CERN COURIER

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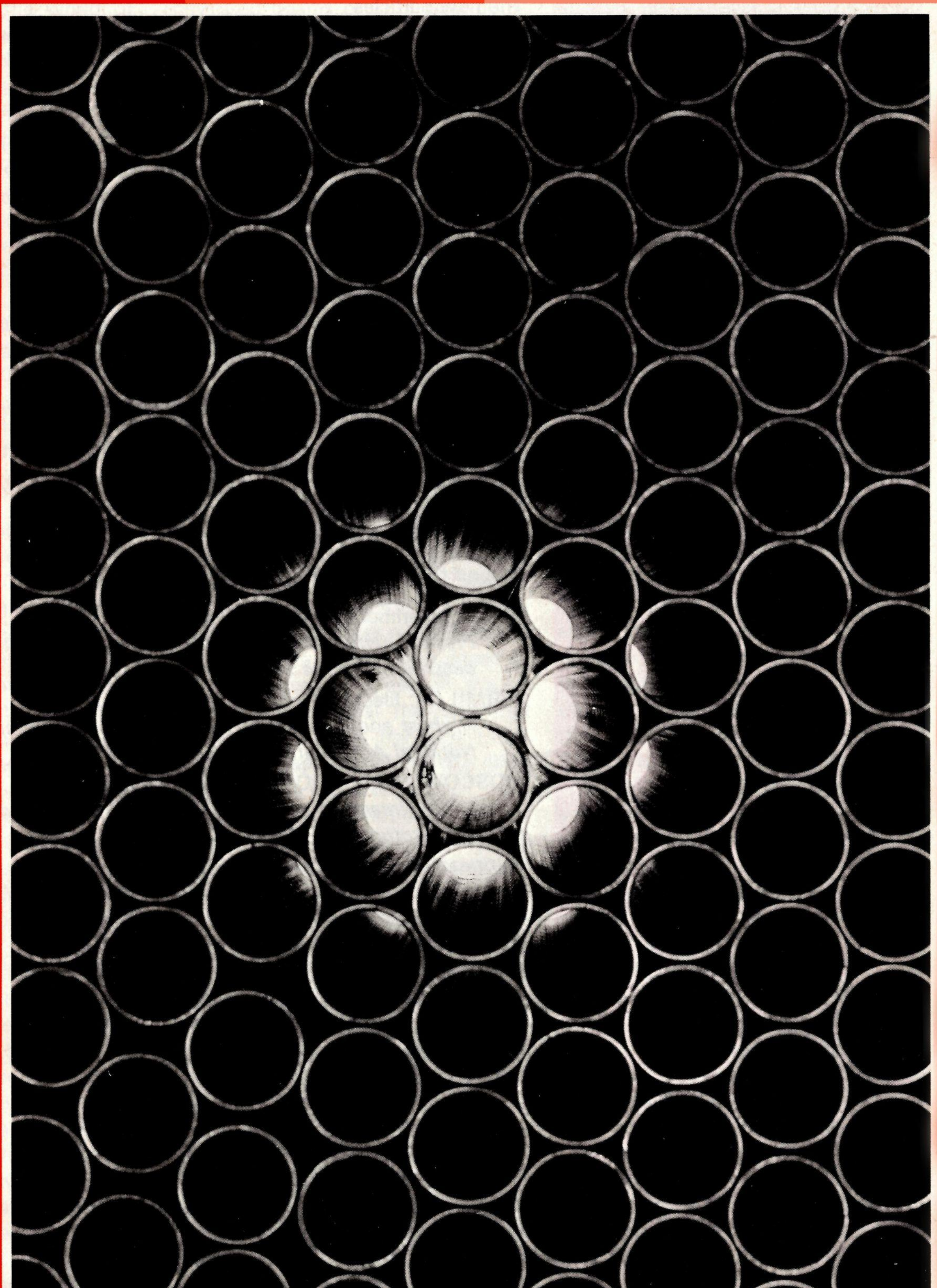

CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, 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: A stack of polyethylene tubes, illuminated from behind, give an usual effect for this month's cover. They are awaiting installation in the tunnel of the 400 GeV proton synchrotron where they slide, as insulation, over the bus-bars which bring power to the magnets. An article on the progress of machine construction appears on page 419. (CERN 99.10.74)

The new particles

Anyone in touch with the world of high energy physics will be well aware of the ferment created by the news from Brookhaven and Stanford, followed by Frascati and DESY, of the existence of new particles. But new particles have been unearthed in profusion by high energy accelerators during the past twenty years. Why the excitement over the new discoveries?

A brief answer is that the particles have been found in a mass region where they were completely unexpected with stability properties which, at this stage of the game, are completely inexplicable. In this article we will first describe the discoveries and then discuss some of the speculations as to what the discoveries might mean.

We begin at the Brookhaven National Laboratory where, since the Spring of this year, a MIT/Brookhaven team have been looking at collisions between two protons which yielded (amongst other things) an electron and a positron. A series of experiments on the production of electron-positron pairs in particle collisions has been going on for about eight years in groups led by Sam Ting, mainly at the DESY synchrotron in Hamburg. The aim is to study some of the electromagnetic features of particles where energy is manifest in the form of a photon which materializes in an electron-positron pair. The experiments are not easy to do because the probability that the collisions will yield such a pair is very low. The detection system has to be capable of picking out an event from a million or more other types of event.

It was with long experience of such problems behind them that the MIT/Brookhaven team led by Ting, J.J. Aubert, U.J. Becker and P.J. Biggs brought into action a detection system with a double arm spectrometer in a slow ejected proton beam at the Brookhaven 33 GeV synchrotron. They used beams of 28.5 GeV bombarding a beryllium target. The two spectrometer arms span out at 15° either side of the incident beam direction and have magnets, Cherenkov counters, multiwire proportional chambers, scintillation counters and lead glass counters. With this array, it is possible to identify electrons and positrons coming from the same source and to measure their energy.

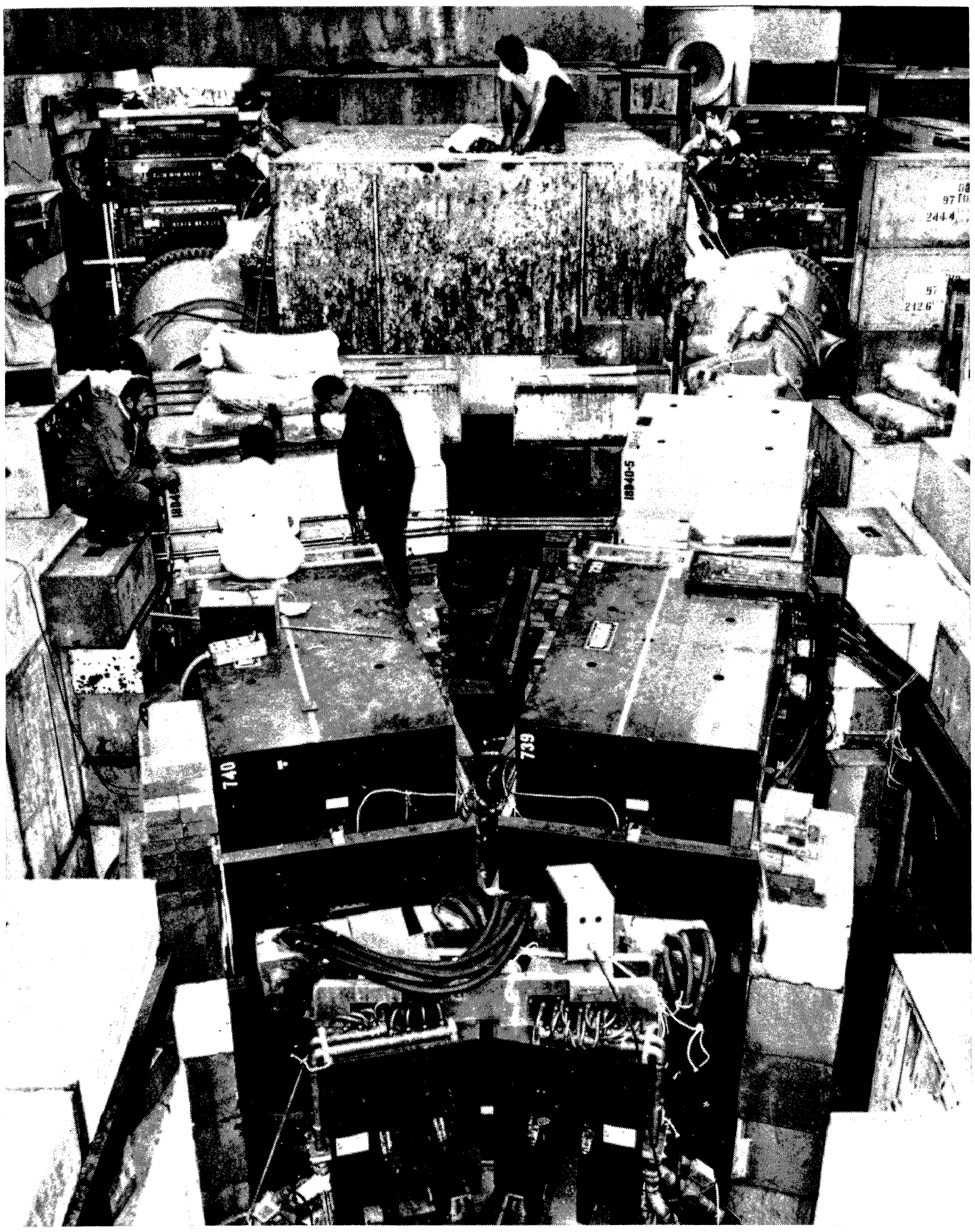
From about August, the realization that they were on to something important began slowly to grow. The spectrometer was totting up an unusually large number of events where the combined energies of the electron and positron were equal to 3.1 GeV. This is the classic way of spotting a resonance. An unstable particle, which breaks up too quickly to be seen itself, is identified by adding up the energies of more stable particles which emerge from its decay. Looking at many interactions, if energies repeatedly add up to the same figure (as opposed to the other possible figures all around it) they indicate that the measured particles are coming from the break up of an unseen particle whose mass is equal to the measured sum.

The team went through extraordinary contortions to check their apparatus to be sure that nothing was biasing their results. The particle decaying into the electron and positron they were measuring was a difficult one to swallow. The energy region had been scoured before, even if not so thoroughly, without anything being seen. Also the resonance was looking 'narrow' — this means that the energy sums were coming out at 3.1 GeV with great precision rather than, for example, spanning from 2.9 to 3.3 GeV. The width is a measure of the stability of the particle (from Heisenberg's Uncertainty Principle which requires only that the product of the average lifetime and the width be a constant). A narrow width means that the particle lives a long time. No other particle of such a heavy mass (over three times the mass of the proton) has anything like that stability.

By the end of October, the team had about 500 events from a 3.1 GeV particle. They were keen to extend their search to the maximum mass their detection system could pin down (about 5.5 GeV) but were prodded into print mid-November by dramatic news from the other coast of America. They baptised the particle J which is a letter close to the Chinese symbol for 'ting'. From then on, the experiment has had top priority. Sam Ting said that the Director of the Laboratory, George Vineyard, asked him how much time on the machine he would need — which is not the way such conversations usually go.

The apparition of the particle at the Stanford Linear Accelerator Center on 10 November was nothing short of shattering. Burt Richter described it as 'the most exciting and frantic week-end in particle physics I have ever been through'. It followed an upgrading of the electron-positron storage ring SPEAR during the late Summer.

Until June, SPEAR was operating with beams of energy up to 2.5 GeV so that the total energy in the collision was up to a peak of 5 GeV. The ring was shut down during the late Summer to install a new r.f. system and new power supplies so as to reach about 4.5 GeV per beam. It was switched on again in September and within two days beams were orbiting the storage ring again. Only three of the four new r.f. cavities were in action so that the beams could only be taken to 3.8 GeV. Within two weeks the luminosity had climbed to 5×10^{30} $cm^{-2}s^{-1}$ (the luminosity dictates the number of interactions the physicists can see) and time began to be allocated to experimental teams to bring their detection systems into trim.



The detection system of the experiment at Brookhaven which spotted the new particle. It consists of two symmetrical spectrometer arms, 20 m long. In the foreground in each arm are three magnets. They are followed by Cherenkov counters (looking like cement mixers) to identify particles (in addition to Cherenkovs in the magnets) and, finally, multiwire proportional chambers which determine precise particle positions. (Photo Brookhaven)

Sam Ting telling the new particle story in an auditorium packed with an enthusiastic audience at CERN on 21 November.

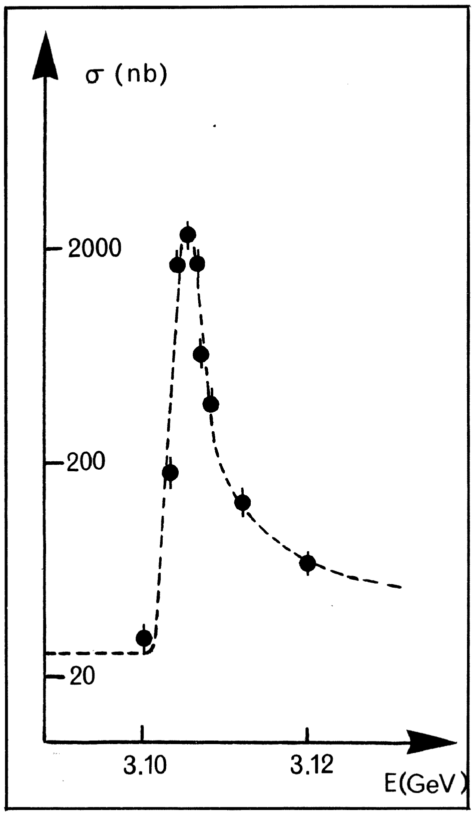
It was the Berkeley/Stanford team led by Richter, M. Perl, W. Chinowsky, G. Goldhaber and G.H. Trilling who went into action during the week-end 9-10 November to check back on some 'funny' readings they had seen in June. They were using a detection system consisting of a large solenoid magnet, wire chambers, scintillation counters and shower counters, almost completely surrounding one of the two intersection regions where the electrons and positrons are brought into head-on collision.

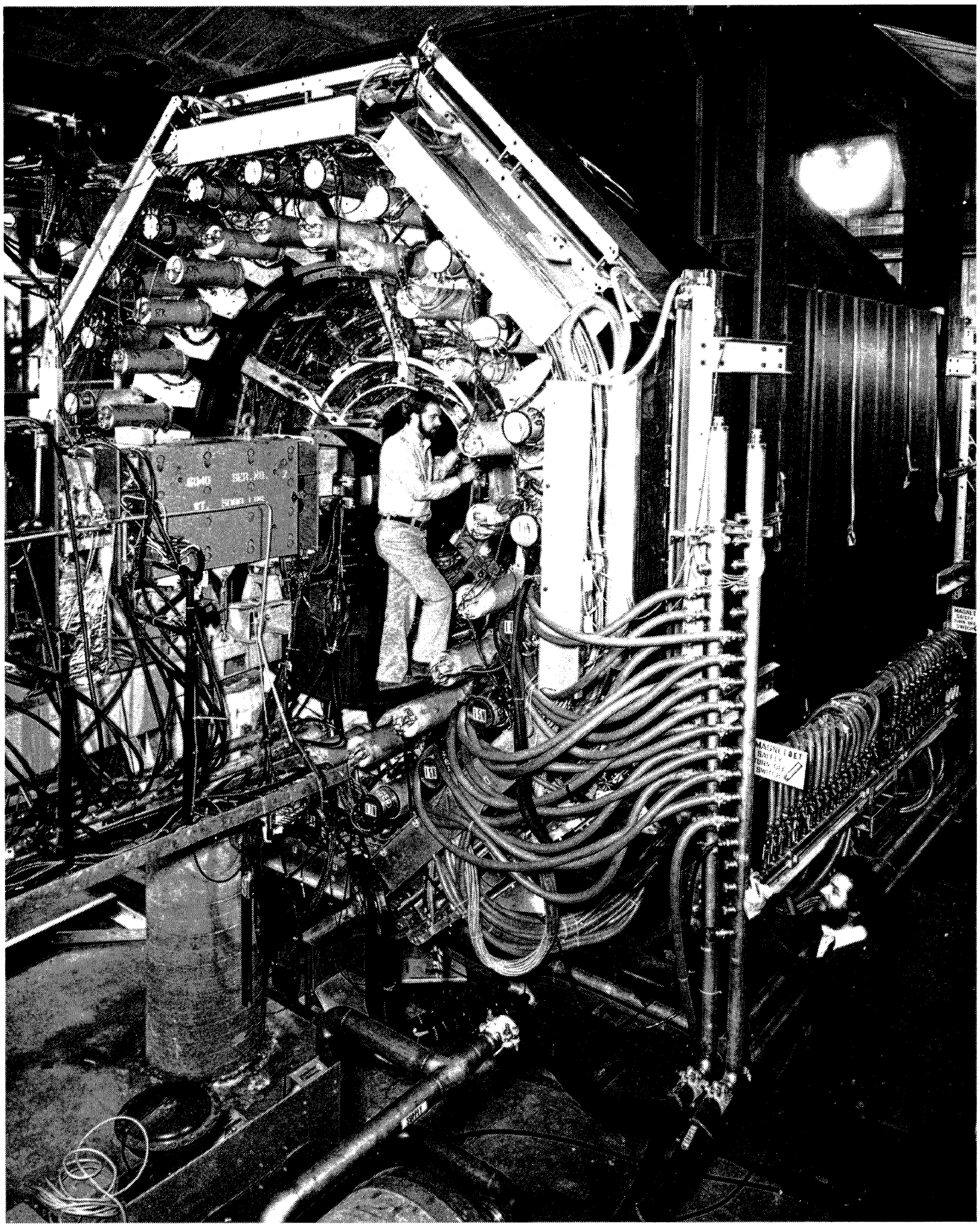
During the first series of measurements with SPEAR, when it went through its energy paces, the cross-section (or probability of an interaction between an electron and positron occurring) was a little high at 1.6 GeV beam energy (3.2 GeV collision energy) compared with at the neighbouring beam energies. The June exercise, which gave the funny readings, was a look over this energy region again. Cross-sections were measured with electrons and positrons at 1.5, 1.55, 1.6 and 1.65 GeV. Again 1.6 GeV was a little high but 1.55 GeV was even more peculiar. In eight runs, six measurements agreed with the 1.5 GeV data while two were higher (one of them five times higher). So, obviously, a gremlin had crept into the apparatus. While meditating during the transformation from SPEAR I to SPEAR II, the gremlin was looked for but not found. It was then that the suspicion grew that between 3.1 and 3.2 GeV collision energies could lie a resonance.

During the night of 9-10 November the hunt began, changing the beam energies in 0.5 MeV steps. By 11.00 a.m. Sunday morning the new particle had been unequivocally found. A set of cross-section measurements around 3.1 GeV showed that the probability of interaction jumped by a factor of ten from 20 to 200 nanobarns. In a state of euphoria, the champagne

The famous detection system at the SPEAR storage ring at Stanford, which already has the high hadron production rate to its credit, now adds the identification of new particles.
(Photo SLAC)

Below is the dramatic signal of the 3.1 GeV particle as seen at SPEAR. The vertical axis measures the cross-section in nanobarns for producing hadrons (in other words the probability that an interaction between an electron and positron will take place producing strongly interacting particles). Along the horizontal axis is the energy showing that the probability jumps a hundred times at 3.1 GeV.





was cracked open and the team began celebrating an important discovery. Gerson Goldhaber retired in search of peace and quiet to write the findings for immediate publication.

While he was away, it was decided to polish up the data by going slowly over the resonance again. The beams were nudged from 1.55 to 1.57 and everything went crazy. The interaction probability soared higher; from around 20 nanobarns the cross-section jumped to 2000 nanobarns and the detector was flooded with events producing hadrons. Pief Panofsky, the Director of SLAC, arrived and paced around invoking the Deity in utter amazement at what was being seen. Gerson Goldhaber then emerged with his paper proudly announcing the 200 nanobarn resonance and had to start again, writing ten times more proudly.

Within hours of the SPEAR measurements, the telephone wires across the Atlantic were humming as information enquiries and rumours were exchanged. As soon as it became clear what had happened, the European Laboratories looked to see how they could contribute to the excitement. The obvious candidates, to be in on the act quickly, were the electron-positron storage rings at Frascati and DESY.

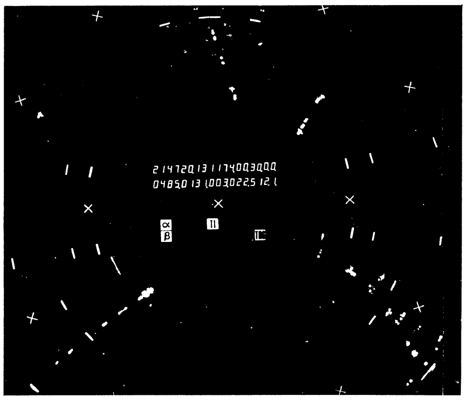
From 13 November, the experimental teams on the ADONE storage ring (from Frascati and the INFN sections of the Universities of Naples, Padua, Pisa and Rome) began to search in the same energy region. They have detection systems for three experiments known as gamma-gamma (wide solid angle detector with high efficiency for detecting neutral particles), MEA (solenoidal magnetic spectrometer with wide gap spark chambers and shower detectors) and baryon-antibaryon (coaxial hodoscopes of scintillators covering a wide solid angle). The ADONE operators were able to jack the beam energy up a little above its normal peak of 1.5 GeV and on 15 November the new particle was seen in all three detection systems. The data confirmed the mass and the high stability. The experiments are continuing using the complementary abilities of the detectors to gather as much information as possible on the nature of the particle.

At DESY, the DORIS storage ring was brought into action with the PLUTO and DASP detection systems described later in this issue on page 427. During the week-end of 23-24 November, a clear signal at about 3.1 GeV total energy was seen in both detectors with PLUTO measuring events with many emerging hadrons and DASP measuring two emerging particles. The angular distribution of elastic electron-positron scattering was measured at 3.1 GeV, and around it, and a distinct change was

Hadron production events at 3.1 GeV from:

1. The gamma-gamma group on the ADONE storage ring at Frascati where a large spark chamber array spots an event giving at least three charged particles plus an electromagnetic shower (bottom right)

2. The PLUTO detector on the DORIS storage ring at DESY where three projections of an event with five charged particles are displayed together via the computer.



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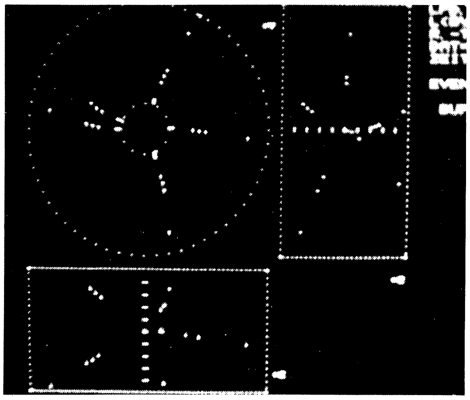


2.

seen. The detectors are now concentrating on measuring branching ratios — the relative rate at which the particle decays in different ways.

In the meantime, SPEAR II had struck again. On 21 November, another particle was seen at 3.7 GeV. Like the first it is a very narrow resonance indicating the same high stability. The Berkeley/Stanford team have called the particles psi (3105) and psi (3695).

No-one had written the recipe for these particles and that is part of what all the excitement is about. At this stage, we can only speculate about what they might mean.

First of all, for the past year, something has been expected in the hadron-lepton relationship. The leptons are particles, like the electron, which we believe do not feel the strong force. Their interactions, such as are initiated in an electron-positron storage ring, can produce hadrons (or strong force particles) via their common electromagnetic features. On the basis of the theory that hadrons are built up of quarks (a theory which has a growing weight of experimental support — see October issue, page 332) it is possible to calculate relative rates at which the electron-positron interaction will yield hadrons and the rate should decrease as the energy goes higher. The results from the Cambridge bypass and SPEAR about a year ago showed hadrons being produced much more profusely than these predictions.

What seems to be the inverse of this observation is seen at the CERN Intersecting Storage Rings and the 400 GeV synchrotron at the FermiLab. In interactions between hadrons, such as proton-proton collisions, leptons are seen coming off at much higher relative rates than could be predicted. Are the new particles behind this hadron-lepton mystery? And if so, how?

Other speculations are that the particles have new properties to add to the familiar ones like charge spin, parity... As the complexity of particle behaviour has been uncovered, names have had to be selected to describe different aspects. These names are linked, in the mathematical description of what is going on, to quantum numbers. When particles interact, the quantum numbers are generally conserved — the properties of the particles going into the interaction are carried away, in some perhaps very different combination, by the particles which emerge. If there are new properties, they also will influence what interactions can take place.

To explain what might be happening, we can consider the property called 'strangeness'. This was assigned to particles like the neutral kaon and lambda to explain why they were always produced in pairs — the strangeness quantum number is then conserved, the kaon carrying +1, the lambda carrying —1. It is because the kaon has strangeness that it is a very stable particle. It will not readily break up into other particles which do not have this property.

Two new properties have recently been invoked by the theorists — colour and charm. Colour is a suggested property of quarks which makes sense of the statistics used to calculate the consequences of their existence. This gives us nine basic quarks — three coloured varieties of each of the three familiar ones. Charm is a suggested property which makes sense of some observations concerning neutral current interactions (discussed below).

It is the remarkable stability of the new particles which makes it so attractive to invoke colour or charm. From the measured width of the resonances they seem to live for about 10^{-20} seconds and do not decay rapidly like all the other resonances in their mass range. Perhaps they carry a new quantum number?

Unfortunately, even if the new particles are coloured, since they are formed electromagnetically they should be able to decay the same way and the sums do not give their high stability. In addition, the sums say that there is not enough energy around for them to be built up of charmed constituents. The answer may lie in new properties but not in a way that we can easily calculate.

Yet another possibility is that we are, at last, seeing the intermediate boson. This particle was proposed many years ago as an intermediary of the weak force. Just as the strong force is communicated between hadrons by passing mesons around and the electromagnetic force is communicated between charged particles by passing photons around, it is thought that the weak force could also act via the exchange of a particle rather than 'at a point'.

When it was believed that the weak interactions always involved a change of electric charge between the lepton going into the interaction and the lepton going out, the intermediate boson (often referred to as the W particle) was always envisaged as a charged particle. The CERN discovery of neutral currents in 1973 revealed that a charge change between the leptons need not take place; there could also be a neutral version of the intermediate boson (often referred to as the Z particle). The Z particle can also be treated in the theory which has had encouraging success in uniting the interpretations of the weak and electromagnetic forces.

This work has taken the Z mass into the 70 GeV region and its appearance around 3 GeV would damage some of the beautiful features of the reunification theories. A strong clue could come from looking for asymmetries in the decays of the new particles because, if they are of the Z variety, parity violation should occur.

1974 has been one of the most fascinating years ever experienced in high energy physics. Still reeling from the neutral current discovery, the year began with the SPEAR hadron production mystery, continued with new high energy information from the FermiLab and the CERN ISR, including the high lepton production rate, and finished with the discovery of the new particles. And all this against a background of feverish theoretical activity trying to keep pace with what the new accelerators and storage rings have been uncovering.

The 400 GeV synchrotron taking shape

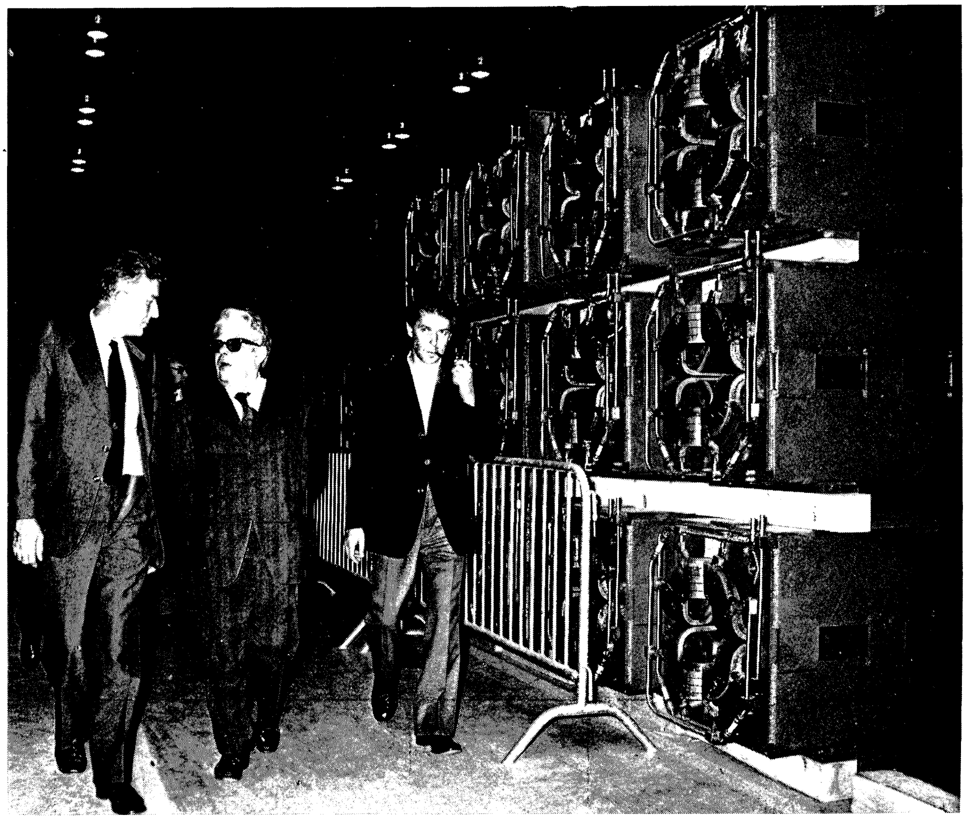
Construction of the 400 GeV proton synchrotron, the SPS, has reached the satisfying stage where parts of the machine are coming together. After the years of design, of placing contracts and of manufacturing and testing separate components, we are now seeing these components being assembled to look like an accelerator.

When all is complete in 1976, we will have a synchrotron 2.2 km in diameter installed in a tunnel averaging some 50 m below ground. It will consist of more than 1000 magnets (bending magnets, quadrupole focusing magnets and correction elements). A peak field of 1.8 T in the bending magnets will hold protons accelerated to an energy of 400 GeV. Beam will be taken from the existing CERN proton synchrotron at an energy around 10 GeV and accelerated in the SPS by two travelling wave cavities operating at 200 MHz. The accelerated protons can then be ejected for experiments to the West (in 1976) and North (in 1978) Experimental Areas.

We have followed the progress of the major events in the civil engineering programme as they have occurred and preparations for experiments were described in the November issue. Here we describe progress on the construction of some of the machine components:

Magnets galore

During 1974 impressive stacks of bending magnets and quadrupoles grew in the large assembly hall. Over 300 dipoles (225 of type A, 75 of type B), 100 quadrupoles and many smaller correction magnets were at one time heaped up after assembly and testing awaiting their turn to be wheeled into the tunnel. Installation in the tunnel began in November and is proceeding at an average rate of five magnets per day. By the end of the



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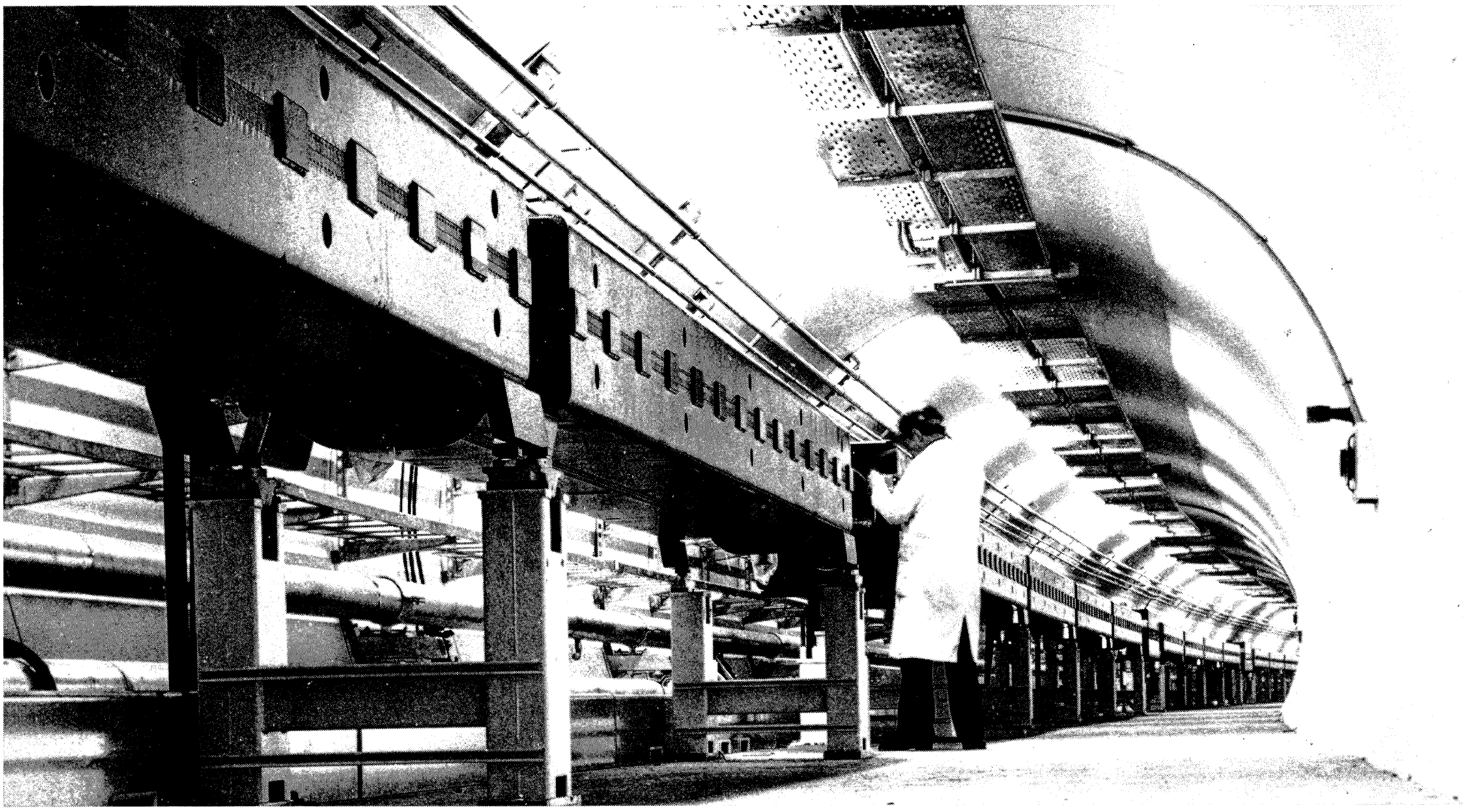
Dr. J.B. Adams, Director General of CERN Laboratory II, escorting distinguished visitors from the Soviet Union through the large assembly hall. He is in conversation with Prof. N.N. Bogolubov, Director of Dubna. On the right is one of the stacks of SPS quadrupole focusing magnets awaiting installation in the machine tunnel.



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year a full sextant's worth of magnets (140 of them) will be installed around 1 km of the circumference. Since this is faster than the production rate, the installation is now nibbling at the magnet stacks and gradually liberating space in the assembly hall again.

Magnet production continues reasonably satisfactorily. Almost all the steel sheet for the magnet yokes has been passed to the manufacturers and is of excellent quality. With over 12 000 tons delivered, the average coercivity has been maintained within 0.002 oersted of the nominal value. Well over half the yokes have been produced, comfortably meeting delivery schedules and design specifications.

The scene is a little less comfortable on bending magnet coils and quadrupoles. The coils are of two types and up to now they have been produced by two different manufacturers. Type A have come through in quantity for assembly at CERN. Type B are further behind and both manufacturers will attack this type as from early next year. About half the quadrupoles have arrived and it is important that the production rate is maintained so as to retain a reasonable stack from which to draw as installation proceeds.

Magnets are going down the tunnel at the rate of five per day. (A spasm of feverish activity to catch up on some lost time actually once pushed this as high as sixteen in a day). They were stacked in groups of 25 according to their magnetic properties and the aim is to even out these properties around the ring. This is done by always trying to have the overall properties of each day's-worth of magnets the same by selecting from among the groups. It is important, therefore, not to run the stack too low so as to avoid nearing the end of installation with a clutch of incompatible magnets in reserve.

Many of the special magnets — enlarged quadrupoles for the ejection regions, correction dipoles to help establish the beam orbit at injection, sextupoles for control of chromaticity etc... are coming through well and are proving to be of good quality.

Ins and outs

Yet more magnets are involved in bringing beam to the SPS, in injection and ejection systems and in taking accelerated beam to the experiments.

The input end is going smoothly. Almost all the bending magnets and focusing quadrupoles, which will sit in the tunnel TT10 which dips down from the PS-ISR beam-line to the level of the underground synchrotron, are on site and satisfactorily tested.

Within the ring itself kicker magnets and septum magnets for injection and ejection systems are amongst the technologically most difficult components of the machine. Assembly of the kickers started in November and will continue, under pressure, throughout the next year. Their power supplies which, as the name kicker suggests, provide a sharp current pulse to the magnets so as to kick protons off on some different trajectory, have been designed and the first models tested. They involve a pulse forming network and switches with a ceramic deuterium-filled thyratron in parallel with a line of three ignitrons. The thyratron ensures the rapid current rise while the ignitrons take the bulk of the current after a few microseconds.

The power supplies will provide pulses of many thousands of amps for up to 24 μs and such long pulses have not been easy to achieve. Further tricks have been played with the power supply for the kicker to send protons into a beam dump during tests of the accelerator or when problems occur. A beam of 10^{13} particles at 400 GeV is equivalent to over half a megajoule of energy and the dump has to take this without too great local heating. The dumps will consist of a cast iron cylindrical shell filled with a copper and aluminium core and the dumped beam will be spread over the core as much as possible by passing it through a rising magnet field. The dump kicker supply will also try to help spread the beam by adding a 20 % oscillation on top of its 10 kA, 25 μs pulse. Such pulses have been achieved but they are hard on the power supply com-

The SPS goes round the bend. Installation in the machine tunnel has progressed to the stage where a full arc of magnets can be seen disappearing around the curve of the ring tunnel. Only six more kilometers to go.

This array of bed-springs sits on top of condensers in the pulse forming network which will power the fast kicker magnets used in getting protons in or out of the SPS. The network is charged to 60 kV and sends out pulses of 4 kA for 25 μs with a rise-time of 100 ns. In operation, the condensers and their bed-spring inductances are in a bath of oil. Fourteen of them will be located in service buildings around the SPS ring and will send their pulses to magnets as far as 250 m away.

ponents and lifetime tests are now being carried out.

The electrostatic septa, which will use a thin curtain of tungsten wires (0.15 mm in diameter with a 1.5 mm spacing) to shield protons still orbiting the ring from protons being ejected towards the experiments, have been further developed during the year. An aluminium oxide (peraluman) cathode has given better voltage holding characteristics than the titanium type (130 kV per cm compared with 100 kV per cm or less depending on the pressure). The oxide layer is, however, more easily damaged by electrical breakdown and it has become important to stop ions produced in the region of the orbiting beam from entering the gap between the wires and the cathode where they can initiate breakdown. Clearing electrodes to collect these ions will therefore be installed above and below the orbiting beam.

Most of the related components — the septum magnets, beam monitors, splitter magnets, targets . . . are on schedule. An intense year's work is ahead to have them ready in line with the general installation programme.

The r.f. system

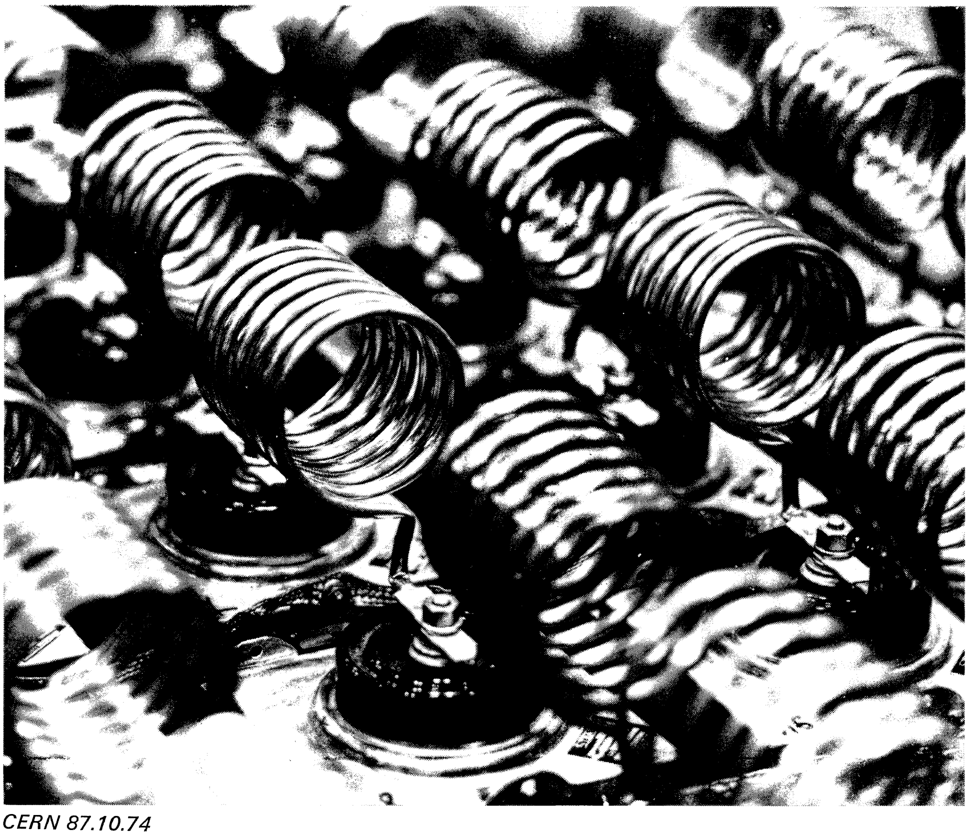
The radiofrequency accelerating system had its fair share of difficulties in the first half of 1974 — not in the esoteric world of the r.f. power amplifiers, etc. but in the seemingly more mundane world of welding and brazing of the cavities. Two cavities will be installed in the accelerator ring, each consisting of five tank sections with each section housing eleven drift tubes. Welding around the positions where the drift tube stems are attached to the tank and brazing of the copper drift tube assemblies to the required accuracies and qualities proved very difficult.

By now we seem to be on top of these problems. A complete tank section has been delivered and the drift tubes installed. Four more sections, to complete the first cavity, are expected soon and all is ready to test them under r.f. power early in 1975. If this goes well, the cavity will be lowered to the tunnel in April and be followed by its twin late summer.

Many associated components — vacuum windows, couplers to link the cavities to the r.f. power transmission lines, the lines themselves (together with their ceramic discs) and terminating loads have been delivered.

Each cavity will be fed with 500 kW of r.f. power at 200 MHz from an amplifier using five 125 kW power tubes. All the componnents for powering the first cavity are now being assembled. Two further power amplifiers will be built leaving one spare which could eventually be used to power a third cavity if this is required in a future development of the accelerator.

The enthusiasm for r.f. systems operating at 200 MHz is extending also to the PS in its role as injector for the SPS. Laboratory II is constructing a system with four cavities for installation in the PS where modulating the beam at 200 MHz will make it easier to study its behaviour as it arrives at the SPS using the same units that will monitor the beam throughout the acceleration cycle. It is probable that the r.f. system in the PS will go further than this and actually impose a bunch structure at 200 MHz before the protons set off for the SPS. This will ease the 'capture' problem for the r.f. system of the big machine and probably reduce radiation problems due to losing particles. Collecting unbunched particles can be done in a more controlled way within the PS than in the SPS.



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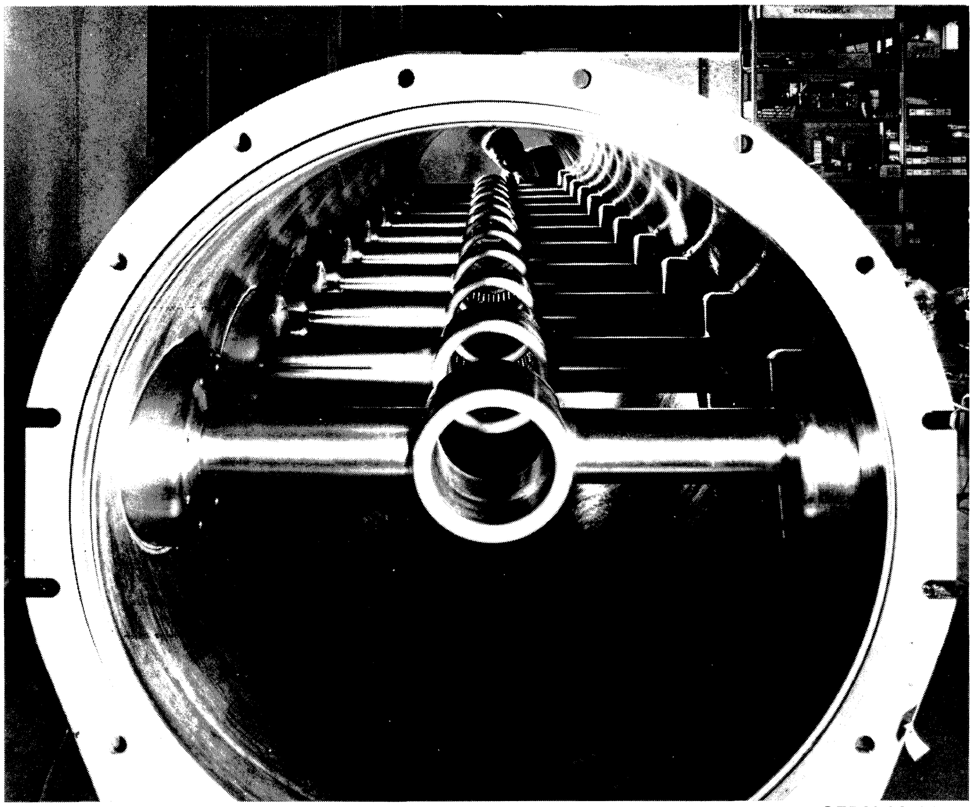
A section of an r.f. cavity which will accelerate protons in the SPS. A novel feature of the machine is that the technique of acceleration is similar to that used in linear accelerators—hence the line of drift tubes along the axis of the cavity. Five of these sections will make up one cavity and two cavities will be installed initially.

The control room of the SPS. Three of the consoles (the one on the left and the outer ones behind) will be able to call any or all of the machine components under control. The centre console will carry the safety controls and alarms. The computers, which will link the consoles to the accelerator hide behind the wall on the right. It is hoped to have one console completely equipped by the end of the year for tests and further development of the control system, which is the most advanced and versatile of any accelerator yet built.



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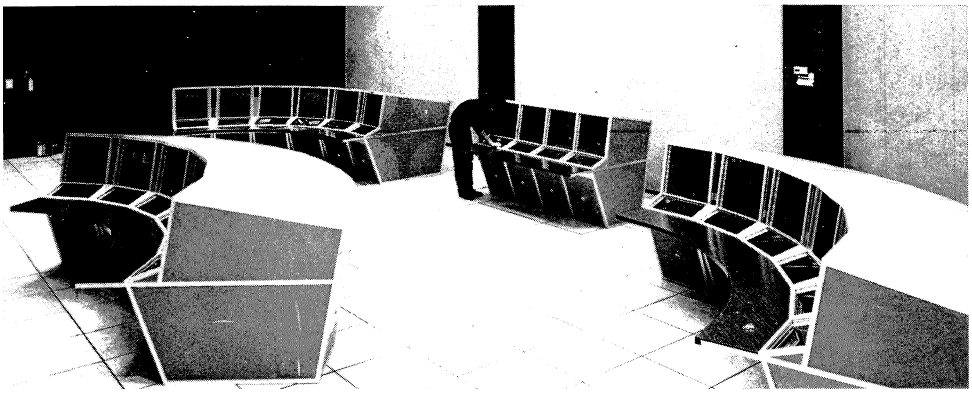

CERN 25.11.74

A great deal of work is also involved in the various control elements linked to operation of the r.f. system in the SPS. They have to gather information on beam behaviour and tell the r.f. what to do to keep the behaviour good. We have come a long way since the famous feedback circuit built into a Nescafé tin which helped so much in bringing on the PS in 1959. Intricate components and circuitry will make versatile control possible (via an intermediate frequency of 10.7 MHz) at the SPS, regardless of whether we are handling intense beams, weak beams, single bunches, etc...

Among the pick-up electrodes involved, a wide band version has been tried on the PS and has worked very well. They have been developed to take signals from 100 Hz to 5 GHz and might even be extended to d.c. by replacing the co-axial electrodes by beam current transformers. It is the first time such pick-ups have been brought into efficient operation at very high frequencies at CERN.

Under controls

Remaining in the domain of controls — the assembly of the control system for the whole machine is one of the most daunting aspects of the project. Quite apart from the sophisticated features, like the extended abilities in the use of computers, installing the hundreds of miles of cable, needed for monitoring and controlling the myriad components, and making the tens of thousands of connections correctly is an impressive exercise in logistics in itself. About 175 km of cable have been laid in the first sextant of the machine to be installed and, at the peak period, an average of one connection every ten seconds will have to be made and tested.

All twenty-four NORD-10 computers, which will take care of the control functions, have been delivered. An additional one to look after the North Experimental Area will arrive in February. They are performing well and the recent ones have been passing their acceptance tests within about a week of reaching CERN. These computers have proved so successful that they are now finding their way into other parts of CERN also.

Many of them have been sprinkled around the Laboratory II site in their destined positions, for example in the auxiliary buildings near the access shafts 2 and 3, and have been used in the first tests on the message transfer system. Signals have been bounced around to check the specified performance (less than one undetected error in 10^{11} bits transferred) and, in a test, almost 10^{10} bits have been passed without problem. About half of the CAMAC equipment for the interface with the computers has arrived (much of it is already installed) and modules

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for the multiplex system are coming through to schedule.

For the computer programmes, an improved version of the command language has been developed. It is now possible to switch programs and data between the computers with simple statements fed to a computer. The emphasis on programming has moved to producing the special programs which are linked to the specific machine components. This could have been a very difficult job but the basic simplicity of the computer control techniques which have been worked out should make it possible to cover all the special requirements rapidly.

At the control desks which are now being built up, the remarkable abilities of the system become evident. It is possible to pick out a machine setting for modification or any component for detailed investigation via a touch screen (see April issue, page 117). For example, from an initial set of legends written on the screen by the computer it is possible to call the r.f. suite of programs. The computer then writes a list of r.f. functions on another screen and a more detailed set on the touch screen. Settings related to a particular r.f. function can then be summoned and, finally, the operator is linked to it via a control knob.

To check the operation of the beam monitors of the SPS, a beam current transformer, ionization beam scanner and secondary emission monitor have been installed on the 28 GeV synchrotron and in the West Experimental Hall in collaboration with the PS Division. They are linked to NORD-10 computers. The tests were very successful with the ability to zoom in on a particular piece of the information coming from the monitor, via the control computer, proving a new asset in studying beam behaviour.

It will not be very long before these monitors are looking at protons over ten times more energetic.

High intensities with the PS

As construction of the 400 GeV synchrotron progresses in Laboratory II, the proton synchrotron of Laboratory I prepares for its task as injector. For this, it must be capable of accelerating, to 10 or 14 GeV, a beam with an intensity of 10^{13} protons per pulse.

In the course of a machine development period on 7 November a beam of 9.3×10^{12} ppp was accelerated. This test showed no unexpected phenomenon related to the high intensity and gives good ground for believing that the PS will break the 10^{13} barrier without major difficulty.

During the high intensity run, the teams manning the accelerators involved (the 50 MeV Linac, the 800 MeV Booster and the proton synchrotron itself) had to tune up to new performance levels. The Linac, which under normal operation provides pulses of 50 mA, was required to raise 80 mA. This is now easier following modifications to the buncher, which gives a density in the centre of the beam of 11 mA/mm/mrad. Despite the very delicate control needed, particularly with the r.f. system, the stability of the Linac beam remained excellent, both from pulse to pulse and within a pulse.

The Booster has made much progress since it last featured in our pages (see vol. 14, page 251). It has reached intensities of 1.3×10^{13} ppp, but the

An exhibition was organized in November to present the work of maintenance and improvement which is needed for the three hundred magnets of the beam-lines in the PS experimental halls. This service has been in action about four years aiming to achieve the highest possible reliability taking into account such features as aging effects due to radiation and maintenance difficulties in radiation environments.

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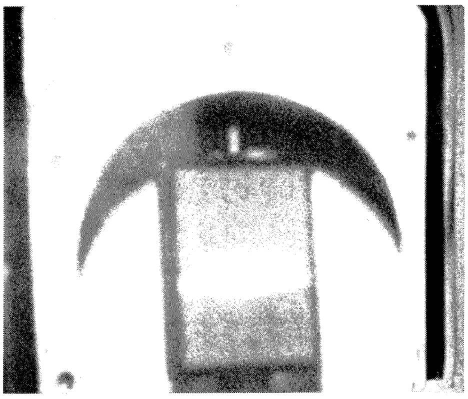

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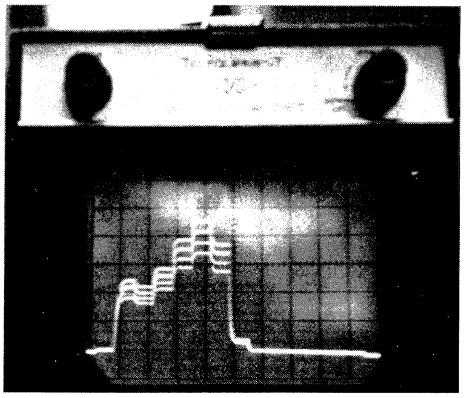

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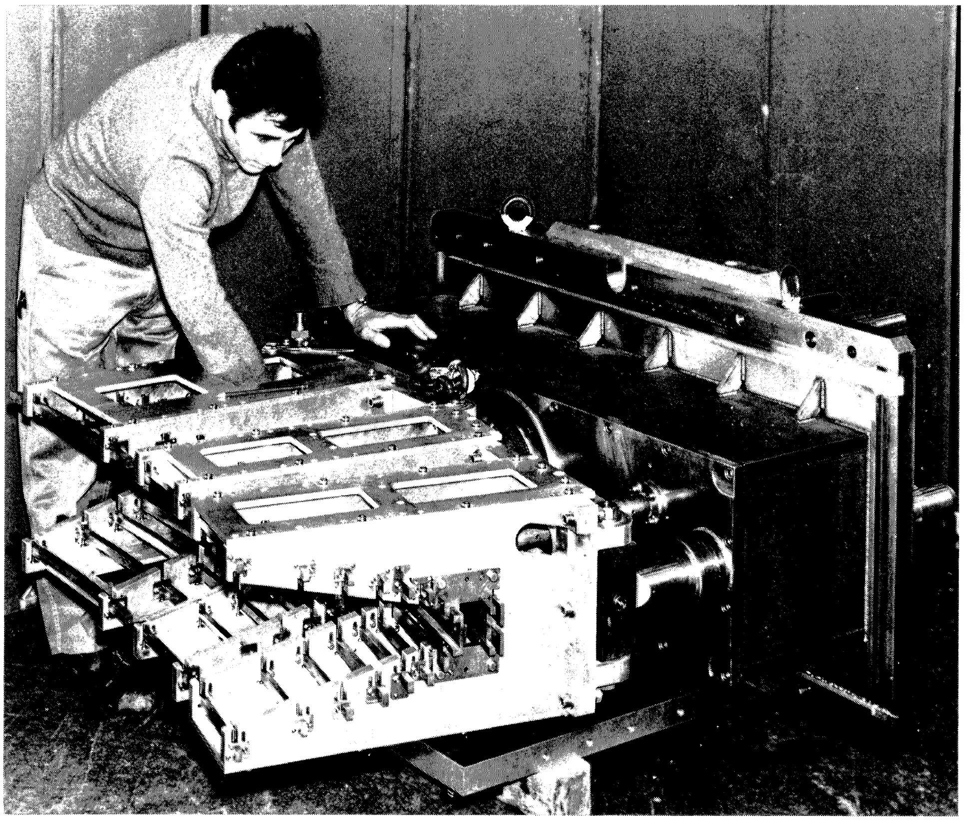
1. An oscilloscope picture of the spot produced by the extracted beam in the synchro-cyclotron hall.

2. The radial beam intensity distribution in the synchro-cyclotron near the extraction channel as seen by a new secondary emission detector.



The electromagnetic septum channel of the 600 MeV synchro-cyclotron extraction system prior to its installation in the accelerator. The first tests of extraction from the rebuilt machine yielded more intense beams.

CERN 56.10.74

beam was still too large to be comfortably injected into the PS. At high intensity, space charge effects produce a downward drift and spread of the betatron frequencies; resonance lines are crossed by the particles leading to beam blow up. By appropriately programming the working point during the acceleration cycle, it has been possible to minimize this phenomenon of increased emittance by steering clear of the most dangerous resonances and the vertical emittance at 800 MeV has been reduced.

In addition, a more sophisticated method of damping the longitudinal instabilities (see vol. 14, page 251) has been developed. Rearrangement of the particles within a bunch is induced by exciting (twice during the acceleration cycle) the beam at a frequency double that of the synchrotron frequency.

These improvements gave a 800 MeV beam with the required emittance for injection into the PS. Further improvements will, however, be required to obtain perfect recombination of the bunches during the transfer process and to adapt the beam even better to the acceptance of the PS.

It was the first time that the PS had received so intense a beam and the machine settings which were then made will be optimised in the course of coming development periods. The tricky points are the compensation of resonances at injection (mainly sextupole for which 32 new sextupole correction lenses have been installed) and the programming of the working point as a function of time in order to reduce beam blow up during the acceleration cycle.

Crossing transition with the aid of the gamma-transition jump system (see vol. 14, page 10) was problem-free. As predicted theoretically, a small increase in emittance was measured, but this should be eliminated when the quadrupoles receive their faster power supplies which are now being built. It was possible to damp the collective instabilities of the beam by means of octupoles and to achieve fast ejection at 10 GeV/c with 93 % efficiency without particularly refined adjustments.

Much remains to be done to obtain a beam of the intensity and quality required by the SPS but the results achieved in this test are very encouraging.

Extraction in action

The first stages of the re-commissioning of the CERN 600 MeV synchro-cyclotron, following its programme of improvements, were reported in the October issue page 334. At that time, to reduce the complications for the initial tests, the extraction system was not in action. It was brought on for the first time on 20 November and healthy extracted proton beams were rapidly achieved.

Beam emerged at the very first attempt and, after a few development runs, the ejected beam intensity was measured as being around 300 nA (2×10^{12} protons). This is with the r.f. system pulsed at one sixteenth of its design repetition rate (to limit irradiation of the machine while mastering the beam) and corresponds to 5 μA when the r.f. is going full blast. The 300 nA obtained so far are already three times the intensity of the extracted beam before the rebuild and well on the way to the new design figure of 7 μA.

During these tests, it proved possible to obtain novel information on the behaviour of the spiralling beam within the accelerator. The combination of the magnetic field, the r.f. field and the closeness of the beam orbits usually makes it extremely difficult to draw any clean information about what the beam is doing in a synchro-cyclotron. A new method, using

Views of streamers in hydrogen. The gas in the chamber has a small impurity content (0.5 % methane and 0.1 × 10^{-4} % of sulphur hexafluoride), the pressure was 500 torr and gave about 1.5 streamers per centimetre along the particle track. The track is about 10 cm long.

1. *Taken parallel to the electric field showing the length of the streamers (3 to 8 mm in the chamber).*
2. *Taken perpendicular to the electric field showing the diameter of the streamers (0.3 to 1 mm) in the chamber*

This is not the usual way a camera is pointed in BEBC. This photograph is taken from inside the 3.7 m European bubble chamber looking up at the ports where cameras normally peer into the chamber to see particle tracks. The chamber is now almost completely reassembled after the repairs to the magnet and tests will begin again soon.

the secondary emission technique with very thin foils at an angle to the spiralling beam, is giving good data which will be very helpful in optimizing the extraction efficiency.

Hydrogen streamer chamber

Some new results have recently been obtained in the development of hydrogen streamer chambers. Such chambers could have particular advantages for some experiments — they retain the qualities of 'conventional' streamer chambers (especially the ability to be triggered to record only the events of interest) while serving also as the target. Interactions with protons in the hydrogen (and neutrons if deuterium is used) can be observed in a similar way to interactions in a hydrogen bubble chamber.

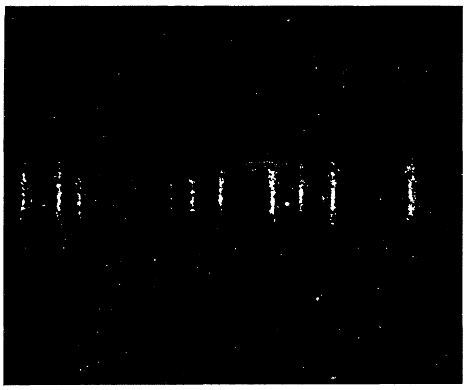
Work has begun again in the Track Chambers Division in collaboration with the Orsay bubble chamber group. A few years ago, the possibility of obtaining streamers in hydrogen was investigated at Argonne (vol. 10, page 283) at Dubna and at CERN (vol. 10, page 228). First tracks at low pressure (0.4 atmospheres) were achieved at CERN in 1971 (Nuclear Inst. III, 1973, 485-495). The new work has improved the performance.

The first effort was to repeat the earlier results using the existing small streamer chamber (9 × 21 × 26 cm^3) and to extend the performance to atmospheric pressure. A Marx generator capable of very high voltage (up to 2 MV) has been made and is used with a new conical Blumlein line (oil insulated) to produce very short (about 6 ns) high voltage pulses on the chamber electrodes. The high voltages demand great care in the construction of the chamber to avoid breakdown problems and this has been achieved by careful choice of shapes and materials and by ensuring scrupulous cleanliness.

Better quality tracks are achieved with pressures up to 0.8 atmospheres in a mixture containing less than 1 % impurities (mainly methane). The tests involve using an image intensifier developed in the ISR Division at CERN.

Particle track photographs are obtained with high contrast. The streamers are 0.3 to 1 mm in diameter and 5 to 8 mm long and of even quality from streamer to streamer. The necessary field gradient to form the streamers is about 54 kV per cm at 0.8 atmospheres with a pulse of 6 ns which is close to the theoretical prediction.

There are some technical difficulties still to be overcome but it is believed that the construction of a large hydrogen streamer chamber could now be confronted if it seemed to be the appropriate detector for some particular experiments.



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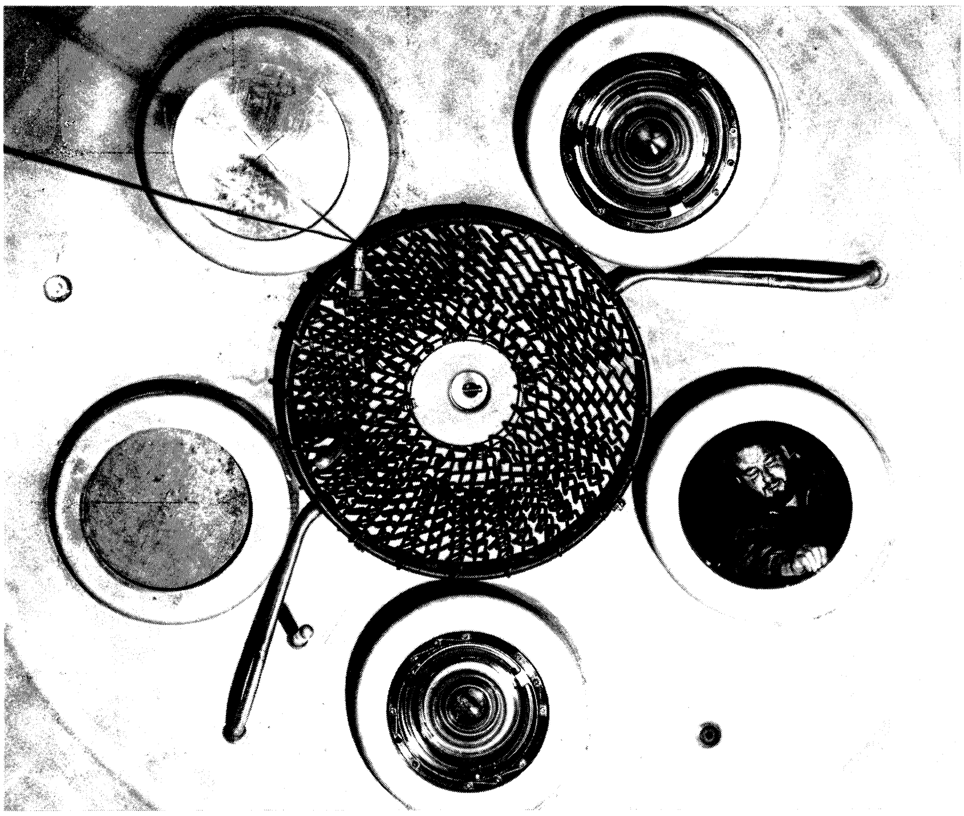


CERN 273.10.74

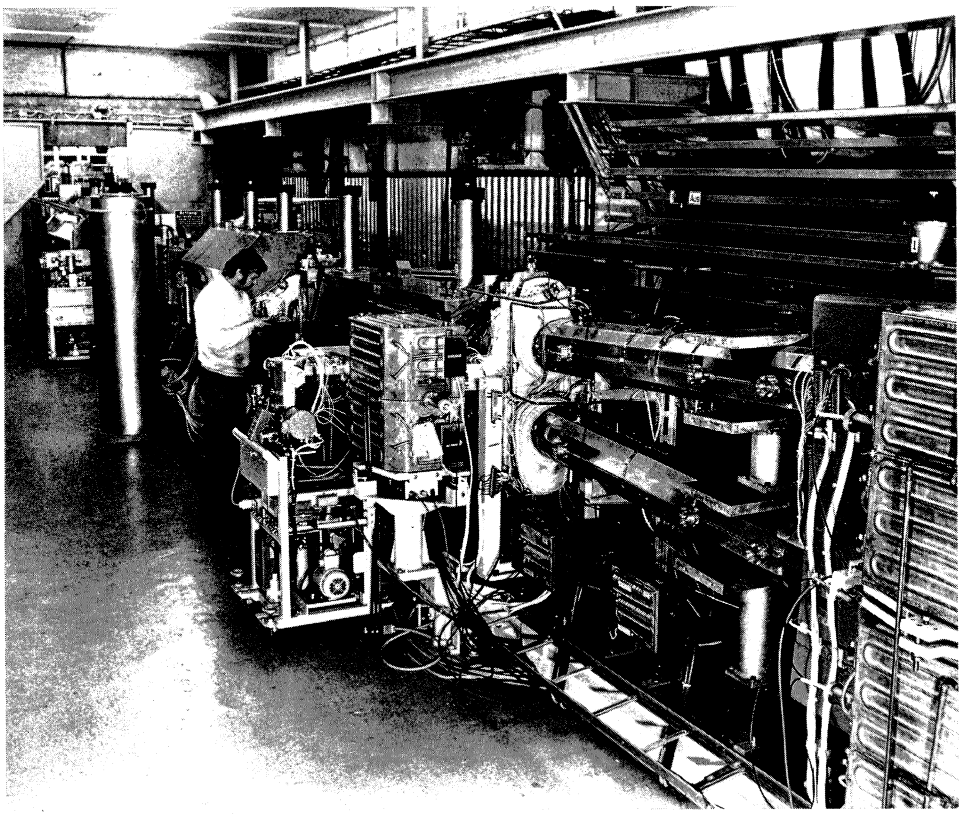
Around the Laboratories

The DORIS storage rings at an intersection where the electron and positron beams orbiting in their separate rings are brought together for colliding beam studies.

DESY Experiments start at DORIS

DORIS, the 3.5 GeV electron-positron storage rings of the Deutsches Elektronen Synchrotron, DESY, has begun regular operation for colliding beam experiments. Since beams were first stored in December 1973, there has been a hard struggle to hold down the complex and versatile machine. Commissioning continues and has so far resulted in a luminosity of 10^{30} $cm^{-2}s^{-1}$ at an energy of 2 GeV. This luminosity, which is obtained with stored electron and positron currents of about 250 mA and a beam life of about four hours, is used for physics runs.

Unlike the other electron colliding beam machines in this energy range, DORIS is a double ring machine, confining the two beams in rings one on top of the other and intersecting at two points with a small vertical crossing angle. This makes it possible to collide electrons not only with positrons but also with electrons or protons. Electron-electron collisions are a rather clean source of the so-called gamma-gamma reactions, which also occur in electron-positron collisions but then have to be separated from the events coming from single photon exchange. This mode of operation is, therefore, an important part of the experimental programme. In addition, protons will be accelerated in the DESY synchrotron and stored in one of the DORIS rings, providing electron-proton collisions for machine studies on the stability of intersecting electron and proton beams and maybe also for some physics experiments.



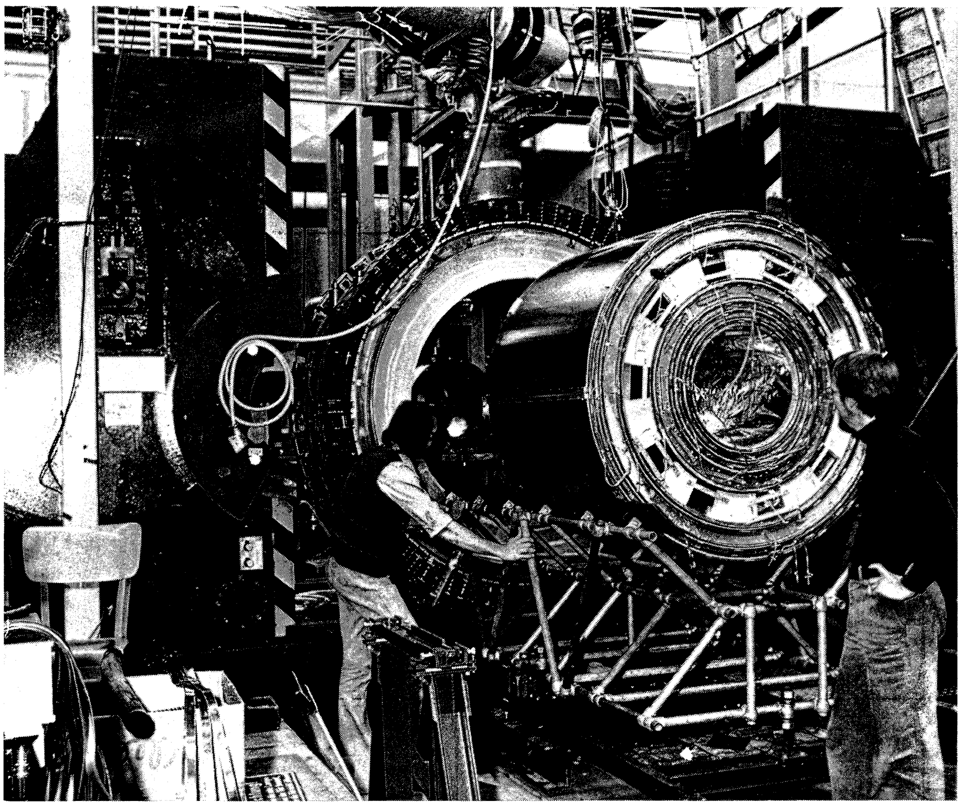
The separation of the beams in the double ring permits operation with many bunches orbiting the rings potentially enhancing the luminosity at medium and lower energies. Unfortunately, problems have to be overcome arising from multibunch instabilities in a single beam. The maximum single beam currents stored in DORIS so far are 0.8 A of electrons and 0.35 A of positrons. Initially, the currents were limited by several instabilities deriving from the electromagnetic interaction of the beam with its environment and leading to transverse or longitudinal bunch oscillations of growing amplitude. Interactions with parts of the vacuum vessel and, especially, with higher resonance modes in the r.f. accelerating cavities were identified and partially cured. In the cavities, the three most dangerous resonances were strongly damped by inserting coupling antennas. This significantly improved beam stability and current.

Another clearly identified phenomenon is the so-called 'head-tail effect'. In this instability, the particles in the front of a bunch recurrently excite betatron oscillations of the particles in the rear. Since their roles are exchanged during every half synchrotron oscillation period, accompanied by a periodic variation of betatron frequency, the oscillation amplitude grows exponentially and leads to losing the bunch. A well known remedy consists in removing this variation of betatron frequency by sextupole magnets. To do this properly in DORIS, a new focusing scheme was designed. It not only cured the head-tail effect but also reduced the beam width and greatly improved injection and stability of the beams.

The DORIS rings are filled at 2 GeV by injection from the 7.5 GeV DESY synchrotron which operates at 50 Hz and transfers electrons and positrons in any preselected pulse to pulse sequence while using the remaining pulses for experiments at the synchrotron. Injection efficiency has risen to between 50 and 80 % with the new beam optics, owing to a smaller beam

One of the large detection systems, PLUTO, at DORIS. A good impression of the superconducting solenoid can be obtained from the picture. The surrounding iron yoke is pulled back on each side of the beam intersection region.

(Photos DESY)



dispersion at the injection point. In a few months, newly equipped transfer channels will permit injection also at higher DORIS energies. Meanwhile, the energy can be raised in the storage ring without basic problems. Beams of more than 100 mA have been carried to 3.2 GeV and a smaller beam current to 3.45 GeV.

In its present form, DORIS is equipped for an energy of 3.5 GeV. There will be three 500 MHz r.f. klystron transmitters per beam, each delivering a power of 250 kW. Two of these are now operable and the third is nearing completion. All bending and focusing magnets are capable of being energized up to 5 GeV and the corresponding magnet power supply will be installed early in 1975. However, the present r.f. system will carry the beams up to about 4.2 GeV only. New accelerating units of higher shunt impedance are being prepared for raising the energy further.

For the experiments, two large complementary detection systems have been installed and tested in the straight sections: a magnetic spectrometer of large solid angle and medium momentum resolution, called PLUTO, and a double arm magnetic spectrometer of high momentum resolution over a smaller solid angle, called DASP.

The PLUTO magnet is a 2 T superconducting solenoid 0.4 m in diameter and 1.15 m long, that is coaxial to the beams and enclosed in a 90 t steel yoke. To minimize the effect on the stored beams, two additional superconducting coils are incorporated in the yoke compensating the integrated field along the beam axis. Tests at full magnet excitation have demonstrated that the field does not disturb storage ring operation. The system for the detection of multiprong events mainly consists of sixteen concentric cylindrical proportional chambers with wires spaced 2.5 mm apart. The preamplifiers for the 17 000 wires are placed between the cryostat and magnet yoke while the main amplifiers are 20 m away and are read into a PDP 11/45 computer. Events are preselected by hardware logic, then further reduced by the PDP to less than ten per second, and finally evaluated by an IBM 37/168 computer. Outer muon counters are formed by arrays of proportional counter tubes placed in the iron yoke. The solid angle of the assembly is 94 % of 4 π sterad; the momentum resolution is about 5 % at 1 GeV over 65 % of 4 π.

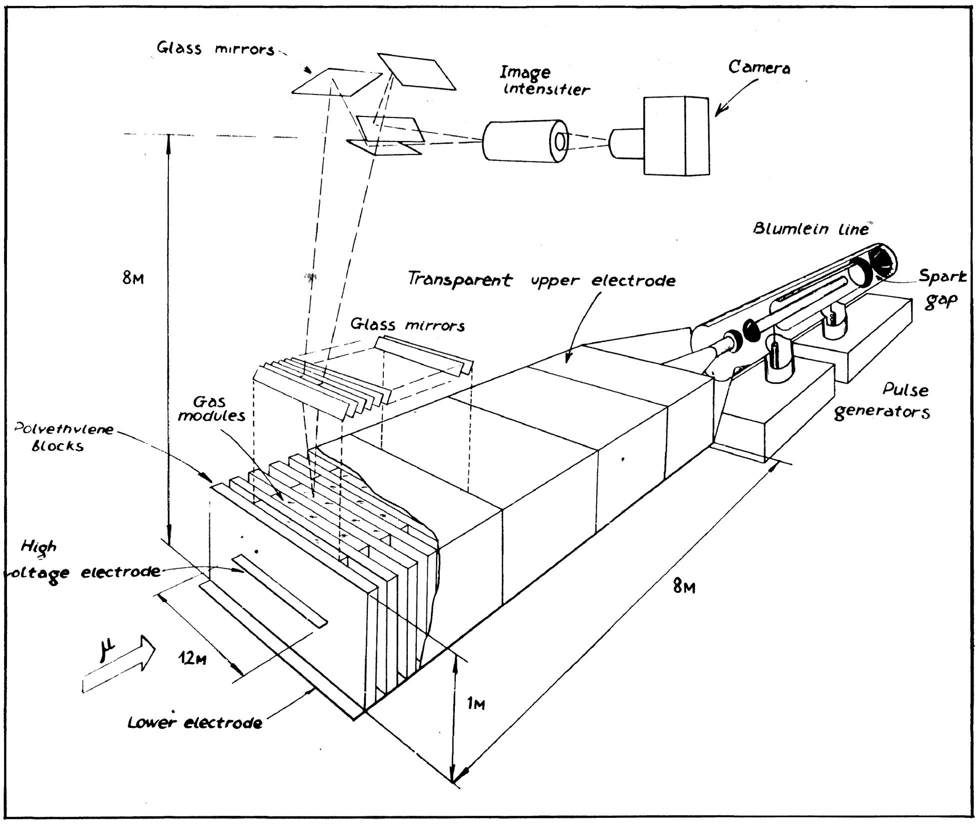
DASP permits high precision momentum measurement in conjunction with good particle identification in a restricted solid angle. Its primary interests are two-body and quasi-two-body reactions, inclusive reactions and gamma gamma processes. DASP has a large aperture magnet of variable geometry on either side of the interaction point. With a gap height of 90 cm, the total solid angle for magnetic analysis is 2 × 0.39 sterad and the integrated field is 1.8 Tm providing a momentum resolution of 0.8 % at 3 GeV/c.

Tracks are measured in front of the magnet to within ± 0.5 mm by proportional chambers and behind the magnet to within ± 0.25 mm by spark chambers. A time-of-flight path of 4.7 m between inner and outer scintillation counters permits separation of pions and kaons up to an energy of 1.8 GeV. Of the solid angle not used for momentum analysis, about 11 sterad are covered by an inner detector that measures track direction and distinguishes between gammas, electrons and hadrons. It consists of scintillation, proportional and shower counters tightly enclosing the beam pipe. The total weight of the magnet is 500 t, plus 300 t for muon counters. Data taking and checking is done with a PDP 11/45 computer which sends the events via a direct link to the central computer for storage and further on-line processing.

Both PLUTO and DASP are in the running in phase at present. Measurements of multiprong hadronic events are intended with PLUTO, while DASP investigates the validity of quantum electrodynamics and studies the pion, kaon and proton single particle spectra, completing the deep inelastic electron scattering experiments which strongly suggested a composite nature of the nucleon.

FERMILAB
Electrons and photons from protons

The Fermi National Accelerator Laboratory brought the world's highest energy electron and photon beams into action at the end of October. In the first test run, electron energies



Sketch of the 8 m streamer chamber constructed at the Moscow Physical Engineering Institute for an experiment at Serpukhov.

were taken to 225 GeV passing the 45 GeV beam of Serpukhov.

The electron/photon beam is set up in the Proton Experimental Area where the ejected proton beam from the synchrotron is directed onto a thin bar of beryllium 30 cm long. Among the spray of particules produced in the interactions in this target, there is copious production of neutral pions which decay rapidly into two photons. The particle spray is passed through a magnet which bends off all the charged particles leaving the neutrals, including the photons, travelling in the direction they were initially produced.

The number of neutrons in this neutral beam is high and the photon beam is therefore not suitable for use at this stage. It passes onto a sheet of lead where the photons 'materialize' into electrons and positrons. A series of fifteen bending magnets take the electron flux and select out and focus electrons of a particular momentum. Care has to be taken that the all-penetrating muons from the initial charged particle interactions cannot get in amongst the electrons. The pure, monoenergetic electron beam can then be used on a second thin lead plate where they radiate photons whose energies can be 'tagged' by measuring the resulting electron energies.

An experiment to measure total cross-sections is using the tagged photon beam. The photon intensity is about 10^5 per second from a 10^7 per second electron beam. These beams open up a new high energy range of experiments. The electron energy will be taken to 300 GeV or higher and the beam intensities will increase when the Proton Experimental Area regularly receives 5×10^{12} or more from the accelerator.

The accelerator has been operating very reliably with 300 GeV beam intensities above 10^{13} per pulse. The operating efficiency during a month of scheduled time for high energy physics reached 72 % during which 2.3×10^{18} protons were fed to experiments.

MOSCOW / SERPUKHOV
8 m streamer chamber

The world's largest streamer chamber has recently been built at the Moscow Physical Engineering Institute (MPEI) and used in the experiment to search for mechanisms of muon production in nucleon-nucleon collisions (looking for the intermediate boson, muon pairs, etc.) at the Serpukhov 76 GeV proton synchrotron (IHEP). The experiment is a collaboration between MPEI and IHEP led by B. Dolgoshein, V. Davidenko, V. Kirrilov-Ugrumov and S. Somov.

The chamber dimensions are 8 m long, 1 m high and 1.2 m deep with two 50 cm inter-electrode gaps. To stop the muons, polyethylene plates (10 tons, 400 gcm^{-2}) are inserted inside the chamber. These plates, each 60 mm thick, are sandwiched by 120 streamer chamber cells — hermetically sealed plastic boxes filled with a neon-helium gas. A gas cycling system is used to keep the neon-helium gas very pure (oxygen and nitrogen content less than 10^{-4}). A memory time of 10 μs, which is necessary to record decay electrons, is achieved by adding small quantities of freon or sulphur hexafluoride to the neon-helium mixture.

The high voltage electrode at the centre of the chamber and the earth electrode enclosing the chamber, form a pseudo-coaxial transmission line with an impedance of 33 ohms. The voltage pulses are produced by a special Blumlein line charged by two Marx generators. Pulse shaping is achieved by discharging the Blumlein onto the electrodes via a high pressure spark gap triggered by x-rays (100 kV, 30 ns).

After the passage of a muon through the streamer chamber, a first high voltage pulse of 300 kV and 40 ns duration was applied. Electron multiplication along the muon track was ten to a hundred. The delay time between the passage of the muon and the application of the second high voltage pulse (of 800 kV amplitude and 20 ns duration) was 6 μs. During this time 90 % of stopped muons decayed in the chamber. As a result of the application of two high voltage pulses, the track formed by a muon was brighter than the track formed by an electron. The brightness of muon and electron tracks could be changed by varying the amplitude of the first pulse.

The streamer chamber is photographed by four cameras via image

Pieces from photographs taken in the streamer chamber showing
1. *Muon tracks*
2. *A muon-electron decay*

intensifiers which give good pictures with a mean streamer length of 5 mm. The chamber was exposed to a muon beam with an average muon momentum of 2.5 GeV. Polarized muons were produced in an internal copper target at 9° to the incident proton beam. They travelled along the streamer chamber, stopped and decayed in the polyethylene plates and the polarization was measured by detecting the asymmetry in the muon-electron decays.

A total of 10^5 pictures have been obtained and detailed analysis of the data are in progress.

European Science Foundation

Scientists from sixteen nations* assembled in Strasburg on 18 and 19 November for the first plenary session of the European Science Foundation which is now complete with statutes, budget and seat — although permanent offices will not be available for a few more weeks. This was the culmination of a year's hard work by the founding committee under its president Prof. H. Curien following initiatives taken in Scandinavia and in the Commission of the European Communities.

The Foundation brings together delegates from the national authorities organizing research and the government sponsored academies so that both the administration of research and its scientific appreciation are represented. The first officers of the Foundation indicate immediately this scope with, as President, Sir Brian Flowers, physicist, and as Vice-Presidents — Prof. O. Reverdin, a hellenist representing the humanities and Dr. P. Riis, medicine. The Secretary General is Dr. F. Schneider of the Max Planck Institute, Munich.

The principal objectives of the Foundation are to assist and encourage cooperation in basic research and to promote the mobility of research workers. This first meeting showed the many areas where a worthwhile contribution could be made and demonstrated the active spirit of international cooperation that is already familiar to high energy physicists. To begin with, three topics have been singled out for immediate study — astronomy, which is particularly topical as proposals are being prepared at present in many Western countries for expensive facilities; archaeology, where recent developments in research techniques can be widely exploited; social science ethics, with particular reference to what is becoming known as genetic engineering. Other subjects which may come up for early study are the mathematical education of physicists and space research.

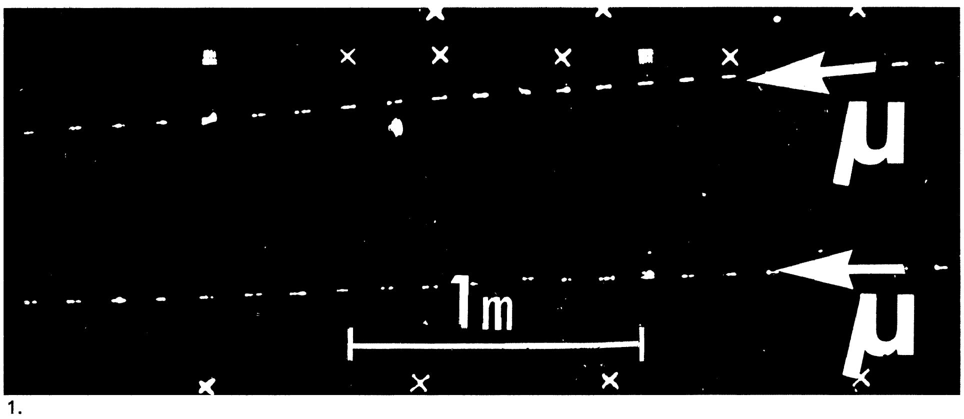
Sir Brian, at the press conference which followed the session, laid stress on the newness of the organization and the absence of any pre-established plans of how the work will be tackled. He also stressed that the Foundation is not wanting to 'take over' any existing international organizations or interfere with the way they are run. The Foundation expects to be consulted by governments when major projects are being considered and he believes it will allow proposals to be examined in a broader context than had generally been the case in the past.

* The twelve Member States of CERN: Austria, Belgium, Denmark, France, Germany (Federal Republic), Greece, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom plus Ireland, Portugal, Spain and Yugoslavia.

DARESBURY
Playing tunes on NINA

The Daresbury 5 GeV electron synchrotron, NINA, has recently been modified by adding pairs of quadrupole magnets in four of the machine straight sections to control focusing conditions throughout the acceleration cycle. Previously, the beam focusing at injection had to be different to that at high energy.

The radial and vertical Q values



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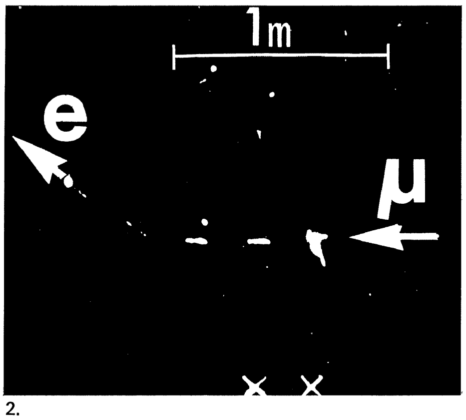

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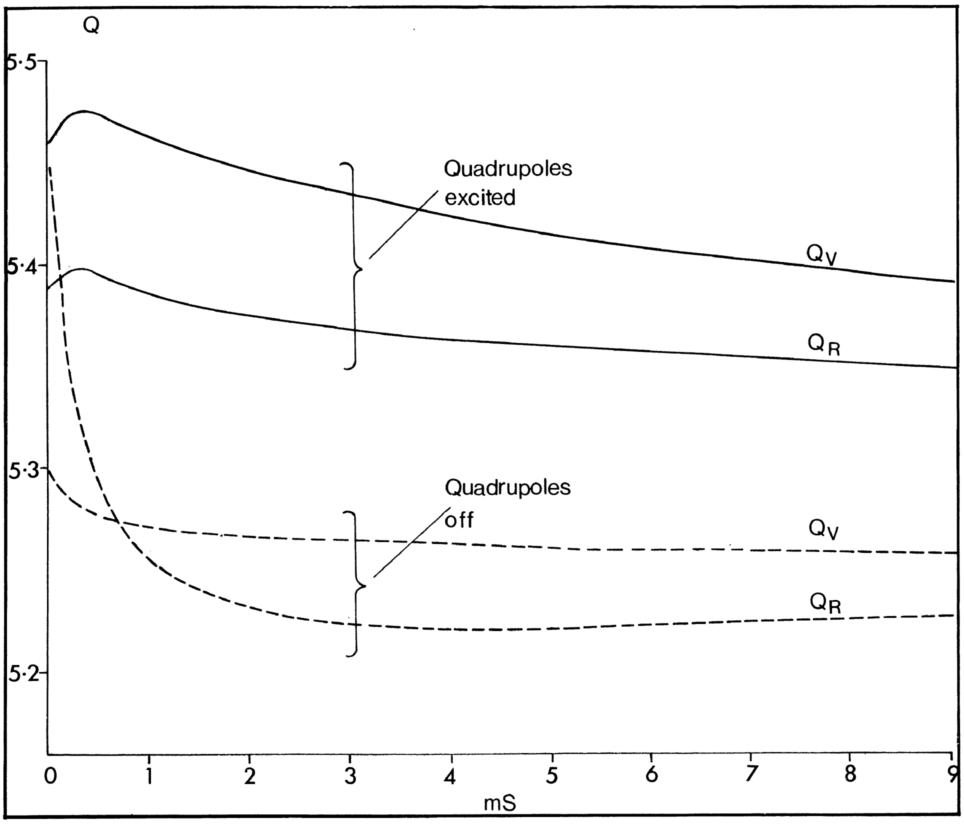


A graph of the NINA Q values in the vertical (Q_V) and radial (Q_r) planes during the 9 ms of acceleration. The dashed lines, below, indicate the situation before installation of the programmed quadrupoles. The full lines, above, show the effect of the quadrupoles which enable resonances, causing beam loss, to be avoided.

(the number of betatron oscillations of the beam particles per revolution in the radial and vertical plane) are a measure of the focusing. Best injection conditions were obtained with Q values close to 5.5 and the beam was disturbed by passing through resonances as the focusing decreased to Q values of about 5.2 at high energy. The quadrupoles control the Q values giving a better high energy value and preventing beam loss. They also provide the change of Q necessary to set up the third integral resonance which is used for a separated function extraction system.

An important feature of the system is the high flexibility of control. The NINA operator uses an interactive graphics terminal which is on-line to the Laboratory's central computer, to draw in the required values of radial and vertical Q during acceleration as two curves on graphs of Q against time that are presented on the terminal. The central IBM 370 calculates the waveforms that need to be applied to the quadrupoles to produce these values and checks that the magnet power supply ratings are not exceeded.

After displaying the voltage waveforms to the operator, the data are transmitted to a PDP 11/05 computer, which is programmed to store the incoming information and then to cycle in step with the NINA acceleration cycle. Separate waveforms for the F and D quadrupoles are required and each is made up of five hundred ten bit words. The two waveforms are fed to the power supplies in 9 ns at a repetition rate of 53 Hz.

A novel design was necessary for the power supplies since they are required to follow any waveform, within the maximum ratings, generated by the computer. The circuit uses transistor banks switching in class C to vary the supply of energy from current carrying inductors to capacitors, the voltages of which are applied to the quadrupoles. Feedback circuits match these voltages to the computer generated waveforms, voltage control being preferable when a magnet is being pulsed.

The quadrupole magnets use forced air cooling, so as to have smaller more economical magnets, avoiding the problems of water cooling in a stranded conductor coil. Another novel technique was used in the magnet construction — thin glass cloth, preimpregnated with epoxy resin, bonds the laminations into the magnet blocks.

The system is now in operation and the measured shifts in Q have been as expected.

EPIC storage ring project

The UK Science Research Council met towards the end of November to consider several projects in the fields of research for which it is responsible. In high energy physics the topic of interest is the proposed construction of EPIC, a 14 GeV electron-positron storage ring.

The Council recognized the strong scientific case for the project (probably given a most timely jolt by the new particle discoveries in the USA) and encouraged further studies. Money is being provided for more detailed design work on the machine, including the construction of model magnets and r.f. components and for a thorough site survey. The project will be put forward again in 1975 and will be re-examined in the light of the money that the Council then has available to allocate to pure research projects and of the needs of other branches of science.

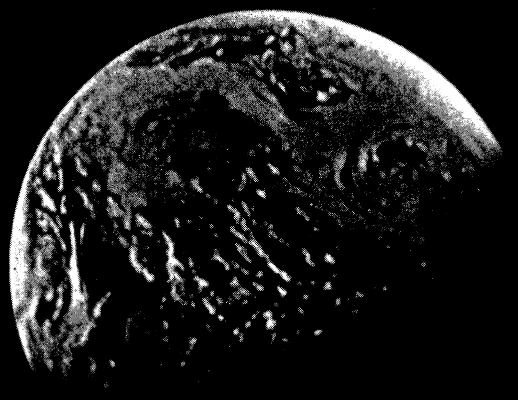
EPIC (Electron Positron Intersecting Complex) was described in outline in vol. 13 page 373 and a fat project description was published at the Rutherford Laboratory in September (report no. RL-74-100). It is intended to succeed the 8 GeV proton synchrotron, NIMROD, at Rutherford and the 5 GeV electron synchrotron, NINA, at Daresbury as the base for the high energy physics programme within the UK. It is at present conceived as a single ring machine, 2.2 km in circumference, constructed in a tunnel close to the location of NIMROD at Rutherford. The NIMROD buildings would be used as much as possible to house the linacs and NINA (brought down from Daresbury) which would serve as a 4.8 GeV Booster.

The Council urged full consultation on the project with the rest of the European high energy physics community. Such consultations were, of course, already under way but they will now be extended with an open invitation from the Rutherford Laboratory to all their colleagues in Europe to discuss collaboration in any stage of the construction and/or exploitation.

POUR L'ULTRA-VIDE

une nouvelle génération de roulements à billes

RMB



dont les éléments - bagues, billes et cages à billes - permettent pratiquement d'éviter le soudage de contact que favorisent l'ULTRA-VIDE et les HAUTES TEMPERATURES, et d'assurer une longévité particulièrement remarquable grâce:
à la grande dureté des chemins de billes,
aux billes adaptées à l'application et
à la cage de nature autolubrifiante.

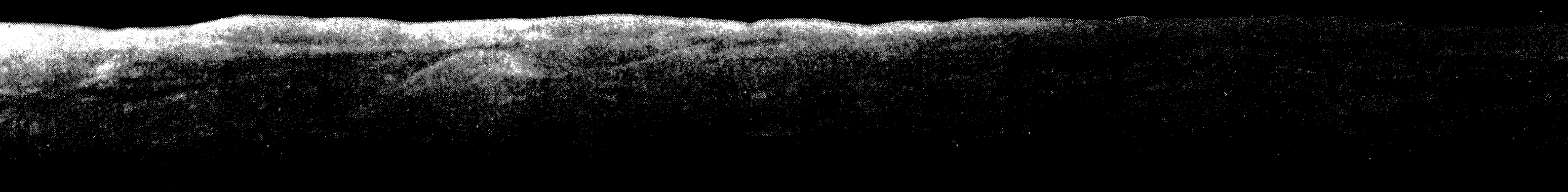


Tableau de durées de vie comparatives dans l'ULTRA-VIDE

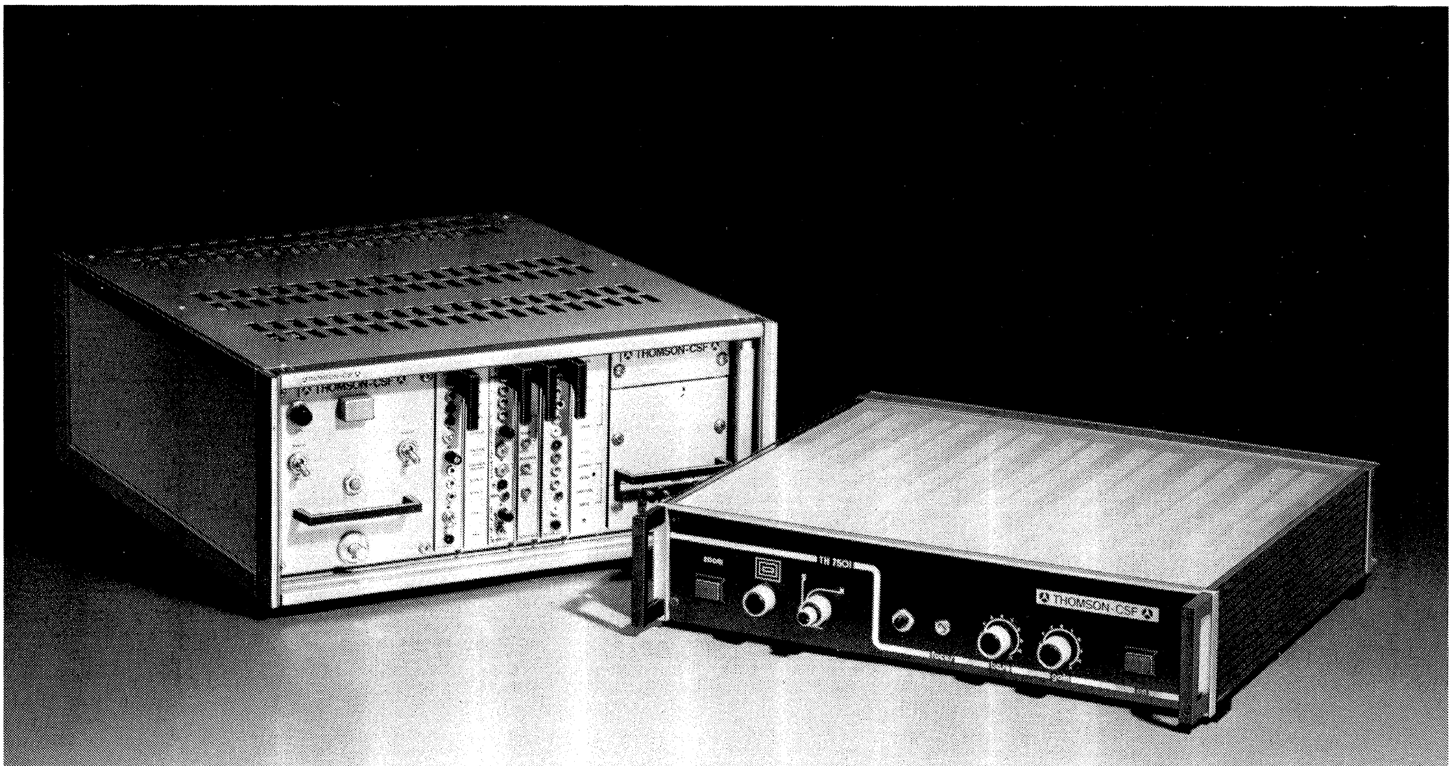
Durée en heures à 3000 t/min. ▶ 0 — 1000 — 2000 — 3000 — 4000 — 5000

Roulements standard	à 20° C, secs: durée <30 min. à 20° C, avec traitements autolubrifiants: durée <100 h.
Nouvelle génération de roulements RMB	en haute température = 450° C: durée minimum 1000 h. en vide propre à 20° C: durée minimum 4000 h. en ultra-vide à 20° C: durée plus de 5000 h.

Nombre de tours ▶ 0 — $1{,}8.10^{8}$ — $3{,}6.10^{8}$ — $5{,}4.10^{8}$ — $7{,}2.10^{8}$ — 9.10^{8}

Note: Ces valeurs, réalisées en laboratoire, n'engagent pas RMB

Roulements Miniatures SA, Eckweg 8, Tél. 032 41 47 21, CH-2500 Bienne (Suisse)



good shots
come through THOMSON-CSF storage units.

☐ TV image freeze
☐ XY, Standard TV or slow scan access
☐ Electronic Zoom ☐ Full grey scale

All applications dealing with our single or double-ended recording storage tubes, can be achieved with the adequate unit:

REFERENCE	RACK	FEATURES	APPLICATIONS
TH 7501	19" - 2 units	Zoom x 4 Integration adjustment provided	TV image freeze
TH 7502	19" - 3 units	Simultaneous write and readout. Provision for controlled decay.	Standard and slow-scan TV
TTV 3900	19" - 4 units	Sequential erase, write and read	Multipurpose. Read and/or write access: standard or slow-scan TV, random.
TH 7500	19" - 5 units	Two trace widths in black or white	Remotely addressed XY write and TV readout.

THOMSON-CSF

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Sweden - THOMSON-CSF Elektronrör AB / Box 27080 / S 10251 STOCKHOLM 27 / Tel. (08) 22 58 15
United Kingdom - THOMSON-CSF Electronic Tubes Ltd / Bilton House / Uxbridge Road / Ealing / LONDON W 5 2TT / Tel. (01) 579 55 11 / Telex : 25 659
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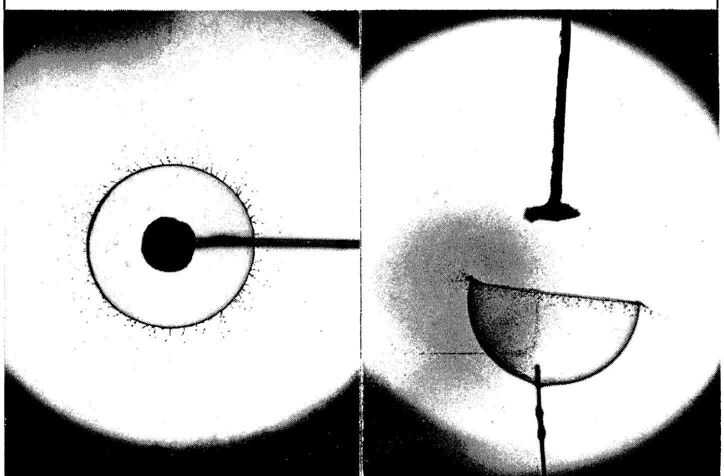
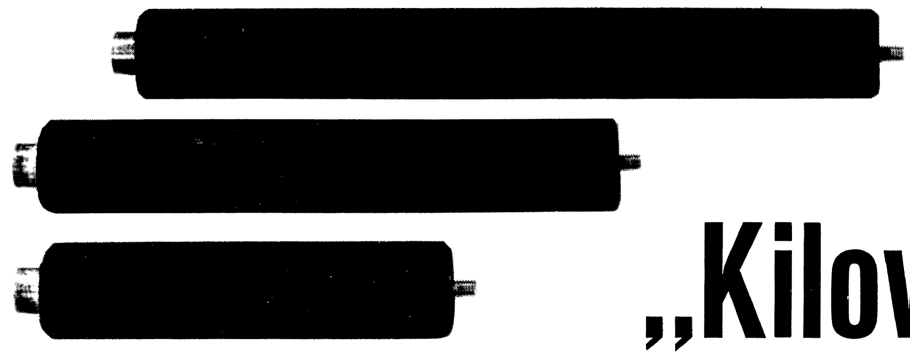
2146

Five new low-cost lab computer systems with a big heart.



Semtech

high voltage silicon rectifiers



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PIV: 12,5/18/25/33/45/50/66/75/100/150&200KV

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0,1/0,2/0,3 & 1,0A

V_F: @ 100mA at 25°C:
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NEW SEN FADC 2068 A/D CONVERTER

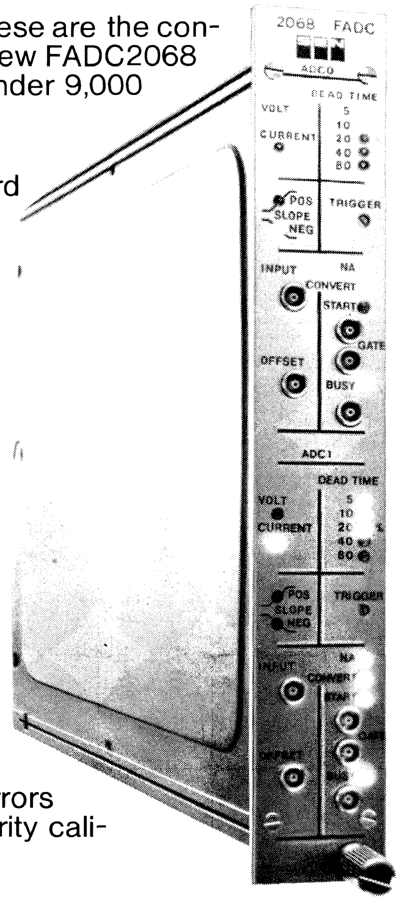
faster conversion speeds for less strain on your pocket

2 μs for 10 bits, 4.5 μs for 12 bits. These are the conversion speeds you get from SEN's new FADC2068 A/D Converter for an investment of under 9,000 Swiss francs.

Packaged in a double-width standard CAMAC module, the device is primarily designed for people running fast processes or events who need high-speed real time digital signal processing, e.g. in high energy physics (proportional wire chambers) or in oil refining and chemical processing (crackers, etc.).

Sample and hold with aperture from the SEN FADC2068 is less than 50 ns ... with less than 5 ns available as an option. The unit uses DMA in conjunction with the crate controller 2023, and can be directly connected to a SEN 2046 to provide a 128-word buffer memory and digital window.

The FADC2068 uses a successive approximation technique with fixed errors on certain channels modified by linearity calibration provided with each unit.



Here are the specifications:

Input signal:	±10V, 0–+10V DC coupled other ranges on request
Trigger:	internal on end of positive or negative slope, range ∞ to 1V/μs rise time
Sample and hold aperture time:	less than 50 ns
Dead time:	300 ns + read time (min. 1 CAMAC cycle)
Digital output range:	10 or 12 bits
Offsets:	analog, external, internally DC subtracted from input signal analog offset range: ±10V digital, added internally to conversion result: value is given through a CAMAC command
Speed:	2 μs/conversion 10 bits 4.5 μs/conversion 12 bits
Digital interfaces:	2 complete interfaces are implemented: a) through CAMAC crate controller and dataway b) through SEN 2046 Digital Window Discriminator, acting as a discriminator and buffer for 128 16-bit numbers. (25 p. Cannon connector)
Linearity:	a) integral: 1,5 10^{-3} b) differential: 2.5% over 99% of full scale. The statistical correction delivered with each module allows a differential linearity of better than 0.5% over 100% of the channels to be reached.
Temperature coefficient:	< 65 ppm/°C (after 1 hour warm-up time)
Accuracy:	±1 LSB adjustable over ±1 LSB for zero and ±1 LSB for gain

SEN
ELECTRONIQUE

31, av. Ernest-Pictet, 1211 GENÈVE 13, Suisse –
Case postale 39 – Tel. (022) 44 29 40 – Telex 23359 CH

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I'd like more information on SEN's new FADC2068 A/D Converter

☐ send me a specification sheet with application notes

☐ send me a SEN man who can not only tell me about the new FADC2068 A/D Converter but who makes sense talking applications, too!

I'm interested in a high-speed A/D Converter for ______________________

____

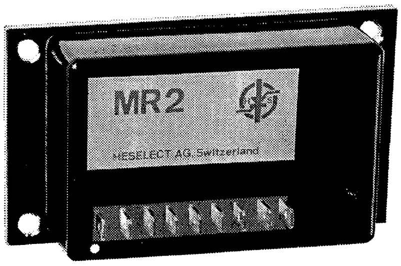
______________________ (brief description of process or event here please)

Name ______________________

Company/Institution ______________________

Address ______________________

Rectifier-Voltage Regulator

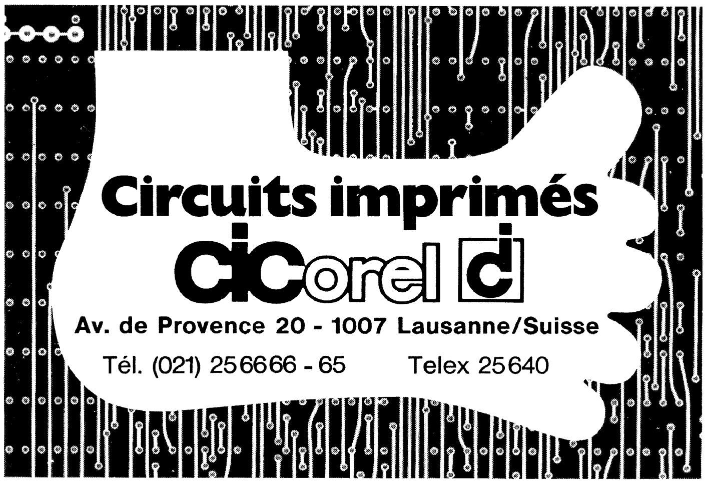


Prices:
1-9 Fr. 114.– each
10-49 Fr. 98.– each
50-99 Fr. 94.– each
> 100 Fr. 89.– each

- Max. input voltage: 40 V_{rms} or 60 V dc
- Max. current: 6 A
- Power loss: max. 80 W (T_c = 25 °C)
- Load regulation 0 – 100 %, max. 0.03 %
- Stability: 0.1 %/ 1000 hours
- Temperature coefficient: < 0.015 %/ °C
- Thermal resistance: 2 °C/W

Type	Output voltage	
MR 1	2 to 7 V dc	Voltage adjustable by built-in
MR 2	7 to 33 V dc	cermet pot
MR 3	2 to 7 V dc	Externally programmed
MR 4	7 to 33 V dc	voltage
Dimensions	87×50×25 mm	Weight: 270 g

Telemeter Electronic AG
8027 Zürich Tel. 01 25 78 72



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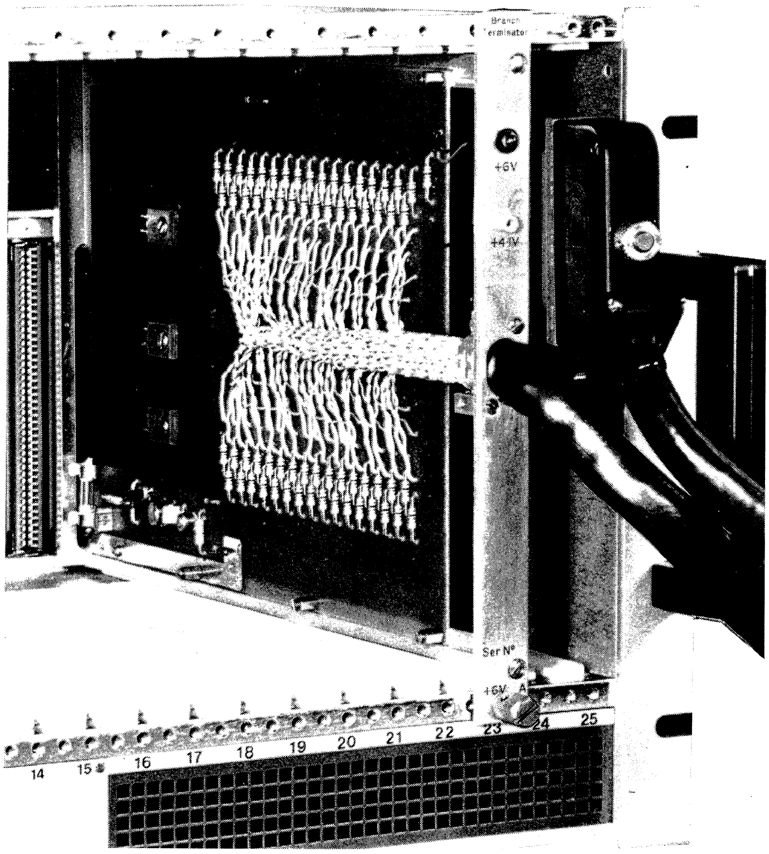
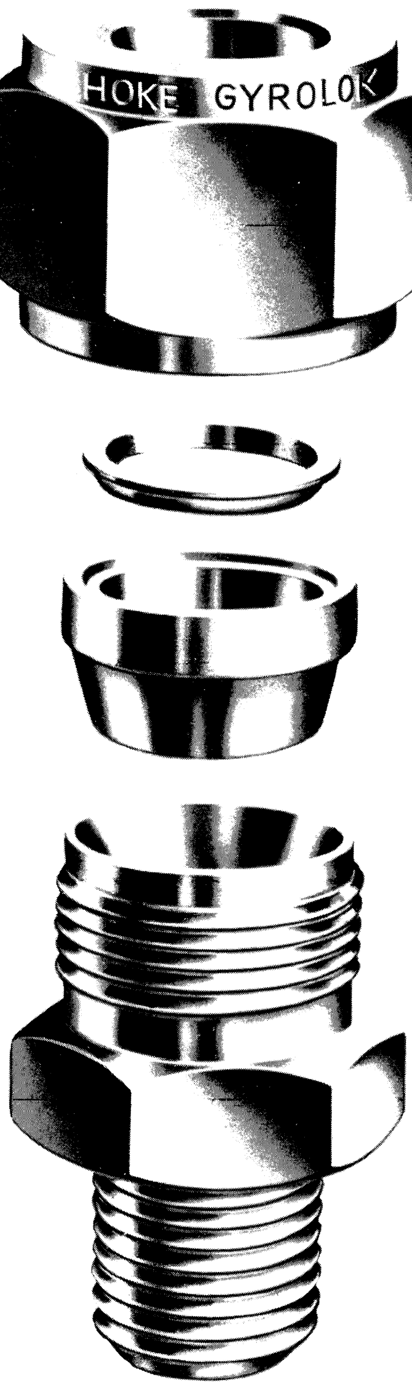


HOKE GYROLOK FLARELESS TUBE FITTINGS



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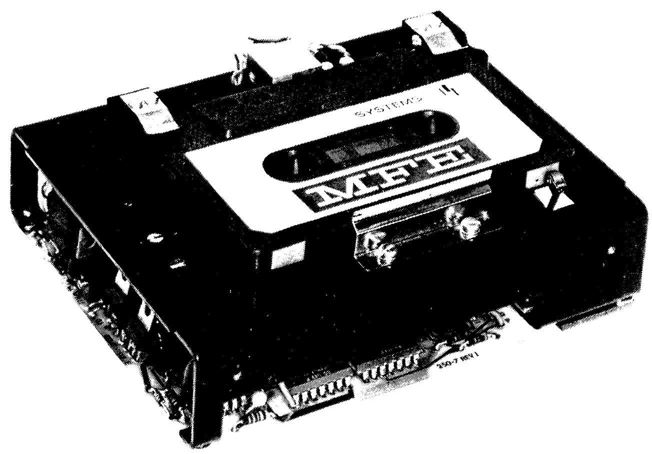

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