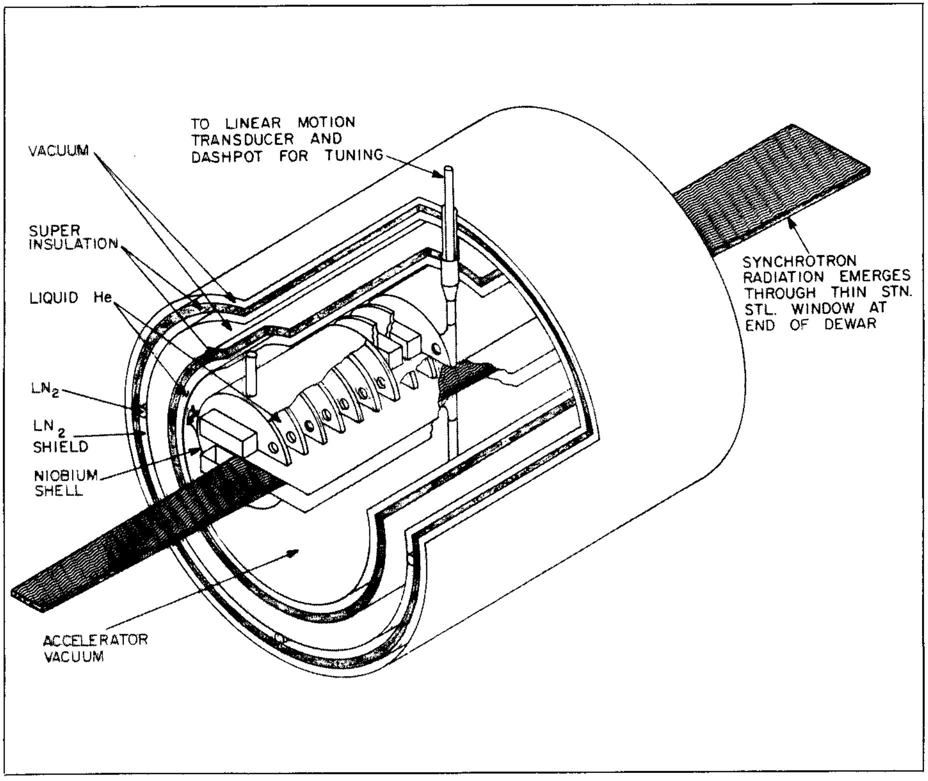
The cavities could make it possible to operate the accelerator at higher energies with the same input power, or to operate at present energies with considerable savings in electric power costs. For example, the r.f. power into a 1 mA electron beam at 12 GeV in the Cornell synchrotron is about 20 kW, while the r.f. power delivered to the present cavities is about 220 kW. With superconducting cavities, 220 kW would permit acceleration of a 1 mA beam to 17 GeV. Alternatively, one could still operate at 12 GeV but with an r.f. power only slightly in excess of 20 kW.

The technical difficulties in using superconducting cavities in a synchrotron are somewhat different from those encountered in a linac application because of the synchrotron radiation which emerges from the electron beam. In order to avoid exposing the superconducting surfaces to the intense sheet of ultraviolet radiation, an open type of accelerating waveguide is being developed. The structure, a short length of which will soon be installed in the synchrotron, operates at about 3 GHz. An artist's conception of the cavity with its cryostat is shown in the Figure. Single cavity tests in the laboratory have already shown Q's over 10^9 and fields greater than 3 MeV/m.



1.

1. Schematic drawing of the 'muffin-tin' design of the superconducting r.f. cavity under development, at Cornell. The open slot between the top and bottom sections acts as a waveguide beyond cut-off and allows the synchrotron radiation to escape without damaging the superconducting surfaces.



2.

2. Sketch of the accelerating cavity and its cryostat. As indicated, the synchrotron radiation can emerge from the dewar through a thin stainless steel window.

DARESBURY
Polarised photons

A polarised photon beam has recently become available to experimentalists at Daresbury. The first experiment (neutral pion photoproduction) has already been completed and the second (eta photoproduction) is nearing completion. Future studies will involve the simultaneous use of a polarised proton target opening up a completely new range of experiments.

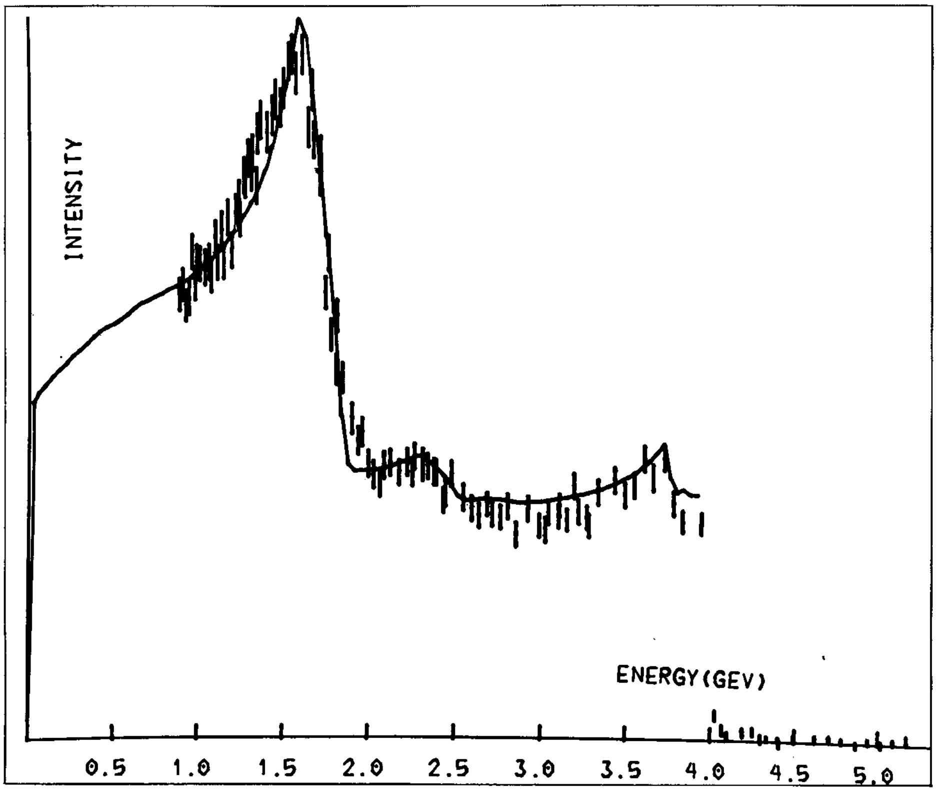
The first polarised photon experiment was performed by a team from the Universities of Liverpool, Glasgow and Sheffield. They measured the asymmetry parameter in the reaction:

$$\gamma + p \rightarrow \pi^0 + p$$

using a liquid hydrogen target. Data was taken in the range from -0.2 to -1.4 (GeV/c^2) for photon energies of 1.5, 2.0 and 2.5 GeV. A proton-gamma coincidence was the trigger, the photons from the neutral pion decay being detected in a lead-glass hodoscope that was sufficiently close to the target to catch both decay photons in a large number of cases. Only these 'two decay photon' events were selected for the data analysis. The direction of a photon was determined by finding the centre of the electron shower it initiated by observing the distribution of pulse heights from the hodoscope. Analysis of the results will be completed soon.

The photon beam is linearly polarised with a typical polarisation of 70 %. It is produced by coherent bremsstrahlung from an oriented diamond target situated within the vacuum vessel of the 5 GeV electron synchrotron. Details of existing beamlines and the lay-out within the experimental hall dictated that the diamond target be positioned within a magnet sector of the synchrotron, which meant that some difficult engineering problems had to be solved. The main problem was orienting the

Intensity of the photon beam emerging from the Daresbury electron synchrotron plotted against the photon energy in GeV. Unpolarised photons give rise to a background upon which can be clearly seen the peak due to the polarised photons. Polarisations of, typically, 70% have been used in experiments with photon fluxes of several 10^9 equivalent quanta per second. The cut off at about 4 GeV is the normal end of the bremsstrahlung spectrum.



diamond with respect to the electron beam. The crystal axes of the diamond can be set to a precision of +0.1 mr and maintained in the correct direction by continuously monitoring the spectrum with a pair spectrometer on-line to a PDP 8 computer.

In setting up the polarised beam, collimators are used to sift out coherent bremsstrahlung in the forward direction from the background of incoherent radiation which has a broader angular distribution. As a typical example, when the synchrotron is operating at 4.5 GeV and the beam is collimated to 10^{-4} radians, a spike is produced in the energy distribution at 1.5 GeV when the (022) diamond lattice plane lies closely along the electron beam direction. The linear polarisation of the beam in the energy peak is then about 70 %. The amount of internal electron beam that can be used is limited by the pair spectrometer to about 0.3 μA and this corresponds to about 4×10^9 equivalent quanta per second.

The pair spectrometer has an energy resolution of 1 %. The electron-positron pairs produced in a thin radiator (about 10^{-4} radiation lengths) are detected in coincidence by an array of scintillation counters. At any energy, a rough figure for the polarisation is given by the ratio of the height of the peak above the background compared to the total height. The system has been successfully used with a polarised beam of up to 3 GeV.

MANCHESTER

Ten years of heavy ions

The University of Manchester heavy ion linear accelerator has reached ten years of operation and its research programme is now more lively than ever due to the new heavy ion interests of the cosmic ray community.

The machine began life very modestly in 1960 accelerating ions to energies of 1 MeV per nucleon. This was using a tank of the Sloan-Lawrence type 9 m long with 40 drift tubes fed with 600 kW of power at 25 MHz. Very soon afterwards, two other tanks of the Alvarez type were added taking the output energy to near 10 MeV per nucleon in 1963. Tank 1 is about 14 m long with 48 drift tubes fed with 1.3 MW of power at 75 MHz; Tank 2 is about 13 m long with 27 drift tubes fed with 1.8 MW of power at 75 MHz. The linac is presently undergoing further improvement to increase its repetition rate from 16.6 to 25 pulses per second and to increase the pulse length to over 3 ms. There are also some ion source modifications being carried out following techniques developed at Orsay.

Collaboration with other European Laboratories has been under way for many years — particularly with nuclear physics research centres in France and the Federal Republic of Germany. The Manchester Laboratory is of a scale which makes such contacts very easy and flexible — the high energy physics community has almost forgotten the days when an experiment could be arranged by the simple exchange of letters.

Four beam-lines are available in an experimental area of about 40 m². They can provide ions from helium 3 to krypton with energies usually set at either 1.04, 4.14 or 9.6 MeV per nucleon. Typical intensities are 4×10^{12} particles per second of oxygen 16, 2×10^{11} of magnesium 24, 3×10^{10} of argon 40, 10^9 of iron 56, 10^8 of krypton 84.

The accelerator has supported a large number of experiments in nuclear physics over the years. During the last two years, the ability to provide beams of elements such as iron, copper and krypton has attracted the cosmic ray physicists particularly because of their interest in studying the behaviour of heavy ions. For example, rocks from the surface of the moon have been compared with samples bombarded with iron ions. This sort of study can convey a lot of information about the composition and energies of cosmic rays.

At present a major search for superheavy elements is being prepared at the accelerator. It will involve bombarding uranium with copper ions followed by observation of emerging heavy ions with mica detectors. The total number of particles to be used (10^{16} to 10^{17} copper ions) will make this one of the most thorough searches yet performed.

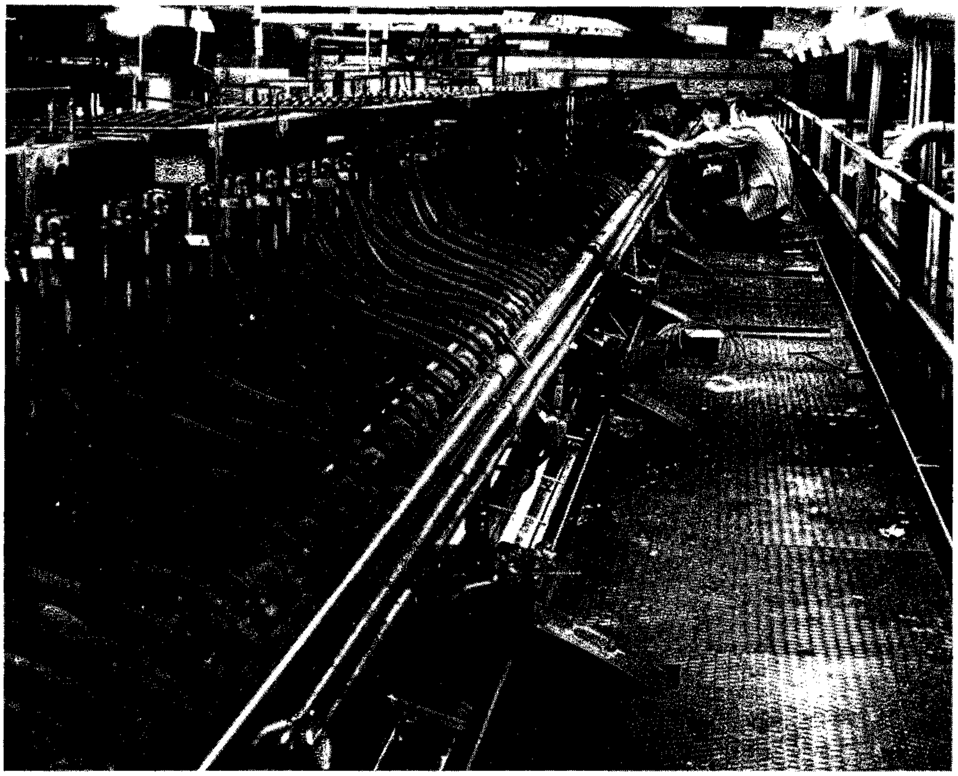
Pavia Conference

The proceedings of the IVth International Symposium of Multiparticle Hadrodynamics are now available. The Symposium was held at Pavia in Italy. It was organized by F. Duimio, S. Ratti and A. Giovannini and held from 31 August to 4 September 1973. It was the fourth in an excellent series of topical conferences on multiparticle production, being preceded by Paris (1970), Helsinki (1971) and Zakopane (1972).

The aim was to discuss the most vital questions on this rapidly growing topic in more detail than was possible at the general elementary particle conference in Aix (6 to 12 September). This aim was well realized to the satisfaction of about a hundred participants. Reviews and invited talks were given by J. Ballam, G. Belletini, A. Bialas, H. Cheng, C. de Tar, J. Gunion, A.D. Krisch, J. Lach, A. Levesque, F. Low, A.D. Martin, P. Schubelin, J.C. Sens, L. Van Hove, G. Veneziano, A. Wroblewski, J. Young, and A. Zichichi.

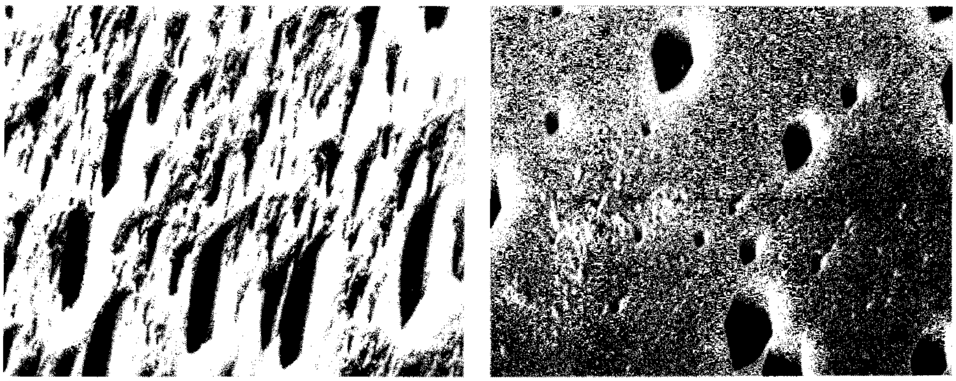
The large number of submitted papers demonstrated the growing interest in this conference series. As far as possible, the papers were presented by their authors in discussion sessions chaired by M. Block, L. Foa', S. Fubini, W. Kittel, I. Pless, G. Ranft, P. Trower and A. Zalewski.

Both scientifically and socially, this meeting proved a great success. The only drawback was that many physicists could not attend due to the limited number of participants for this conference series. Proceedings are now available from La Goliardica Pavese, V. le Taramelli 16, I-27100 PAVIA (Italy).



On top of the Alvarez tanks of the Manchester heavy ion linac looking towards the high energy end. The drift tube stems can be seen emerging from the tanks and the array of pipework is for machine cooling.

(Photo Callaghan-HILAC)



1

2

Scanning electron micrographs of feldspar grains from the surface of the moon which have been irradiated by iron ions at 540 MeV. Micrograph (1) is of an unannealed sample; micrograph (2) is of a sample annealed for three days in vacuum at 150°C. They were produced at the Manchester linac in an experiment by a team from Orsay.

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ANNOUNCES

biomation

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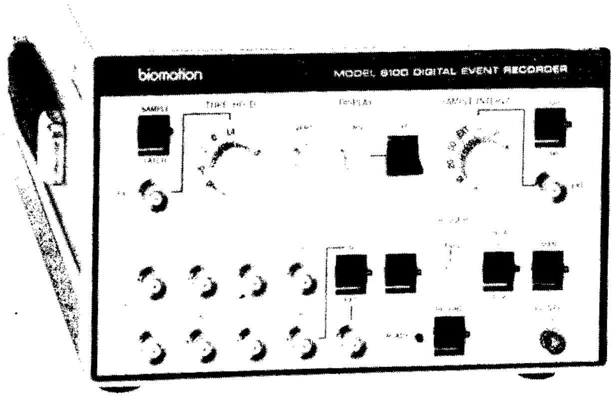

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- OR INTERNAL CLOCK SELECTION–20 Hz TO 10 MHz
- SAVES SELECTABLE AMOUNT OF PRIOR-TRIGGER DATA
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- DIGITAL OUTPUT ALLOWS COMPUTER ANALYSIS OR MASS STORAGE

Waveform recording doesn't have to be all that complicated.

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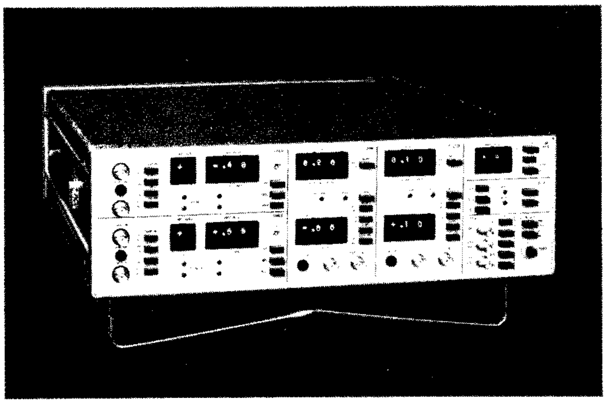
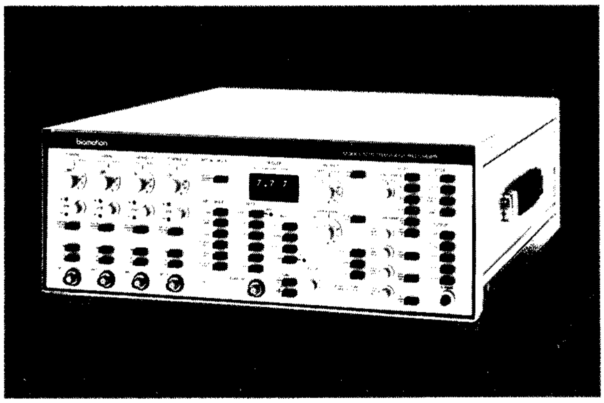
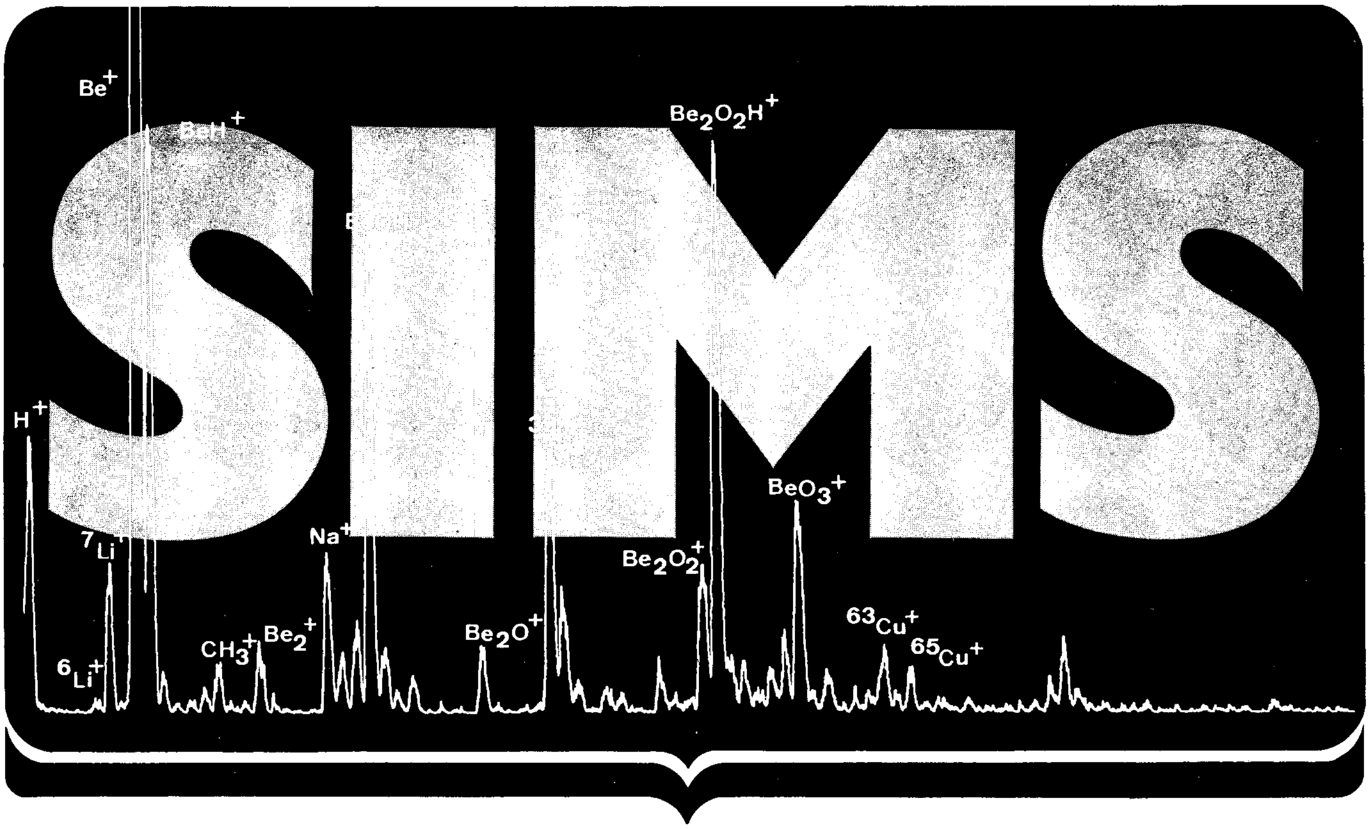
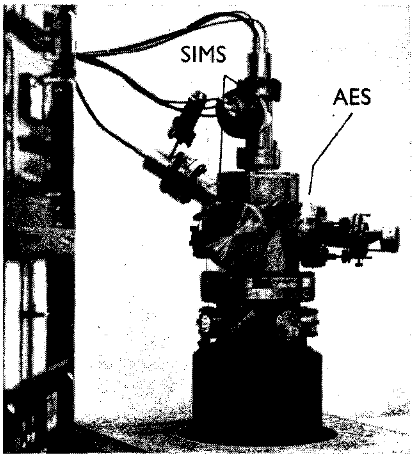
MODEL 8100
8 BIT 100 MHz 2000 WORD





MODEL 1015
10 BIT 100 kHz 4000 WORD
4 CHANNELS !


SIMS
Be^+
BeH^+
$Be_2O_2H^+$
H^+
$^7Li^+$
Na^+
BeO_3^+
$Be_2O_2^+$
$^{63}Cu^+$
$^{65}Cu^+$
$^6Li^+$
CH_3^+
Be_2^+
Be_2O^+


SIMS
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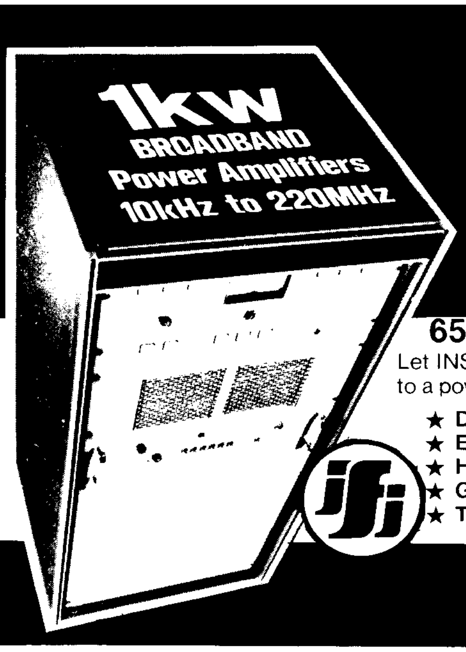
LAP 50



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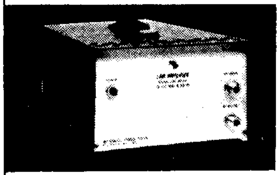

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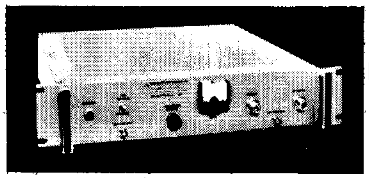

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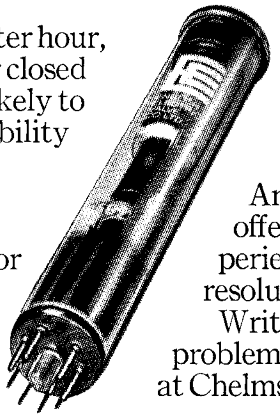

Reliable operation – hour after hour, year after year – is essential for closed circuit cameras. You're more likely to get this kind of consistent reliability with tubes from the vidicon experts: EEV.

EEV vidicons cover all TV pick-up applications, in mono or colour, for most cameras – in electrostatically focused and magnetically focused types (separate or integral mesh) with a range of photo-surfaces. Special rugged types are available to withstand shock or vibration.

The EEV vidicon range is wide. And it grows. And every tube offers you the benefits of EEV experience: good picture geometry and resolution and a long life expectation.

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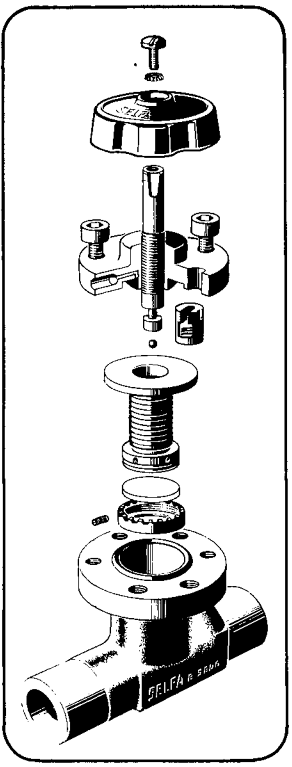
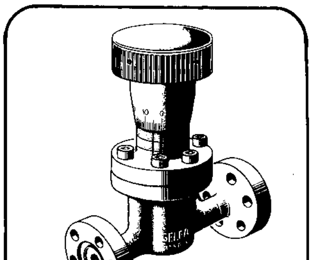
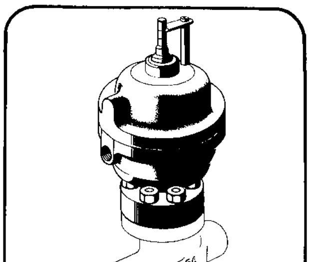
robinets à soufflet métallique







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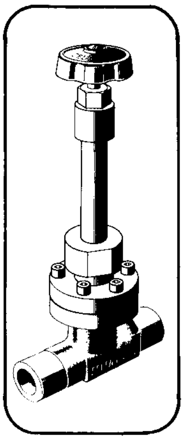

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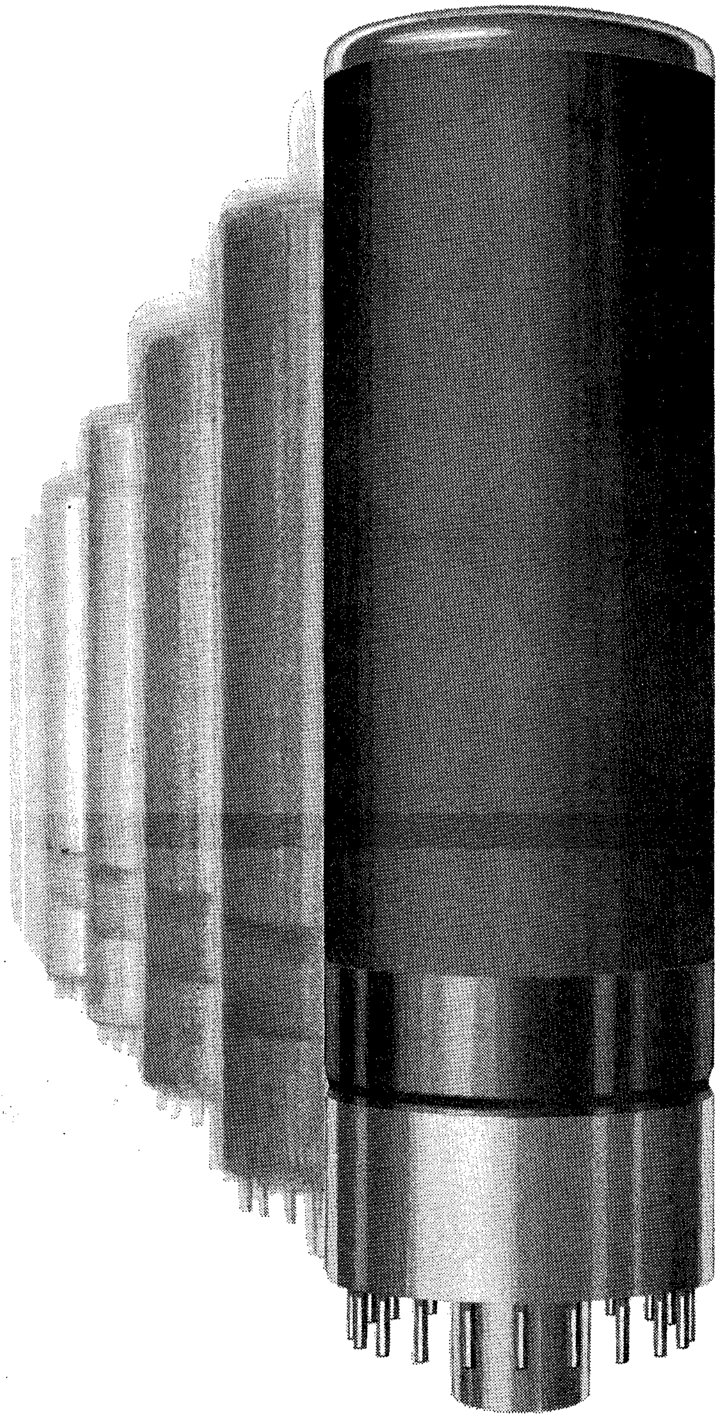

FAST, FASTER, FASTEST

0,3 ns transit time fluctuation is the new standard in photomultipliers.

The new XP 2020 sets the state-of-the-art for high speed photomultipliers. A transit time fluctuation of only 0,3 ns and a 1.5 ns rise time makes it ideal for fast coincidence techniques or Cerenkov detections. Moreover it is competitive on price with slower equivalents.

Almost as fast is the new PM 2203, a 12-stage linear-focused tube with a bi-alkali photocathode. It is ideal for applications having low luminous fluxes, such as single photon counting, as well as for time measurements.

The table below gives the main specs. Data sheets and samples for evaluation are available on request.

	XP 2020	PM 2203
Spectral response	type D	type D
Useful cathode diameter	42 mm	45 mm
Quantum efficiency at 400 µm	25 %	30 %
Cathode sensitivity at 400 µm	85 mA/W	100 mA/W
Rise time	1,5 µs	1,6 ns
Transit time fluctuation	0,3 ns	0,35 ns
Gain at 2,6 KV	10^8	10^8

Type PM 2203 is a direct replacement for type 8575 and a near equal to the 9814B.

For more information on these new tubes plus an updated product survey of the extensive Philips range write to :

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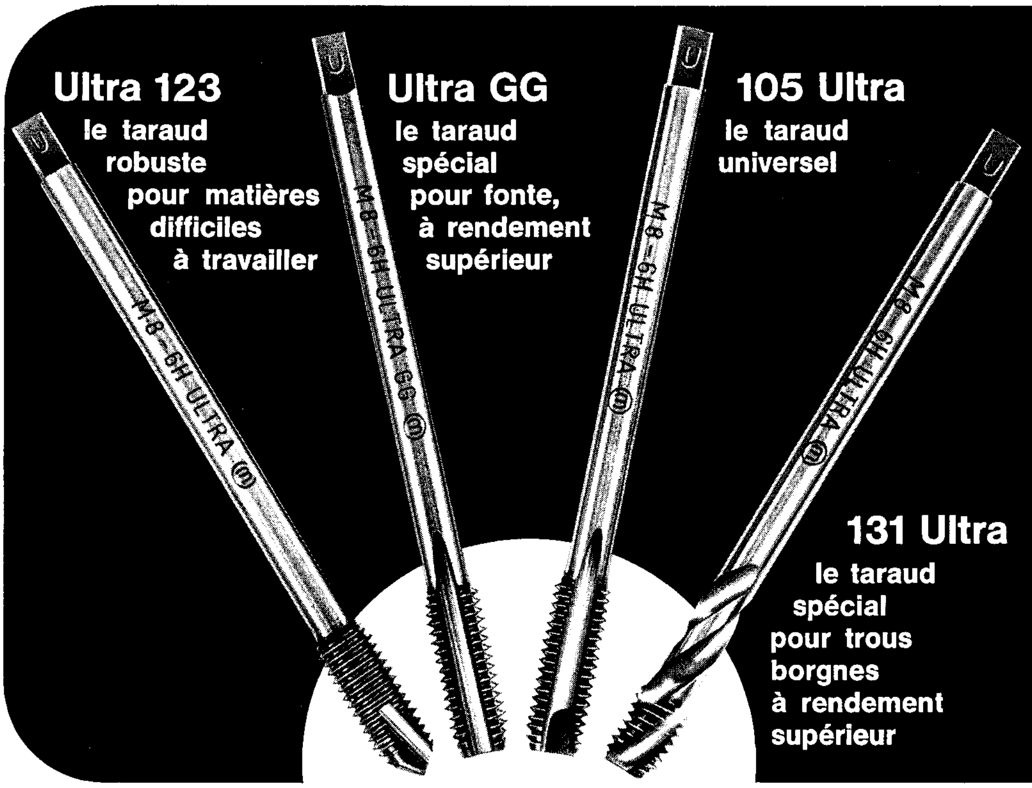
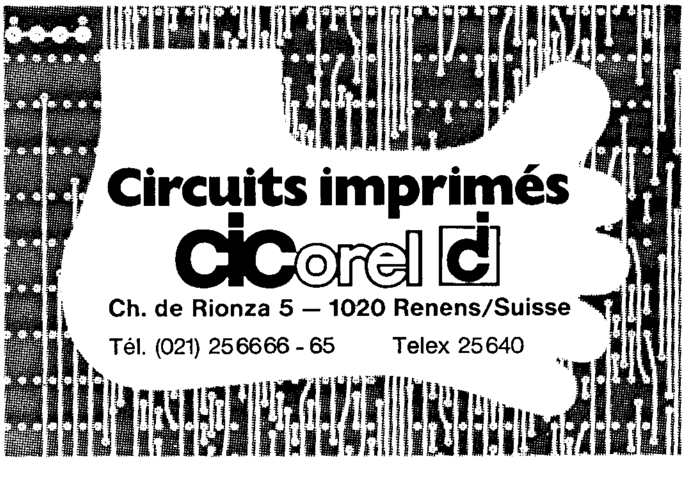
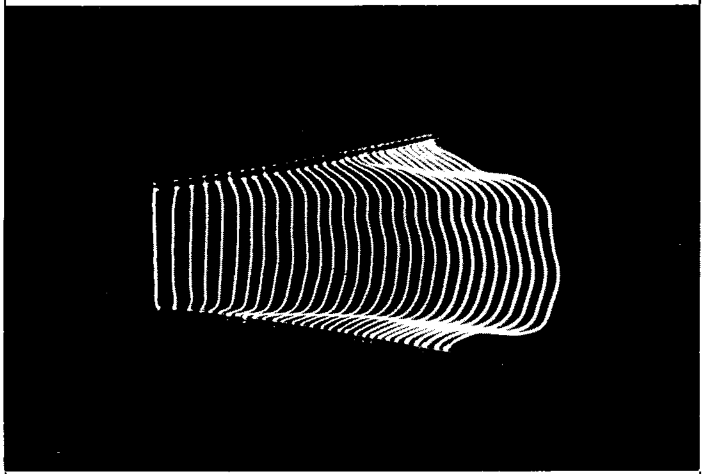
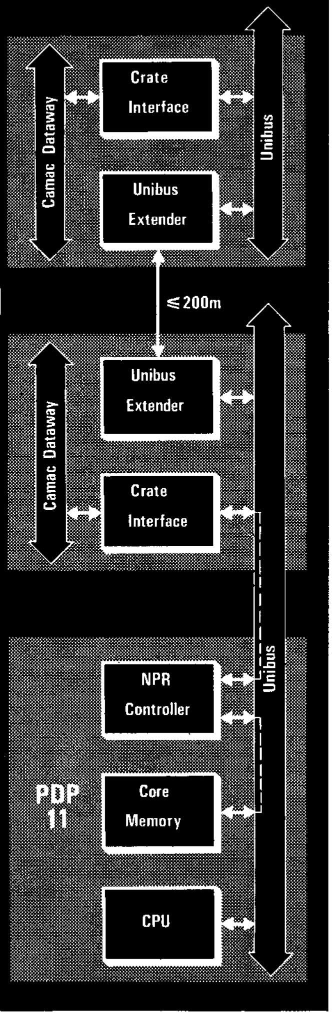

M 8 6H ULTRA
M 8 6H ULTRA GG
M 8 6H ULTRA
M 8 6H ULTRA






Crate Interface
Unibus Extender
Camac Dataway
Unibus
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Unibus Extender
Crate Interface
Camac Dataway
NPR Controller
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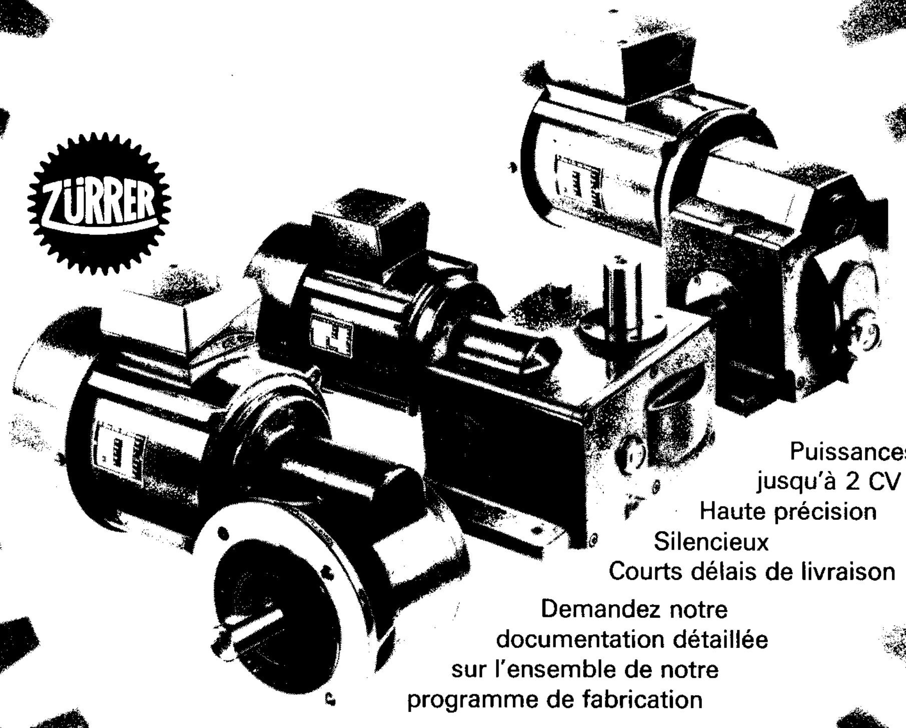

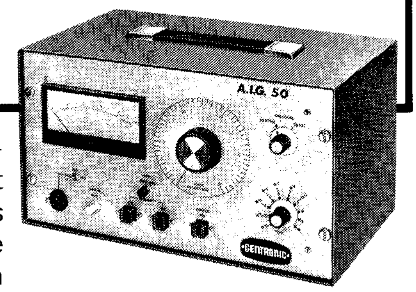
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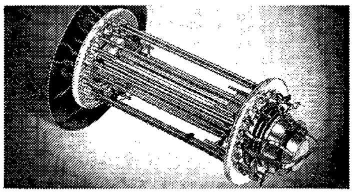
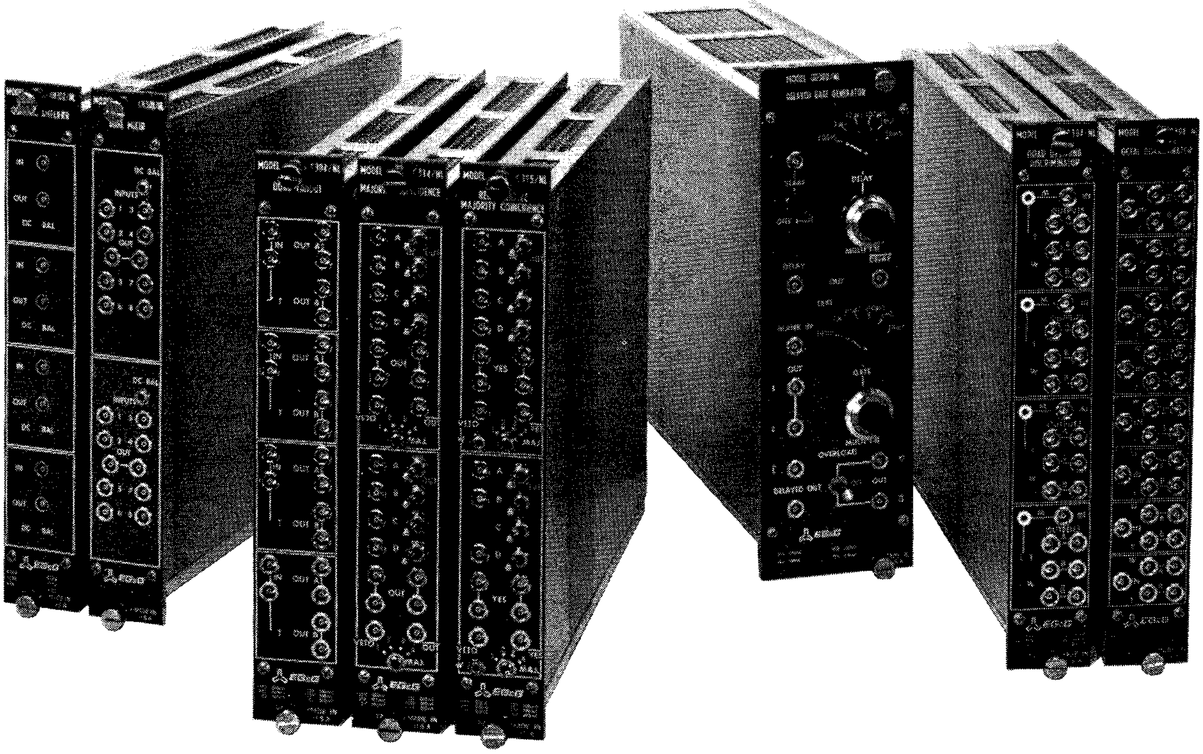
CENTRONIC



See us at the Optics-Physics Show, Washington, D.C., April 22-24.



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For complete technical data, contact your nearby Ortec representative or EG&G/Ortec High Energy Physics Products, 110 Midland Road, Oak Ridge, Tenn. 37830. Phone (615) 482-4411. In Europe: Ortec Ltd., Dallow Road, Luton, Bedfordshire. Phone 0582 27557. Ortec GmbH, 8 München 13, Frankfurter Ring 81, W. Germany. Phone (0811) 359-1001.

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M300 Series modules in photo, left to right:

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AN308/NL DUAL 8-INPUT MIXER. Fast response and bipolar input capabilities for current summing of either anode or dynode signals from fast PMTs. Simple interconnection of dual current outputs permits additional mixers to be used in parallel.

F304/NL QUAD FANOUT. Four independent, direct-coupled sections with total fanout capability of 16 NIM fast signals (4 quad, 8 dual, 16 single). Unique time-over-threshold input discriminator permits reshaping of logic signals attenuated by long cable runs.

C314/NL DUAL MAJORITY COINCIDENCE. Two dual, 4-fold selectable majority logic circuits with direct-coupled veto. Operating speed 200MHz with better than 5nsec pulse pair resolution and 1.5nsec overlap at full NIM output.

C315/NL MAJORITY REGENERATIVE COINCIDENCE. Like C314, but with internal updating discriminator for each of the two coincidence sections. Output width adjustable from approximately 4 to 400nsec.

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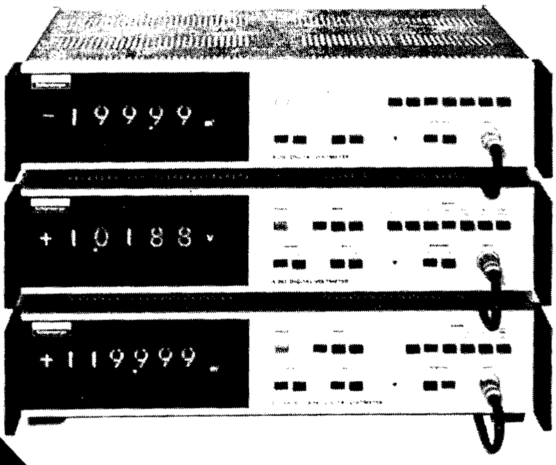
T304/NL QUAD UPDATING DISCRIMINATOR. Two dual normal and one dual complement NIM fast outputs per section. Threshold adjustable from —25 to —500 mV; pulse width from 3 to 400nsec. CW rate 125MHz.

T308/NL OCTAL DISCRIMINATOR. Only one output pulse per threshold crossing (non-multipulsing). Two dual NIM fast outputs from each section. Threshold adjustable from —25 to —500 mV; pulse width from 7 to 500nsec. CW rate 100MHz.

5812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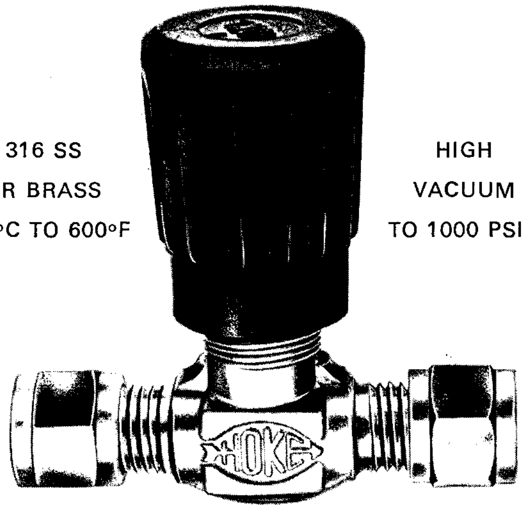
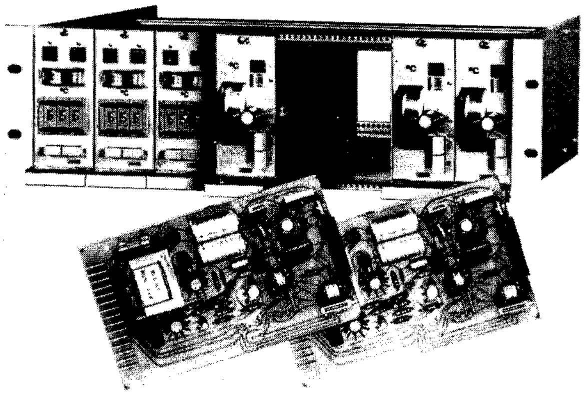
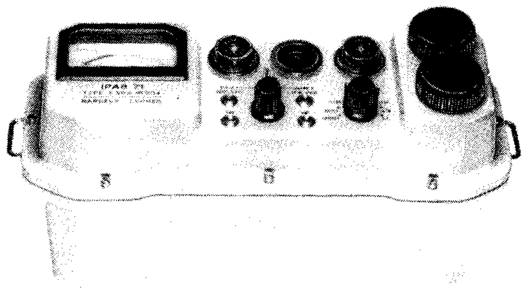

HOKE



RADIO PROTECTION



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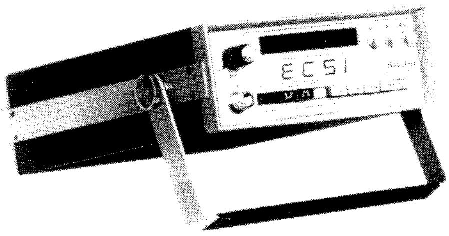

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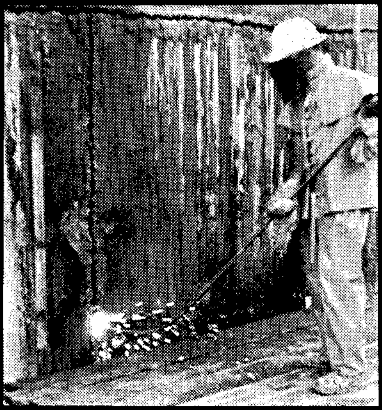

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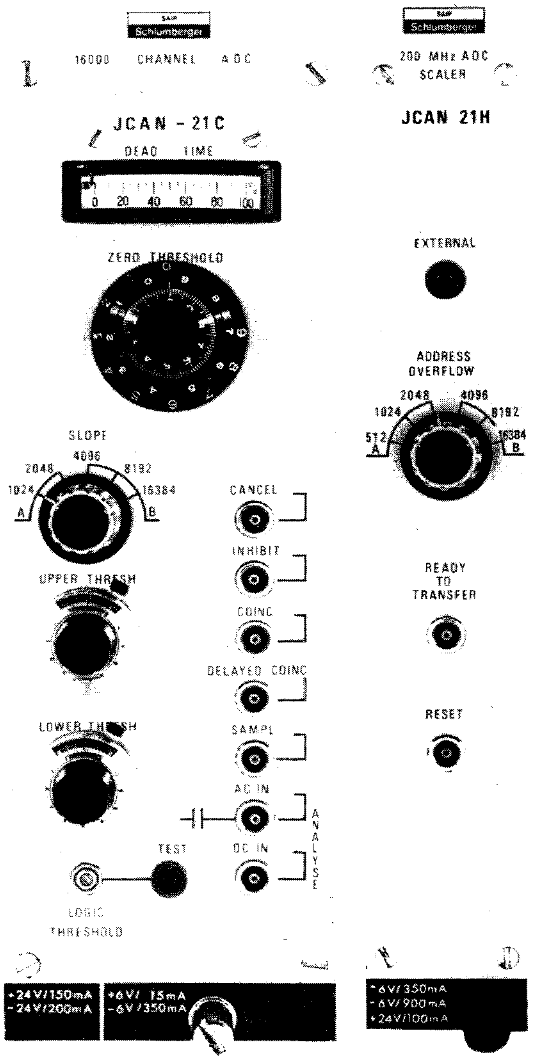

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For 16 384 channels.

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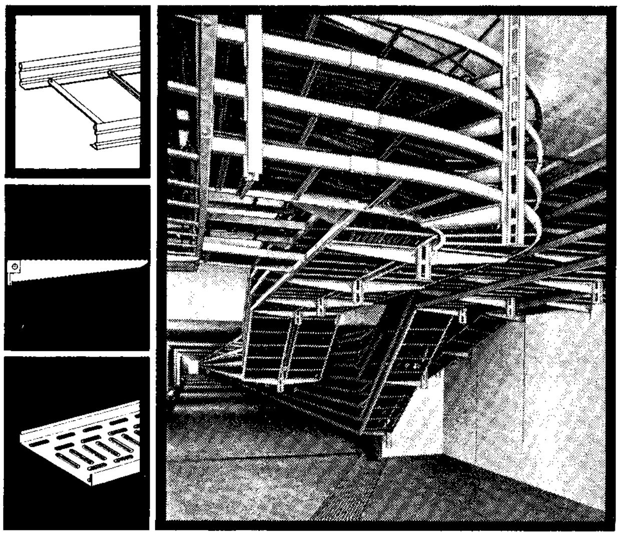

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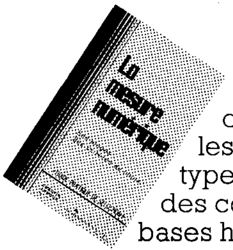
C'est ce que vous propose Chauvin Arnoux avec son Guide pratique de sélection: "La mesure numérique, ses pièges, ses critères de choix".



Cette brochure est destinée à faciliter votre choix car elle traduit en termes clairs les caractéristiques de chaque type d'appareil et vous propose des comparaisons établies sur des bases homogènes.

Elle vous permettra de lire entre les lignes les documentations que vous aurez à consulter.

Enfin, elle vous apportera une assistance non négligeable dans l'établissement des calculs parfois compliqués auxquels vous devrez obligatoirement faire face avant de fixer votre choix.

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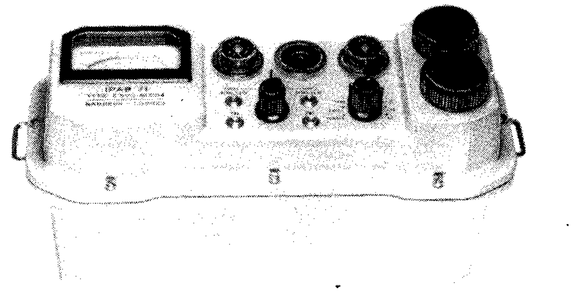
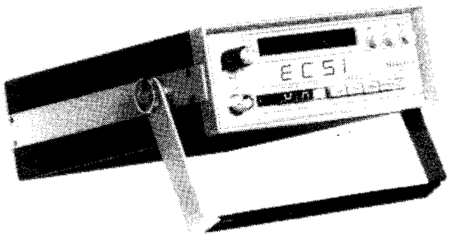
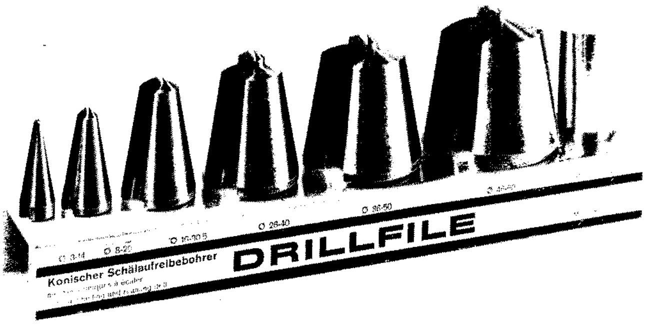
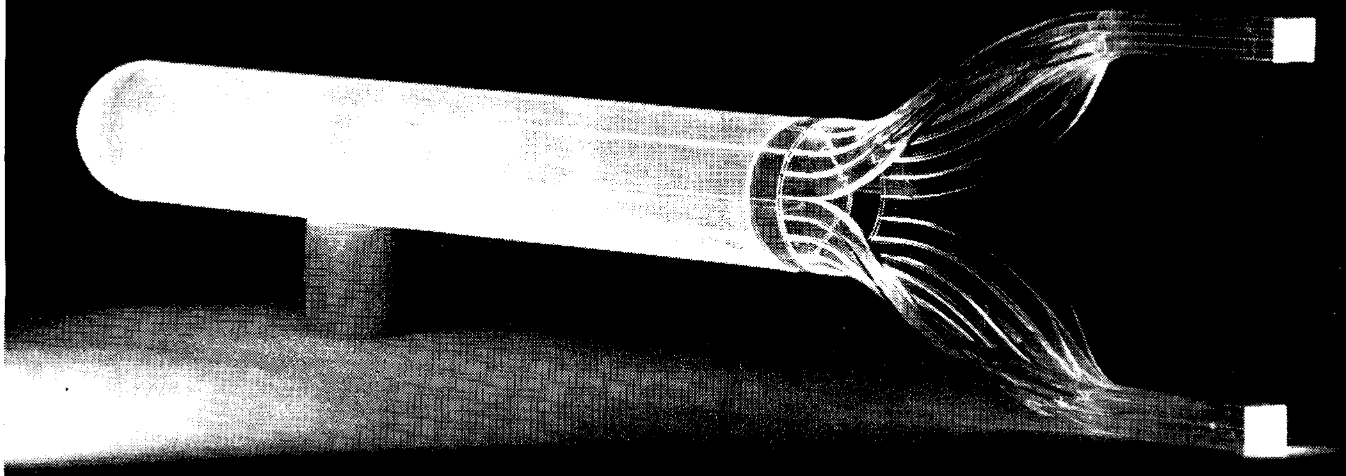
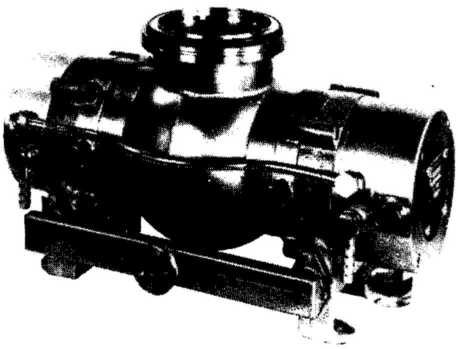


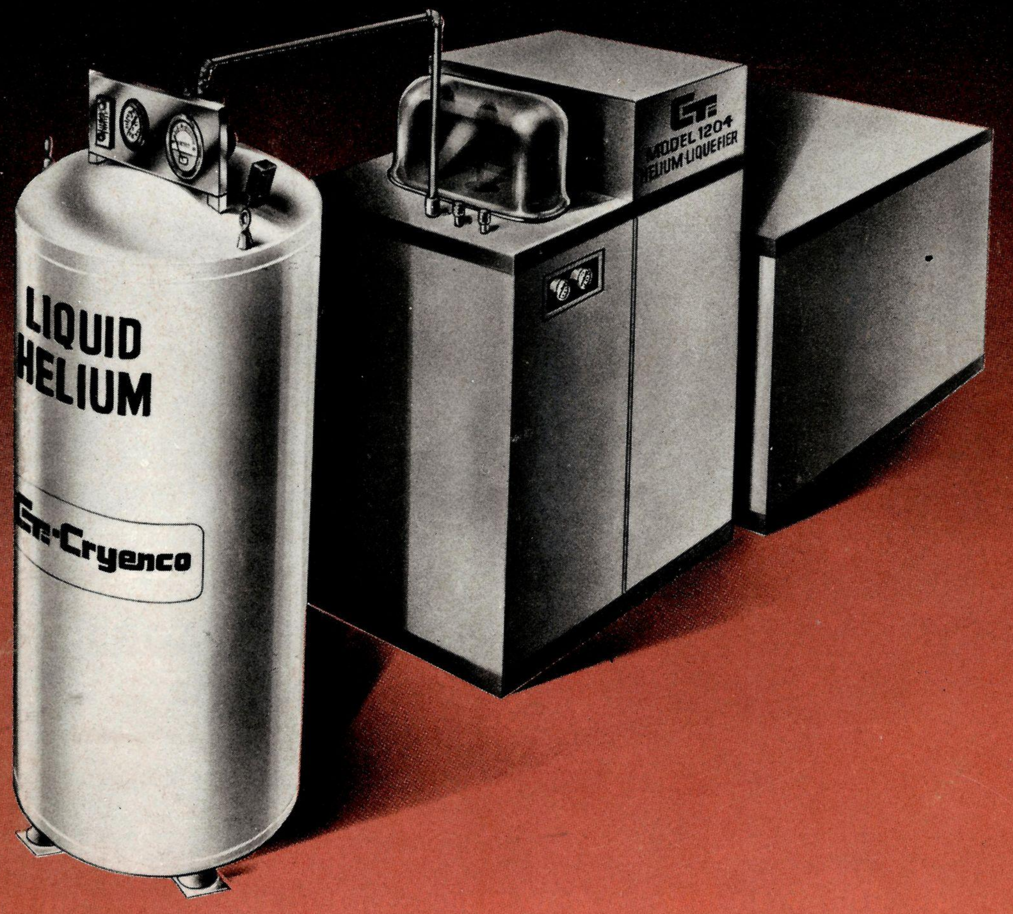



DRILLFILE
Konischer Schälaufreibebohrer





NOW ANY LABORATORY CAN AFFORD TO MAKE ITS OWN LIQUID HELIUM



CTi's new Model 1204 Helium Liquefier/Refrigerator was designed especially for the laboratory with a growing requirement for liquid helium or continuous cooling of superconducting magnets. It answers the need of research centers that have always wanted a reliable in-house supply of liquid helium, but felt that helium liquefiers were too expensive.

The Model 1204 is a "compact" version of the CTi Model 1400 Helium Liquefier/Refrigerator, widely used throughout the world in university, industrial and government laboratories. It is a reliable and inexpensive system that can provide up to 5 liters per hour of liquid helium or 15 watts of refrigeration at 4.5°K *without liquid nitrogen precooling.* Its optional, integral purifier and gas collection system allows reuse of helium gas recovered from experiments. The Model 1204 is capable of both intermittent service and continuous, around-the-clock duty without operator attendance.

And . . . its cost is low (less than many scientific instruments commonly found in the laboratory).

FEATURES

☐ Hands-off, semiautomatic operation ☐ No foundation required (The Model 1204 can be moved easily) ☐ Simple to install and operate ☐ Proven design, standard components ☐ Quiet, vibration-free ☐ Liquefies directly into any storage or experimental dewar ☐ Simple, preventive maintenance twice a year (The user can do it) ☐ Parts and service available worldwide ☐ Built and guaranteed by the world's leading manufacturer of helium liquefiers

A companion system, the new Model 1220 Helium Refrigerator, is available to provide 75 watts of continuous-duty, closed-cycle cooling at 20°K for hydrogen recondensing, target cooling, and cryopumping application.

Write or call CTi today for complete technical and price data on the new economical helium liquefier/refrigerator that *any* laboratory can afford. And ask about CTi's complete line of closed-cycle refrigerators, liquid nitrogen generators, dewars, and other cryogenic accessories.

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