CERN COURIER

No. 9 Vol. 10
September 1970

European Organization for Nuclear Research

CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure 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. CERN is one of the world's leading Laboratories in this field.

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

The Laboratory is situated at Meyrin near Geneva in Switzerland. The site covers approximately 80 hectares equally divided on either side of the frontier between France and Switzerland. The staff totals about 2850 people and, in addition, there are over 450 Fellows and Visiting Scientists.

Twelve European countries participate in the work of CERN, contributing to the cost of the basic programme, 244.1 million Swiss francs in 1970, in proportion to their net national income. Supplementary programmes cover the construction of the ISR and studies for a proposed 300 GeV proton synchrotron.

CERN COURIER is published monthly in English and French editions. It is distributed free to CERN employees and others interested in sub-nuclear physics.

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1260 Nyon, Switzerland

Contents

Cover photograph: A view down the transfer tunnels between the 28 GeV proton synchrotron and the Intersecting Storage Rings at the point where they fork to feed one or other of the rings. At the beginning of September a beam from the PS was taken as far as the ISR down transfer tunnel TT2, which is the one going off in a straight line to the right in the photograph. Beams are scheduled down the full length of TT1 (bending off to the left) at the end of September. (CERN/PI 312.9.70)

Kiev Conference

The XVth International Conference on High Energy Physics was held in Kiev, the lively capital of the Soviet Ukraine, from 26 August to 4 September. This series of conferences, commonly known as the Rochester Conferences, is the most important in our field. (Anyone interested in tracing the history of the Rochester conferences will find a most enjoyable account entitled 'The Rise of International Cooperation in High Energy Physics' by their founder, R.E. Marshak, in the June 1970 issue of 'Science and Public Affairs', the Bulletin of the Atomic Scientists.) It served to assemble a welter of information from experiment and theory since the Vienna Conference of 1968.

The Conference was sponsored by the International Union of Pure and Applied Physics, the USSR Academy of Sciences, the USSR State Committee on the Use of Atomic Energy and the Ukranian Academy of Sciences. Dubna and the Kiev Institute of Theoretical Physics participated in the organization. It was held in the October Palace of Culture where a huge auditorium was amply capable of absorbing the 800 participating scientists. The multitude of services so important to the smooth running of a conference, such as projection and sound services, surrounding catering facilities, etc., functioned very well and the Organizing Committee, chaired by N.N. Bogolubov with A.N. Tavkhelidze as Deputy Chairman, deserve special praise for their efficiency. (There was a strong feeling among many participants that the Committee could most usefully take over Intourist.)

Though there were many beautiful experiments reported with high statistics and accuracies unbelievable a few years ago and much elegant theoretical work, no-one was running round the corridors shouting 'Eureka'. There was little that crystallized out, in terms of trends or highly promising approaches and little in terms of very exciting new experimental results. High energy physics is in a complex phase at the moment. A decade ago the Rochester Conferences were the scene of high excitement as access to higher energies broke new ground in our knowledge of particles and their behaviour. Now it looks as if, with the research facilities available, the plums have been picked and we are in the hard grind of trying to understand the detail. This does not carry with it the glory of ten years ago but it is nothing new in science that periods of dramatic discovery are followed by periods of much slower advance as more complex detail is uncovered.

There is a nice Einstein story to complement this. He once commented concerning those who attack problems of great complexity, 'I have little patience with scientists who take a board of wood, look for its thinnest part and drill a great number of holes where drilling is easy'. His spirit must be beaming down on todays high energy physicists who may need equipment discarded from the Mohole project to drill through their piece of wood.

We will not attempt here a review of the papers presented at the Conference though we hope in coming months to do this in a round about way by surveying the present position in the major areas of high energy physics research. Instead we pick out three topics which were among the more intriguing.

Deep inelastic scattering

A SLAC-MIT group have been using the 20 GeV electron linear accelerator at Stanford to study the structure of the nucleon. They do this by looking at the 'deep inelastic scattering' of the electron.

The series of experiments began in 1968 and first examined the proton. Electrons with energies up to the peak of 20.5 GeV available from the accelerator were fired at a hydrogen target. The scattered electrons were detected in large 20 and 8 GeV spectrometers set at a range of angles. The momentum of the bombarding electron, its momentum when scattered and the angle at which it was scattered were recorded.

'Deep inelastic scattering' means that observations are being made when the bombarding electron gets deep into the structure of the proton giving up a lot of its energy to the proton. (High momentum transfer is another phrase for this phenomenon.) Looking at the way the electrons then scatter is a way of looking deep into the internal structure of the proton.

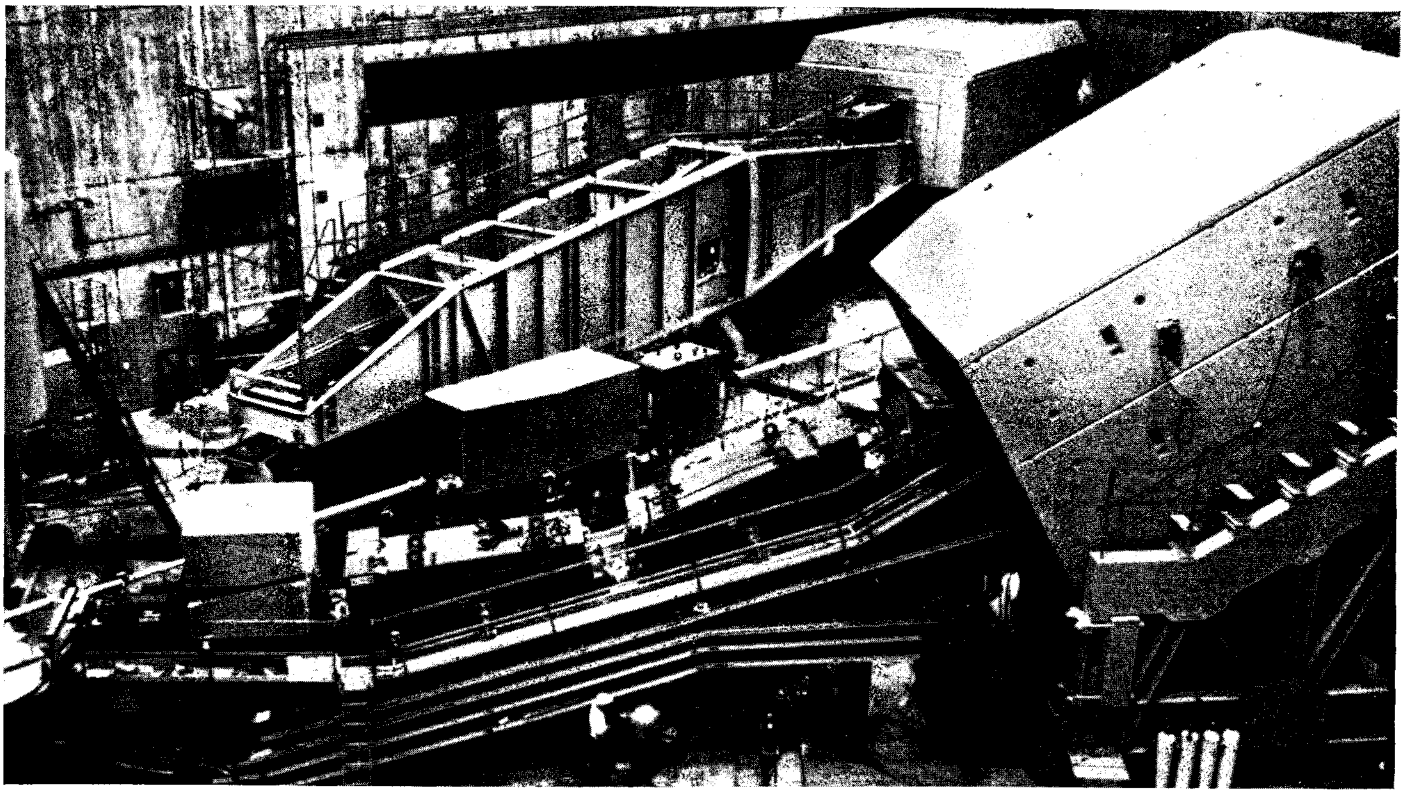
If we think of a simple model of the scattering process we can estimate that as the momentum transfer goes up, the proton will look more and more diffuse and transparent to the electrons, the electrons being more likely to brush past without giving up a lot of their energy to the proton. The probability of electron scattering at an angle will thus decrease as the momentum transfer goes up. This decrease is not observed at the expected rate and the results (reported for example at the Electron Photon Symposium held at Liverpool in September 1969) are more consistent with other models.

One is known as the diffraction model in which the electron-proton interaction is mediated by the exchange of a particle. This can lead to a 'scaling law' which will affect the degree of scattering depending upon the energy and momentum transfer. A second model, which clearly leads to a scaling law, is the parton model in which the proton is seen as consisting of a number of point-like non-diffuse parts (or partons) and the scattering occurs from the partons.

The measurements on protons showed scaling over a wide range and looked more consistent with the parton model at higher momentum transfers. A further check was possible in examining deep inelastic scattering on the neutron because the diffraction model predicts that the results will be the same as for the proton while the parton model predicts that they will be different, since the parton structure inside the neutron will be different to that inside the proton.

Measurements of scattering on deuterium were reported at the Conference. Knowing the proton results it is possible to extract the neutron scattering and the measurements come down clearly on the side of the parton model. At least it is certain that there is more at work than the pure diffraction model. It still leaves us to get to grips with what partons really are.

Other evidence on the side of partons comes from electron-positron storage rings — particularly from one of the first experiments on Adone at Frascati reported at the Conference. It has been found that more pions emerge from electron-positron collisions than are expected via the pro-



cess where photons produced in the collision convert to pions. If partons exist they could act as an intermediary in such conversion and lead to a more copious production of pions. There may be alternative explanations but it was another reason why the new word 'parton' was in common use at Kiev.

Neutral kaon results

There are so many interesting aspects to the behaviour of the neutral kaon that measurements in this field could easily flood a Conference by themselves. The long-lived neutral kaon is still the only particle which exhibits CP violation (in its decay into two pions) and T violation. But the mechanism of these violations is still not clear.

The most popular model involves a new force (the superweak force) which acts on the long-lived kaon converting it to the short-lived (which is 'allowed' to decay into two pions). Results at the Conference in general gave further backing to the superweak theory but there are also some results which are at variance with the theory.

A very nice experiment has been done at the 7 GeV proton synchrotron at ITEP, Moscow, using a xenon filled bubble chamber to observe the decay of the long-lived kaon into two neutral pions. In xenon there is a high probability of seeing gammas (which convert into electron-positron pairs) produced from the neutral pions. The ITEP team used an unusual technique of stereo projection of their bubble chamber pictures and claim a 95 % efficiency in picking out real events. Their results have an exceptionally low background. (A similar CERN experiment of a few years ago claimed about a 70 % efficiency.)

From their measurements they gave a new value for 'eta zero zero' which compares the rate at which the long-lived kaon decays into two neutral pions to the rate at which the short-lived kaon decays into two neutral pions. The superweak theory (via a comparison with the more straightforward eta plus minus measurements) predicts a value of about 2×10^{-3} for eta zero zero. ITEP give $(2.02\pm0.23)\times10^{-3}$. Values generally seem to be clustering around 2×10^{-3} though there are still some well away.

Three new measurements (from Argonne, CERN and Princeton) of the mass difference between the long-lived and short-lived kaons were reported with precision levels down to 1 %. Astonishingly (for neutral kaon measurements) they agreed, and when this value is fed into the calculations of the phase of eta plus minus from different experiments they give results which are no longer incompatible with the superweak prediction of $43.2\pm0.4°$.

Another important result from measurements on the neutral kaon came from experiments at Berkeley and CERN. It concerns the theory of weak interactions which has been developed in terms of the interactions of currents of the leptons (weakly interacting particles). These currents have been found to be associated with electric currents but it was important to know whether neutral lepton currents existed.

A sensitive way of checking this is to look for the decay of the long-lived neutral kaon into a muon pair. The experiments did not observe these decays even at a level way below that at which they would be expected if the neutral lepton current existed. The rate of the muon pair decay compared with all decays was measured at CERN to be below 2.6×10^{-8} and at Berkeley to be below 6×10^{-9}. Neutral lepton currents seem to be out.

A2 split again

An off-beat observation concerning the particle known as the A2 meson with a mass of about 1300 MeV, has been the subject for several years of a controversy which is still not completely resolved (see for example vol. 8, page 233). Experiments at CERN have indicated very clearly that the negatively charged A2 is 'split'. Instead of appearing as a single peak in the measurements it appears as two almost superimposed peaks suggesting that there are two particles with the same quantum numbers and of almost identical mass. This is a very odd observation which is not seen for any other particle and which defies a clear theoretical explanation. Nevertheless the CERN Missing Mass Spectrometer experiments looking at the phenomenon in several different ways, have seen it clearly each time.

A Berkeley team on the other hand have looked at the positively charged A2 and see no splitting. Thus we have the situation where CERN observes splitting in the interaction. $\pi^- + p \rightarrow p + A_2^-$ and Berkeley does not observe splitting in the interaction $\pi^+ + p \rightarrow p + A_2^+$.

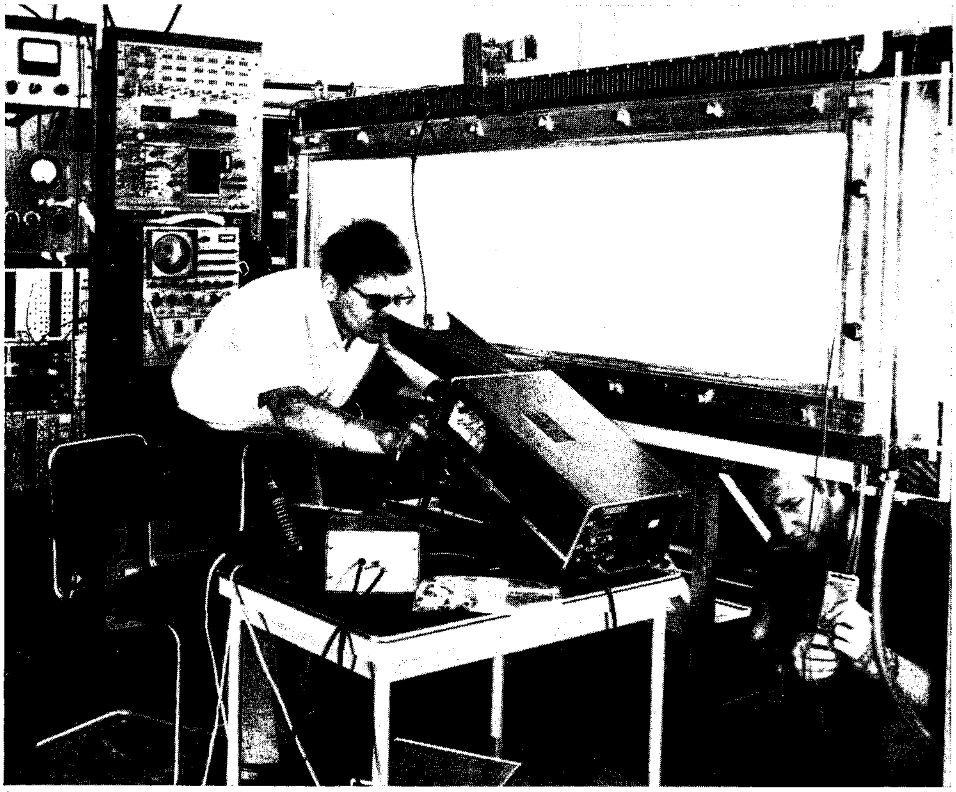
Following the discussion of the conflicting results CERN and Berkeley made a

Left: Mass spectrometers located in 'End Station A' at the Stanford 20 GeV electron linear accelerator. The spectrometers were used in the deep inelastic scattering measurements reported at Kiev. They rotate around a common pivot and from left to right are for 1.6 GeV (circular unit almost off the photograph), 8 GeV and 20 GeV.

(Photo SLAC)

Top right: To continue the study of the neutral kaon with a precision greater than ever yet achieved a CERN-Heidelberg team are building an experiment which will include three large multiwire proportional chambers. The smallest of these is shown being tested. The experiment is due to start after the next shutdown of the 28 GeV proton synchrotron and hopes to record tens of millions of events.

Bottom right: Three graphs summarising the observations on the A2 meson in its three charged modes. The upper one on the left is the A2− showing the splitting observed in the CERN missing mass spectrometer experiments. The upper one on the right is the A2+ showing no splitting observed in the Berkeley bubble chamber experiment. The lower one is the A2° showing the splitting newly observed in the CERN neutral missing mass spectrometer and reported at Kiev.



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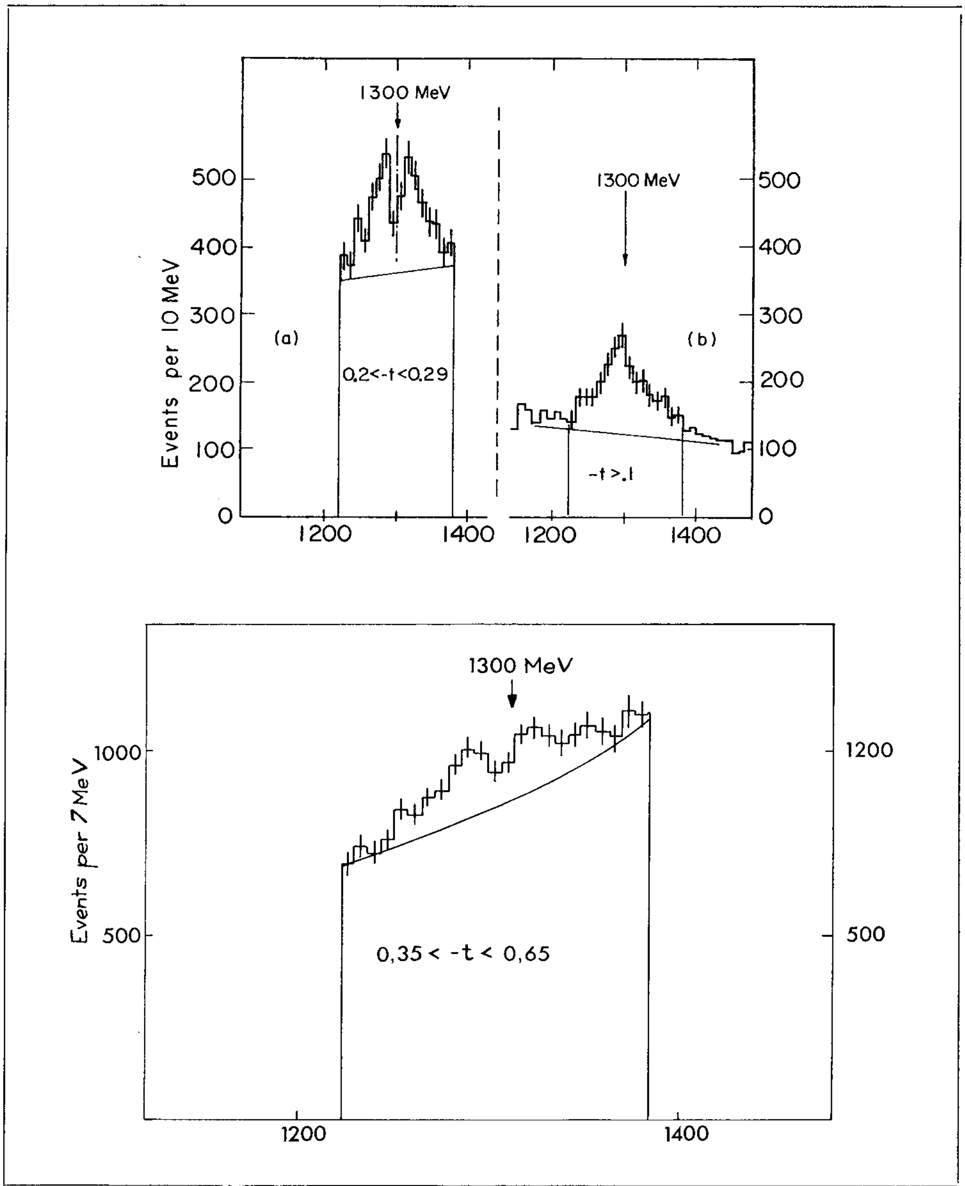


joint statement regarding their results. Its conclusion was that, assuming neither experiment is wrong, the splitting of the A2 depends on its charge (since it is seen in the negative but not in the positive) or on the momentum transfer in the interaction. The CERN results were in the narrow momentum transfer range 0.2 to 0.3 GeV/c^2; the Berkeley range was 0.2 GeV/c^2 and above. If the same narrow range as at CERN is applied to the Berkeley data there is no conflict since their number of events is then an order of magnitude lower than that of CERN and failure to see a splitting is not statistically significant.

However a completely new result was reported at the Kiev conference which reflects back on the joint statement. A Bologna-CERN team used their neutral missing mass spectrometer set-up in the South Hall of the PS to look at the mass region of the neutral A2. The interaction was $\pi^- + p \rightarrow n + A2^\circ$ and events with two charged particles and gamma (from the decay of the neutral particle) together with the neutron were collected. They found the A2° superimposed on the background and the A2° was split. The structure of the splitting agrees well with the results on the A2$^-$.

This new result suggests that the A2 splitting is not charge dependent and it also involved higher momentum transfers than the previous experiments. The evidence leans heavily towards the A2 being a new kind of dipole object which awaits theoretical explanation.

Two general remarks in conclusion. It was very noticeable at the Conference

Dubna Instrumentation Conference

what a great shot in the arm for high energy physics in the Soviet Union the coming into operation of the 76 GeV proton synchrotron at Serpukhov has been. Their results were an important contribution to the Conference and renewed vigour is evident in all aspects of their research. They are making a lot of the opportunities they have in possessing the highest energy accelerator in the world.

The second remark is one which is made many times but which deserves underlining again. The degree of international collaboration in high energy physics is something unique and quite remarkable. We have the collaboration of countries in CERN and the collaboration of countries in Dubna. We have the extensive CERN-Serpukhov collaboration. We have the steady exchange of scientists between Europe and the USA. We have the growing exchange of scientists between the USA and the Soviet Union. A USA team is moving to collaborate in an experiment at Serpukhov. Soviet scientists are spending time at USA Laboratories and will probably propose experiments for Batavia. And there is of course the exchange of information in all directions.

This situation has not fallen out of the sky. Some people have had to believe in it very strongly and to work for it hard. The collaborations are not easy to implement. Each group of people has different ways of doing things and different priorities. To bring them fruitfully together requires careful judgment on the right subjects, the right time and the right scale. The success in terms of work and of human relations was everywhere evident at the Kiev Conference.

As is by now traditional, the Rochester Conference was followed by an 'International Conference on Instrumentation for High Energy Physics'. This year it was held from 8 to 12 September at Dubna and like the Kiev Conference was distinguished by good organization.

The bulk of the Conference was given to reporting the further refinements brought to established techniques for particle detection. On the bubble chamber side there is, in addition to the trend to much larger sensitive volumes, growing interest in rapid cycling techniques to take more pictures per accelerator pulse. At Stanford (SLAC), for example, work is under way to pulse a 1 m bubble chamber at a rate as high as 20 times per second. An on-line vidicon scanning system for use with such a chamber is also being studied at SLAC. Related topics are the ultrasonic bubble chamber research at CERN and Dubna potentially capable of almost continuous sensitivity (see CERN COURIER vol. 8, page 316) and the associated use of counters to fire the chambers or cameras (done for example at Argonne) only when an event of interest is known to have occured.

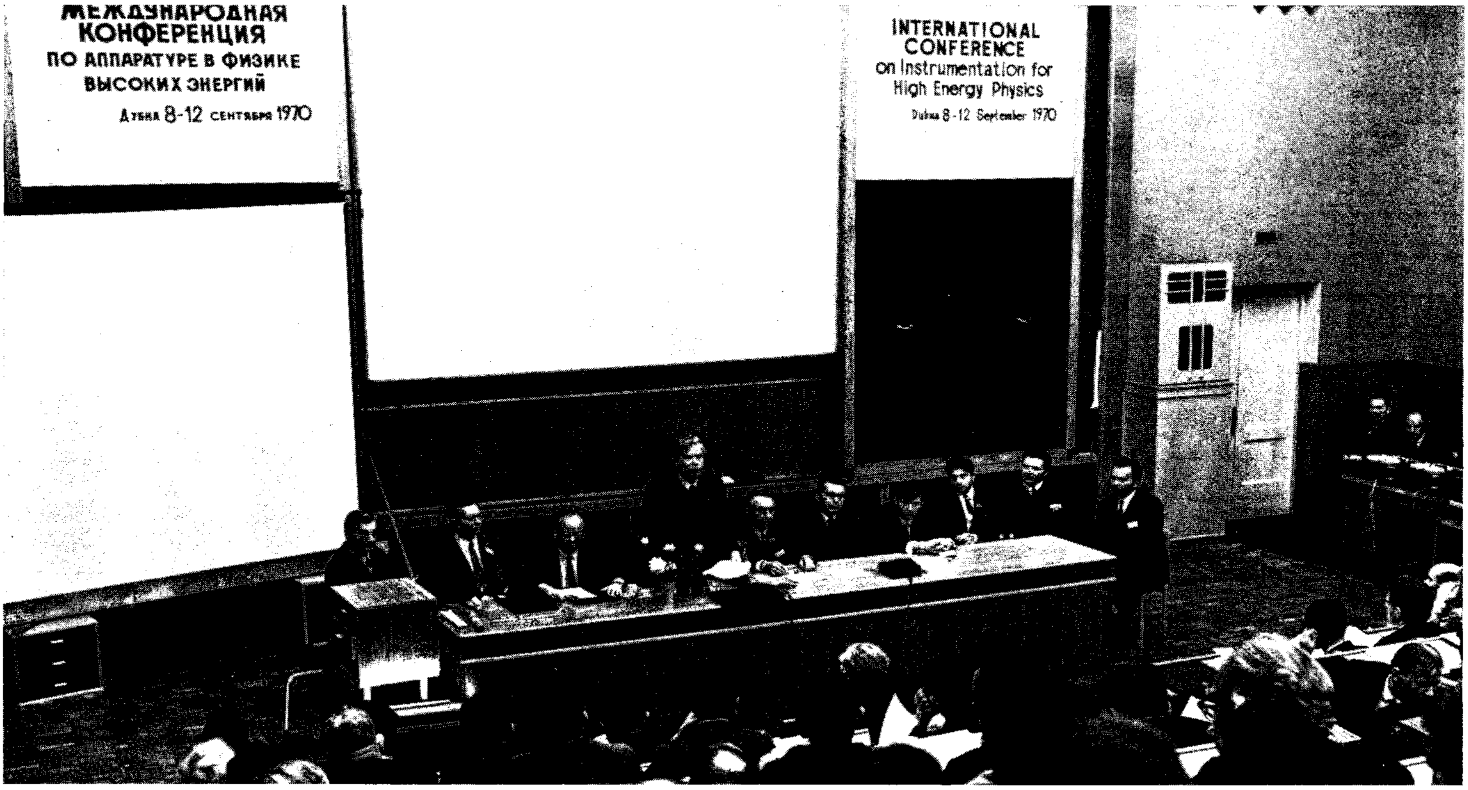
On the electronics experiments side, multiwire proportional chambers developed at CERN (vol. 9, page 174) are now an accepted choice for a wide range of applications — if you can afford them. Wire chambers, read-out systems and associated electronics have become more sophisticated. A CAMAC system to set up and calibrate electronics (ACE — Automatic Calibration of Experiments) has been developed at Daresbury. It is controlled by a computer and has been designed such that with small modification it can plug into any computer. On-line computers have, within a few years, moved from being an innovation to being something we cannot live without. Spectrometer systems are growing bigger, more accurate and more versatile. There is growing mastery of streamer chambers (which should perhaps be listed half way between the bubble chamber and electronics techniques) and there was a particularly nice report on the operation of the chamber at DESY.

Rather than say more on these more established techniques, which we have been covering in any case in CERN COURIER in the normal line of duty, we should like to pick out three comparatively new techniques reported at the Conference, which might — or might not — prove of growing importance in the future.

Liquid filled spark chambers*

Three groups are studying the potential of spark chambers filled with liquid — groups from Novosibirsk, Dubna (led by B.A. Dolgoshein) and Berkeley (reported by R. Muller, the group including L. Alvarez). The aim of this research is to gain a factor of ten in the precision to which a track position can be located (the spatial resolution) compared with gas filled chambers. There seems good reason for hoping that practical liquid chambers will be available in a few years time. This will be nice timing for higher energy accelerators for, without much better spatial resolution or much higher magnetic fields, spark chamber spectrometers will grow to enormous size and cost to cope with higher momentum particles. With liquid chambers plus superconducting magnets it will be possible to measure high momentum particles with a precision now customary only in bubble chambers.

The Berkeley group began with a tube 8 mm diameter filled with liquid argon through which ran an anode wire (diameters varying from 25 to 4 microns). Avalanches were detected (initiated by Compton electrons liberated by a gamma source) but argon proved a rather clumsy liquid. The system always operated in a saturated mode (like a Geiger counter rather than a proportional counter) output pulses being about the same height regardless of the energy of the gamma. The pulses were quite healthy in size (up to 0.5 V) which would make readout simple. The overall efficiency was very low (a few percent), though it increased with increasing voltage. However, particular sections of the wire (hot spots where perhaps there was locally enhanced field gradient) were observed to give zones of nearly 100 % efficiency. The reasons for this are not clear but it was found that



N.N. Bogolubov speaking at the opening ceremony of the Instrumentation Conference at Dubna.

(Photo Yu. Tumanov)

etched tungsten points (about 1 micron radius) always gave hot spots and a simple method of producing large arrays of such points with 25 micron spacing has been developed.

The Novosibirsk group, using argon and a 4 micron diameter wire, believe they have observed the proportional mode. The Dubna group have tried heating the wire to produce bubbles along its surface. The chamber then acts as a two-phase system — initial ionization in the liquid is amplified in the gas bubbles. The idea worked beautifully giving 100 % efficiency with a 100 micron diameter wire but with smaller wire diameters the efficiency fell away rapidly.

Berkeley have just started work with xenon and the results are much more encouraging. The efficiency is up over 50 %, there is no hot spot phenomenon and the rise time of the pulses is only 20 ns (for both points and wires). This holds out the possibility of very good time resolution.

Why charge conduction in xenon is so rapid is not clear. The efforts to produce liquid filled spark chambers are fascinating not only because of their potential as particle detectors, but also because some lovely physics of liquids is going on in the process.

Transition radiation detectors

A Yerevan group, led by A.I. Alikhanian, the Director of the Yerevan Physics Institute, has been studying the possibility of using the phenomenon of 'transition radiation' in particle detection. Most of the related theoretical work has been done by G.M. Garibian. At the Versailles Conference on instrumentation held two years ago, their first attempts to test the technique were reported; at the Dubna Conference they presented the results of further development which have led them to promote this technique for detectors of very high energy particles.

Transition radiation was theoretically predicted in 1946 by V. L. Ginzburg and I.M. Frank. They considered what happens to the field of a charged particle when it moves from one medium to another medium which has different electrodynamic properties. Since the charged particle field will change they showed that radiation is emitted at each transition between different media. At relativistic energies the transition radiation will emerge within a small angle in the forward direction (the angle being proportional to mc^2/E). The integrated intensity of the radiation within this forward cone will depend upon the energy of the particle.

A variety of methods of studying this radiation and its variations (angular distribution and frequency distribution) with type of particle, energy of particle and different media have been tried at Yerevan. They have included observation of electrons over the energy range 20 MeV to 4.5 GeV using glass plates, mylar foils or polystyrene and observing the radiation with photomultipliers, sodium iodide crystals and recently a streamer chamber filled with a xenon-neon mixture. The streamer chamber followed an array of about 1000 mylar foils and photoelectrons were observed in numbers proportional to the radiation intensity and thus to the particle energy. Many foils were needed to achieve sufficient radiation from single particles.

Following the research, a detector of this type is planned for an experiment in which Yerevan is collaborating at Serpukhov. Having selected the momentum of an incoming particle, the transition radiation detector will be used to distinguish between an electron and a pion.

It looks potentially useful for particle energies in the hundreds of GeV region where normal Cherenkov counters have difficulty distinguishing velocities of particles of the same momenta (though the DISC technique looks capable of getting around this) and the use of a streamer chamber could both locate the particle track and, via the transition radiation, give particle identification at the same time.

Hybrid chamber

J. Fischer and S. Shibata have been working at Brookhaven on a detector which tries to combine many of the advantages of the proportional multiwire chambers and of 'conventional' spark chambers. The idea was presented at the Versailles Instrumentation Conference two years ago when the detector went under the name of 'transfer chamber'. It is now known as the 'hybrid chamber' — the offspring of both the proportional and the spark chambers.

V. P. Dzhelepov (left), Director of the Laboratory of Nuclear Problems at Dubna and Chairman of the Organizing Committee, in conversation during the Conference with G. Charpak who has led the work on multiwire proportional chambers.

(Photo Yu. Tumanov)

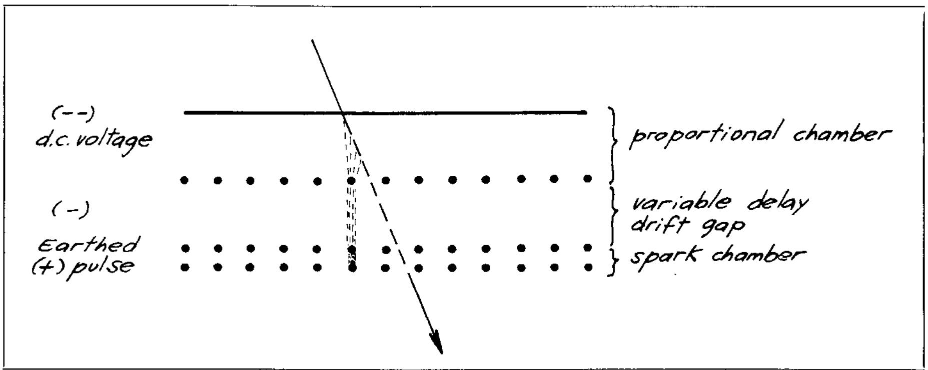


Diagram illustrating the principle of the hybrid chamber developed at Brookhaven. The top gap detects the particle, operating as multiwire proportional chamber, and its information is transferred to a conventional spark chamber, the lowest gap, where it can be read out cheaply.

A major limitation of the spark chamber is its resolving time. When a charged particle passes through, the gas of the chamber holds the ionization produced by the particle for sufficient time while counters and their electronics work out whether the particle is one which should be recorded. If it is to be recorded a high voltage pulse is applied to the chamber and a spark occurs in the ionized wake of the particle. Typically this time in a fairly complex experiment is over 500 ns and during this time the chamber can collect other unwanted charged particles. This limits the particle flux which can be sent through the chamber. The chamber will also take something like 100 μs to 'recover' so as to be ready to record the next particle.

The proportional multiwire chamber is much faster in its resolving time (something like 30 ns) and recovery time (less than 100 ns) and can therefore accept and record a much higher particle flux (provided the event selection electronics can keep pace) being almost continuously sensitive. However, its spacial resolution is generally a little inferior to spark chambers since the wires are spaced out a little more to allow higher amplification of the signal in the gas. Also there is the major problem of the cost of picking the signals from the wires. Amplification (because of the low level of the signals) and delay (to allow the event selection logic time to catch up) usually has to be built in at a cost of about 50 Swiss francs per wire. (Methods of bringing this cost down using special gases to give high amplification and integrated circuit wafers connected to several wires were discussed in CERN COURIER vol. 10, page 152.) This compares with something like 2 Swiss francs per wire for conventional spark chamber magnetostrictive readout.

The hybrid chamber is an attempt to retain as far as possible many of the great advantages of the proportional multiwire chamber while bringing down particularly the cost to near the conventional spark chamber level. The arrangement of the detector is shown in the diagram.

The voltages are so arranged that only the proportional chamber is sensitive to the particle track itself. Some of the electrons produced in the proportional gap will not be collected by the anode wire but will move into the next gap where they drift to the earthed plane of wires, travelling in a direction normal to the plane. The drift time can be varied (depending on the gap width, the type of gas and the applied voltages) so as to allow the event selection electronics time to do their work. If the event is to be recorded, the next gap is then fired as a spark chamber and the electrons which enter will give a pulse on the corresponding wire. This pulse can be detected by the magnetostrictive technique or by core read out. Thus the information from the proportional chamber is transferred to the spark chamber and collected cheaply.

The time resolution is mainly dependent on the selected drift time and can be typically about 75 ns. The recovery time can be kept short since the spark chamber can have a narrow gap and the ions can be quickly cleared so that the chamber is ready to record again. The spatial resolution can approach that of spark chambers since the wires in the proportional chamber can be more closely spaced as less gas amplification in the chamber is needed.

The Brookhaven group have successfully operated a hybrid chamber 15 cm × 15 cm with 75 ns resolving time, less than 80 μs recovery time, efficiency close to 100 % and spacial resolution close to that of spark chambers. A Northeastern University group have built a larger hybrid chamber, 35 cm × 75 cm and achieved a resolving time of 140 ns.

It looks as if the hybrid chamber could prove a useful half-way house between the proportional and spark chambers.

CERN News

A cross-section, taken along the NW-SE axis, of the site alongside the existing CERN Laboratory where it is proposed to construct the 300 GeV proton synchrotron. The top line follows the contour of the surface; the dotted line follows the contour of the top of the underlying molasse. The extent of the molasse makes possible a machine diameter of 2.2 km.

The photograph shows one of the borings being carried out during the site survey.

300 GeV site survey

In June the CERN Council voted a million Swiss francs for detailed studies on the feasibility of installing the 300 GeV European accelerator alongside the present CERN Laboratory. These studies included a number of drillings on the proposed site (see CERN COURIER vol. 10, page 177) in order to discover the quality and shape of the underlying stratum of molasse. The information gained was to supplement that already available as a result of previous drillings made in 1963 and by extrapolation of highly accurate data already existing on the nature of the present CERN ground (determined in the construction of the PS, ISR and transfer tunnels). There were two main questions to be answered:

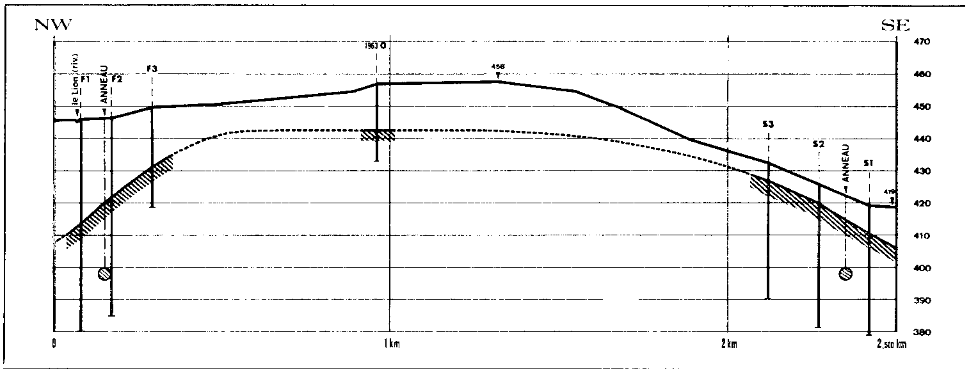
1) what is the largest possible diameter of the ring ?

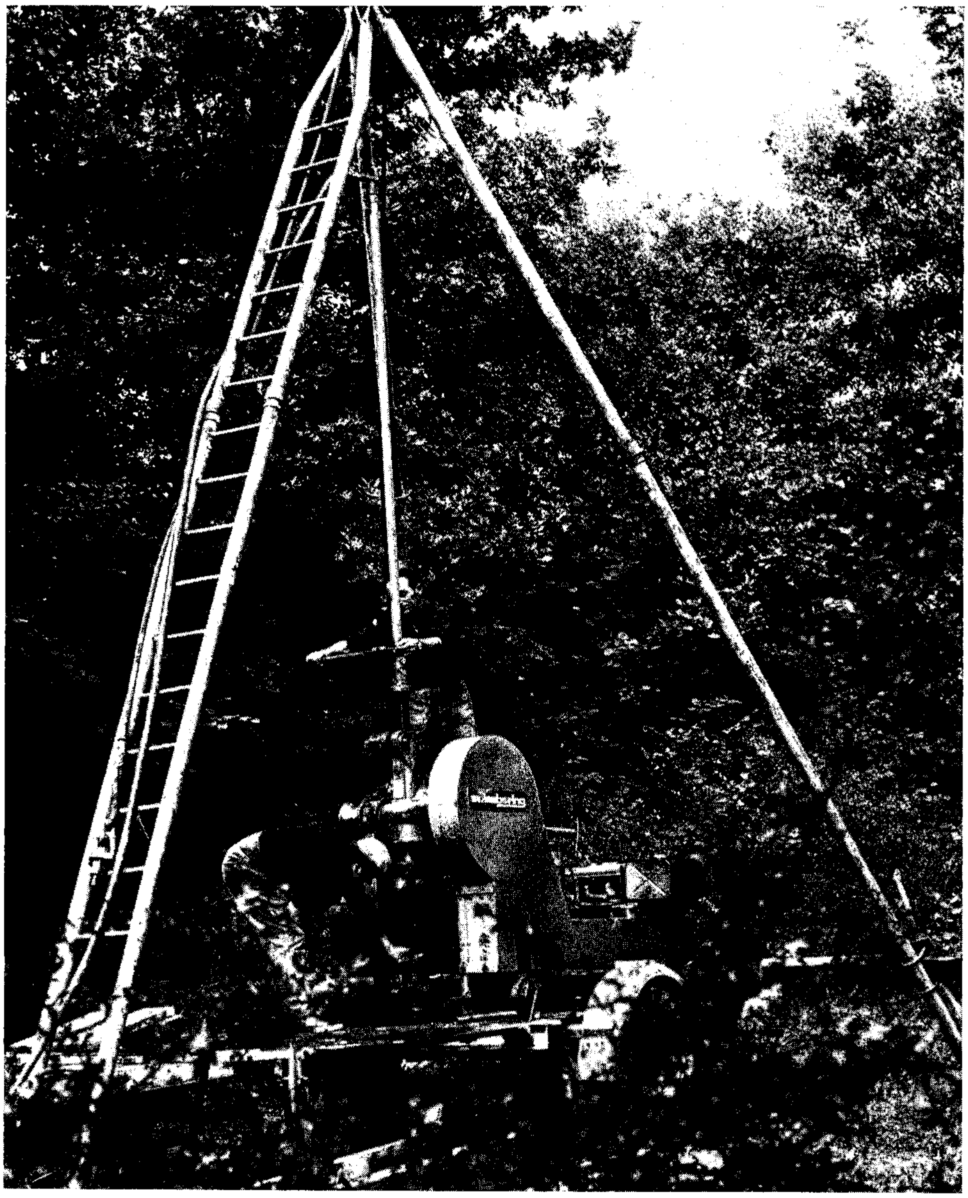
2) is the quality of the rock adequate to receive the machine ?

Drilling points were selected along two perpendicular axes (NW-SE and NE-SW), on the periphery of the ring and along the proposed experimental area, the aim being to obtain cores to depths of up to seventy metres. The work on the NW-SE axis and along part of the ring was completed by the end of August.

1) The drillings made along the NW-SE axis were of prime importance in determining the maximum possible diameter of the machine. In this direction, the subterranean plateau of molasse in which it is intended to bore the tunnel is bounded by two valleys much more sharply marked at the level of the molasse than at ground level. It has been found that the shape of the molasse is such that, in view of the depth at which the tunnel is to be dug (probably about 20 m below the lowest point at ground level), the maximum diameter could be 2.2 km.

At this depth the tunnel will be constructed entirely in the molasse rock. The height difference between the lowest and highest points on the surface over the circumference of the ring is 46 m, and these points lie about 1.5 km apart. Over the experimental area, the difference between the highest and lowest points is less than twenty metres, while the general





CERN/PI 150.8.70

One of the cryostats for the large European bubble chamber arriving at CERN in September. It measures 6.28 m in external diameter, 4.47 m in internal diameter and 1.9 m in height. It weighs 50 tons. The cryostats are manufactured by Alsthom-Neyrpic.

layout greatly helps the natural drainage in this area.

The thickness of the molasse was found by a drilling near the village of Peissy, carried out in 1944 and 1945. The drill was taken down to a depth of 293 metres before it met the limestone supporting the molasse.

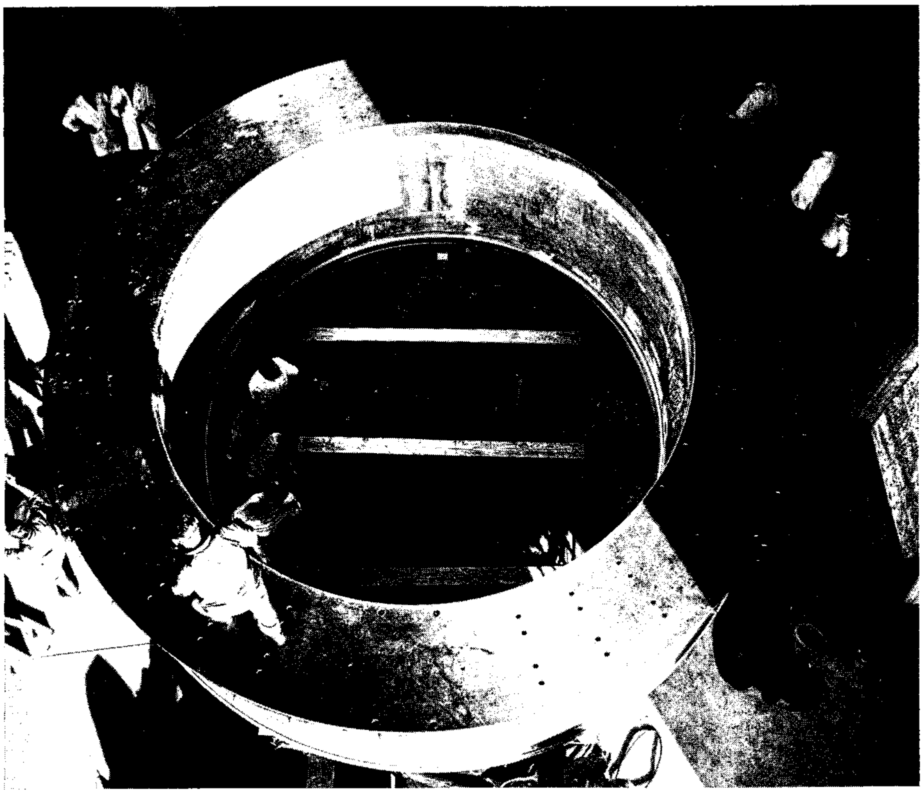
2) The molasse was found to consist of a complex of sandstones and marls of heterogeneous composition at the level of the samples, although cores containing a single piece three metres long have been obtained, indicative of a better quality of rock than on the present CERN site. This type of rock has fairly uniform geotechnical properties.

These results indicate that the ground is suitable for the construction of the machine. Data obtained on the present Laboratory site during the last ten years show that the molasse is sufficiently stable (e.g. 0.1 mm stability in 100 m per annum at the PS level). In addition, the measurements made since May 1970 in the transfer tunnels from the PS to the ISR show the same stability as at the PS (±0.1 mm in five months, both vertically and horizontally). Moreover, these tunnels were blasted out in conditions much more likely to disturb the molasse than the tunnelling machine which it is intended to use to bore the ring for the large accelerator.

BEBC Progress

The main components for the large European hydrogen bubble chamber (the 3.7 m BEBC) are now arriving steadily at CERN. Last month CAFL delivered the disk and the lower ring for the magnetic shield. More recently one of the cryostats arrived from Alsthom-Neyrpic, with the second to follow at the beginning of October. In November or December the two vacuum tanks are expected (from Alsthom and Mannesman), and by mid-December the body support is scheduled from Mannesman. Finally, in April 1971, the body of the chamber itself is to be delivered by the same firm.

At the same time, the building programme is nearing completion, so that it will be possible to begin installing the



CERN/PI 134.9.70

associated equipment, in particular the refrigeration plant, for which the first components have just arrived from Sulzer.

The construction of the chamber, and especially of the large stainless steel vessel has stretched industry to the limit of its capacity and deliveries have been subject to delays (4 months on the cryostats and the chamber body support, 6 months on the body of the chamber). These have been caused mainly by welding and machining difficulties. The delays will affect the completion of the programme and it now seems likely that tests on the assembled chamber, originally planned for the middle of 1971, will take place at the beginning of 1972.

Mortal coils

Within the superconducting coils of the bubble chamber magnet currents can arise by induction when the field rises. These currents could persist for weeks or even years and could be strong enough to cause deformation of the magnetic field. (It is calculated that they may reach 1 to 2 per cent of the theoretical current strength.)

The latest method of eliminating this effect consists of twisting the filaments within the strip (see CERN COURIER, vol. 9, page 22). At the time when manufacture of the conductor strip for the BEBC was being undertaken this technique had only just been discovered and it was impossible to use such twisted filaments without a major change of the programme. It was therefore decided to equip the chamber with precision Hall gauges from which instantaneous maps of the magnetic field can be obtained. These will be taken into account in scanning the photographs.

A very simple additional solution was adopted. It consists of winding in with the superconductor an aluminium heating strip through which a current can be passed (pancake after pancake) at the moment when the magnetic field reaches its maximum (35 kG) so as to cause the conductor abruptly to lose its superconducting property. The resistance in the coil rises and currents quickly disappear and will not return when the superconducting state is re-established, provided there are no significant changes in the field.

Each of the 40 pancakes of the coil requires 250 kJ of energy to bring about the reversion to the normal state. This energy is provided by a current of 1500 A passing for 0.3 s at 600 V. It was therefore necessary to increase the dielectric strength of the winding insulation.

In the course of winding the coil the insulation is being subjected to continuous testing at 2200 V. It was found that ageing effects had destroyed the insulation on two pancakes and necessitated their rewinding. In addition, despite careful examination and cleaning of the strips, it was impossible to exclude metal chips and abrasions completely. Under very high radial stresses their sharp points could cause local damage to the insulator. Since time was available, owing to the delay in delivery of the stainless steel tanks, it was decided to rewind all the 16 pancakes already completed, using a harder and thicker insulation.

By 18 September 10 pancakes had been rewound and it is hoped that the first magnet pole will be finished by the end of October. By the beginning of September, 50 km of the superconducting strip (75 per cent of the contract) had been delivered by Siemens and Thomson Houston and had met the specification.

Interest in CERN solutions

Solutions worked out for the large European chamber are proving of interest to the designers of the 30 m^3 hydrogen bubble chamber, to be built for the 200/500 GeV accelerator at Batavia, for which the plans have just been approved. They aim to have their first cool-down in July 1972 so as to be ready for physics in January 1973. In view of the short time schedule, they are adopting solutions rather than working through the design from scratch themselves. They are interested in adopting the optics (fisheyes and lenses) and the honeycomb plastic piston design (see CERN COURIER vol. 9, page 65) of the European chamber. Manufacture of these components for Batavia may be carried out by European firms as has been the case for some components of the Batavia accelerator itself.

Computing and Data Processing School

The 1970 CERN Computing and Data Processing School was held at Villa Monastero, Varenna, Italy from 30 August to 12 September. This was the first of its type to be organized by CERN and was, in a way, an experiment to test the belief that it would be to their mutual benefit for computer scientists and experimental physicists to rub shoulders and ideas together.

Computer science has been evolving rapidly in recent years and has successfully tackled some of the basic concepts underlying the techniques used in various branches of computing and has made some headway in establishing a theoretical foundation for computing. Experimental physics on the other hand is making ever increasing use of computing to record and analyse growing volumes of data.

The two disciplines have a different approach to computing and an awareness on each side of the problems and potential of the other side was expected to be fruitful. The computer scientist could gain from the opportunity to study closely the problems of data processing applications which arise in experimental physics. The physicist could gain from being able to see his empirical use of computers in the wider conceptual framework of computer science.

66 young students from 16 countries (predominantly Western European but including Poland and USSR) attended the School.

The programme was established by an Advisory Committee consisting of computer scientists and high energy physicists from the CERN member states. It contained courses mainly on programming languages, data processing in high energy physics, and data structures, and on computers in space research, computer graphics, and computer systems. Two evening lectures were also given on 'The Impact of computers on nuclear science' and on 'Artificial intelligence'.

Judging from the reactions of the students recorded at the end of the School, it proved very successful. The computer scientists gained a more precise feeling for the practical problems in handling large volumes of data and perhaps particularly a realization that the most elegant solutions may not always be the most efficient. The physicists learned that there are other useful programming languages and techniques besides those in common use at present and gained a deeper understanding of the methods that they are using. An example of the latter was the course that was given on data structures because of their immediate relevance to the practical problems faced by experimental physicists. ('Data structures' concerns the way in which large volumes of information can be organized in the computer — selecting from among the different methods of storing the raw information in the computer is an important factor in the ease of manipulation of the information to draw out the results.) It was also intriguing to hear that high energy physicists are not alone in their problems of sheer quantity of information. The data processing of experiments carried out in satellites involves similar problems on a scale at least an order of magnitude larger.

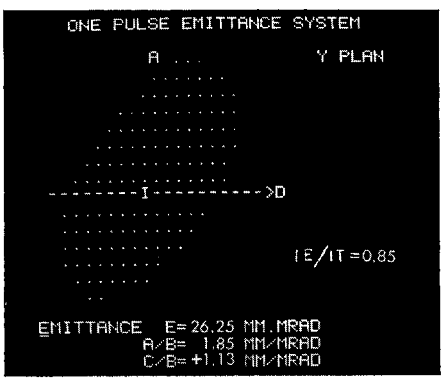
In addition, of course, both sides benefited from the informal discussions and personal contacts which are always a large fraction of the usefulness of any Conference or School.

It is intended to hold further Schools of this type in the future but their frequency and any change in emphasis compared to this first trial run remain to be decided.

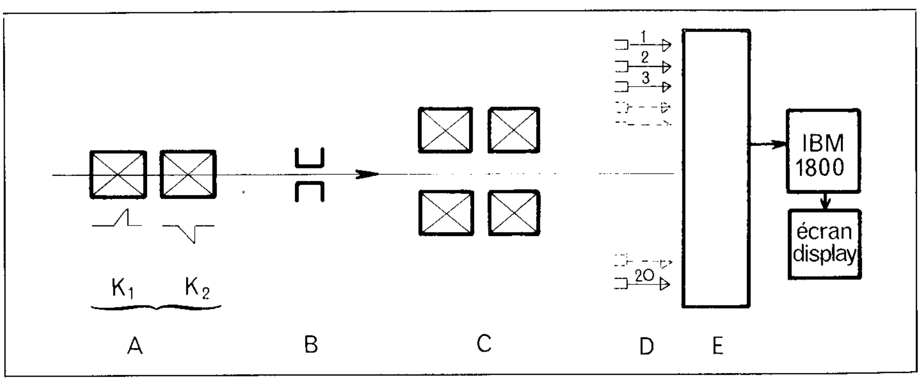
Linac beam in its cups

A new system is being developed for the very rapid measurement of the beam emittance in the 50 MeV linac at the PS.

At present, the emittance is measured by moving a slit across the beam so as to pick out a piece of the cross-section. By means of a focusing system and of a second slit placed further along the beam path it is then possible to determine the emittance ellipse. The method of measurement destroys the beam and takes 100 PS pulses which are thus lost for experimental use. The results are average beam characteristics over 100 pulses, and since there are slight fluctuations between



The linac beam emittance as it appears on a TV screen. A new very rapid system of emittance monitoring is described in the article.



The diagram illustrates the units of the system. Magnets (A) deflect the beam across a slit (B). A focusing arrangement (C) preceeds an array of 20 Faraday cup detectors (D) and electronics (E) link the system to a computer. Applying triangular pulses in opposite polarity to the magnets K1 and K2 causes the beam to sweep across the slit in 10 μs.

pulses it is not possible to obtain very exact data on the beam.

The new system is being developed to give automatic measurement of the beam emittance taking only 10 μs per pulse. This will not only use much less of the beam, but will also allow a more exact and rapid determination of beam characteristics. This will be particularly important when the Booster is commissioned, both because the Linac-Booster injection line is more complex than that between the Linac and the PS, and also because very accurate beam emittance adjustment will be necessary.

The new system will be linked to an on-line computer for direct data processing. The design principles are illustrated in the diagram.

The mechanically operated slit is replaced by a fixed slit, and the beam is deflected radially by means of two magnets excited in opposite polarity by a triangular pulse. The beam is thus made to sweep across the aperture in 10 μs. Through a focusing arrangement the beam is then directed onto a series of twenty thin elongated (1 mm × 80 mm) Faraday cups. With one sweep of the beam over the slit lasting only 10 μs it will be possible to select a part of the linac pulse (which lasts 20 μs at present, and is to be extended to 100 μs in the course of the PS Improvement Programme).

The optics of the focusing system between the slit and the Faraday cups are such that, from the signals received, the emittance of the beam and other beam characteristics such as the charge distribution over the beam cross-section, can be calculated (the voltage signal from the Faraday cups is proportional to the beam intensity). The signal from the Faraday cups will be divided into twenty 0.5 μs pulses, each giving an integrated value of the signal received in this time interval. This process will be controlled by a quartz crystal oscillator.

The number of 20 readings (10 μs divided by 0.5 μs) and of 20 Faraday cups were chosen arbitrarily, and could be made higher; they do, however, ensure sufficient accuracy (400 separate measurements). The emittance ellipse and the main parameters can be displayed on a TV screen.

The system can be used for measurements on high intensity beams, provided that corrections are made for the effect of space charge which arises between the slit and the cups.

The system opens two novel possibilities:

1. The voltage from the Faraday cups can be compared with a standard voltage of opposite sign so that a signal will then appear only above a certain threshold. Hence, by selecting the level of the standard voltage, it is possible to determine emittance ellipses corresponding to different proton densities, or to determine the beam intensity within a given emittance.

2. It is also possible, by a little readjustment of the focusing system, to obtain a zooming effect, as in a variable-focus camera, and to 'magnify' a chosen emittance area for more detailed study.

The new system is scheduled to be installed by the spring of 1971. It will be used on a special beam line, at the output end of the linac, so designed that its characteristics correspond exactly to those of the main beam. In conjunction with it will be installed a system for measuring the energy spread which we shall be discussing shortly. At a later stage it is planned to control the beam automatically, by a servo-loop fed by data from the systems measuring emittance and energy spread.

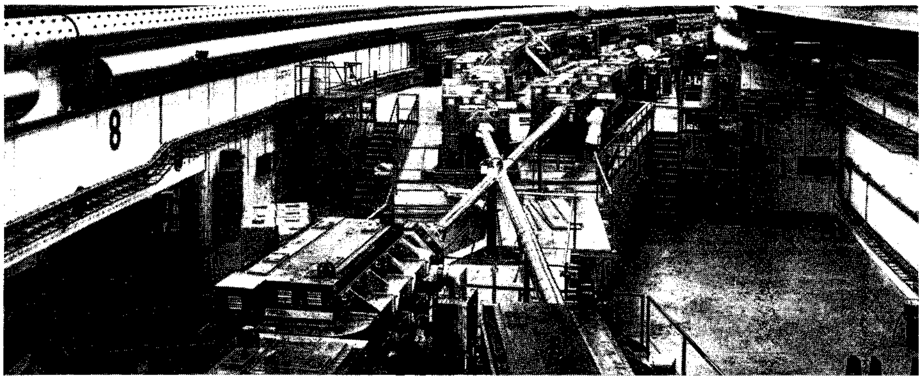
A system involving the use of an on-line computer for the rapid calculation and display of beam emittance and proton density characteristics is in use at Batavia during the commissioning of their 200 MeV linac and an equivalent system is also being developed for LAMPF at Los Alamos.

Beam to ISR

On 3 September, a 15 GeV proton beam was passed for the first time from the PS along the full length of a transfer channel (TT2) to the ISR. It crossed the frontier without the usual customs formalities through a 450 m long underground tunnel and finished in a concrete block placed at the entrance to the storage rings. The block is being used temporarily to absorb the beam until things are ready for injection into a ring of the ISR themselves. The positioning of the beam at this point was achieved with an accuracy of 5 mm in both the horizontal and vertical planes. This was also the first time that a proton beam of this energy had travelled over French territory — the most powerful up to then being the 3 GeV proton beams at Saturne.

The accuracy of beam positioning, remarkable for a first shot, stems first of all from the precise alignment (to within one or two tenths of a millimetre) of the

By the middle of September three of the intersection regions of the ISR were equipped with their vacuum chambers. The photographs from top to bottom are of I8, I2 and I6. By the end of October it is scheduled to have the vacuum chambers in all eight intersection regions and one ring will be 'closed' and baked out. Completion and baking out of the second ring will follow soon after.



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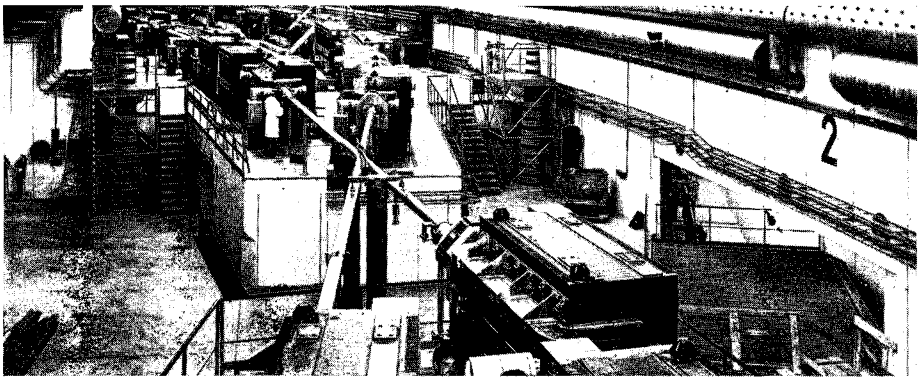

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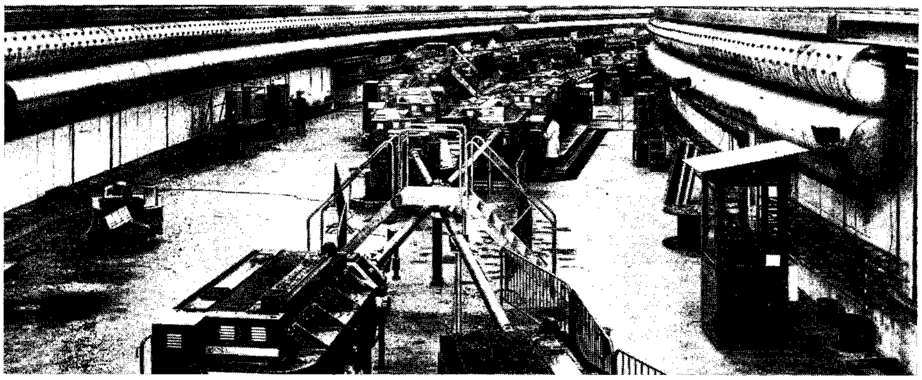

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70 magnetic elements in the transfer lines; this was in itself an achievement as, unlike the situation in normal accelerators, it was necessary to align in three-dimensions since the transfer channels climb up a gradient rising 11.4 m between the PS and the ISR. The performance of the bending magnets (Alsthom), and focusing lenses (Brown Boveri), and of the power supplies (Brentford Electric) also contributed to this high accuracy.

Hitherto the beam had been confined to a 30 m long section adjacent to the PS (CERN COURIER vol. 10, page 147) where since April 1970 a series of tests has been carried out, enabling the finishing touches to be applied to the power supplies and their remote control and also to the beam detectors. The power supplies (of which there are 30 as some elements are connected in series) are linked to the ISR Argus computer. For the time being the computer is used to set up the beam-line conditions and not to control them via a feedback loop, although it is planned to introduce control at a later stage in a semi-automatic mode.

Intensity losses along the transfer line have been almost non-existant (not detectable). This has enabled work in the channels to be continued without problems due to induced radioactivity.

At the end of September channel TTI (400 m) is due to take a beam along its full length. Both transfer channels will then be ready to feed proton beams into the rings of the ISR. First injection into the ISR is planned for this coming November.

Small superconducting lenses

In connection with the development of a negative hyperon beam which could provide the basis for an important series of experiments (involving collaboration between Orsay, the Ecole Polytechnique and CERN), the Engineering Group of the Nuclear Physics Division have designed two superconducting quadrupole lenses. The quadrupoles are now being constructed.

In view of the short lifetime of hyperons, and especially of the sigma minus whose mean free path does not exceed 60 cm at 16 GeV/c, it is desirable to make the beam line between the target where the hyperons are produced and the detectors as short as possible. The aim was therefore to construct short quadrupoles, giving a high field gradient and having an external diameter small enough to be accommodated in the space between the coils of two larger magnets used for deflecting the beam.

The two quadrupoles, respectively 30 cm and 60 cm in length, have cobalt-steel cores, which means that a field of 25 kG can be produced at the poles without reaching saturation. The field gradient is designed to be 11 kG/cm. The external diameter of both lenses is 13.5 cm with an aperture for the beam of 3 cm.

The superconductor is of the intrinsically stable type and is supplied by IMI (UK). It is 0.5 mm in diameter and contains 61 twisted niobium-titanium filaments of 50 micron diameter, carrying a current of 120 A (i.e. a current density of approximately 40 000 A/cm^2). With conventional coils the current density would be several times smaller, necessitating physically larger lenses which could not have been fitted into the beam line.

The superconducting coils with their cobalt-steel cores are immersed in liquid helium (4.2° K at atmospheric pressure) in a thin-walled cryostat. Heat shields cooled by liquid nitrogen reduce radiation heat losses.

Since the quantities of helium in the cryostats are very small it is proposed to feed in the helium continuously through a long transfer line. The daily helium consumption is estimated at 100 litres, the gas being recovered.

Correction

A correction needs to be made to the information given in the August issue: In reviewing the experimental programme at Serpukhov (page 258) we mentioned that a link between the small computer on-line to the CERN-Serpukhov missing mass experiment, and the main Serpukhov computer (BEMC 6) was being developed. The computer which is on-line at Serpukhov is an IBM 1800 not, as was stated, a CDC 3100.

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CERN/PI 361.9.70

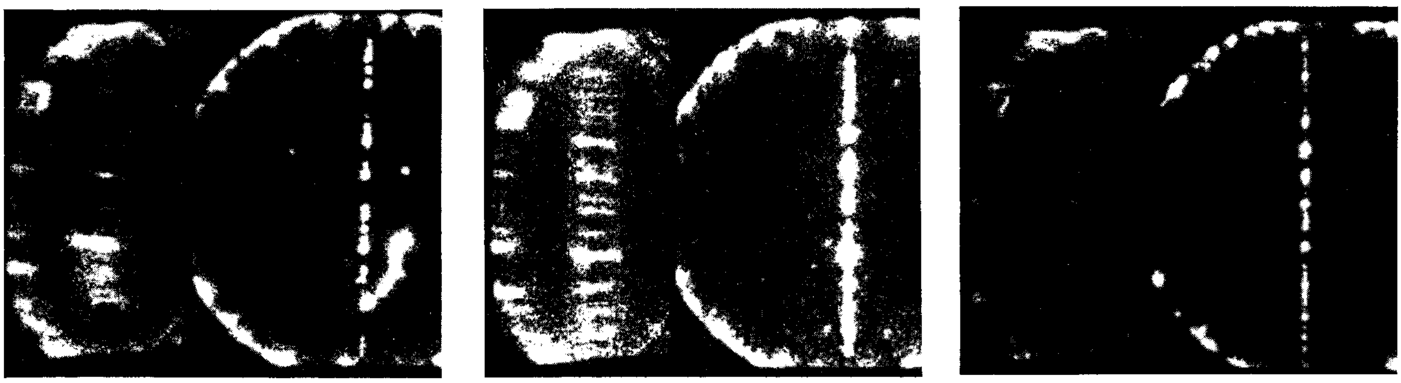
On 16 September the agreement covering collaboration between the European Southern Observatory and the European Organization for Nuclear Research was signed at CERN by the Director Generals of ESO (Professor A. Blaauw, left) and of CERN (Professor B.P. Gregory, right). The work of ESO and a general description of the terms of the agreement appeared in vol. 10, page 248.

CERN/PI 373.9.70

On 24 September the UK Secretary of State for Education and Science, Mrs. Margaret Thatcher, paid an informal visit to CERN. She is photographed here with Dr. P. H. Standley in the control room of the 28 GeV proton synchrotron. During her visit Mrs. Thatcher toured the site and discussed with the CERN Directorate the present and future programmes of high energy physics in Europe.

Around the Laboratories

Three photographs of streamers in hydrogen taken at Argonne. They record tracks of 1 GeV/c negative pions viewed on the right parallel to the applied field and on the left viewed via a 45° mirror.



ARGONNE
Streamers in Hydrogen

A programme similar to that at CERN (reported in vol. 10, page 229) for the development of a hydrogen streamer chamber was begun in the High Energy Facilities Division of the Argonne National Laboratory about a year ago. Preliminary tests in hydrogen were rather encouraging and results were reported at the 1970 Spring Meeting in Washington.

Streamers were observed in a circular glass cell one inch high and six inches in diameter, filled with hydrogen at atmospheric pressure. The applied field was approximately 40 kV/cm, produced by a small Marx generator. The generator pulses were short-circuited by a spark gap, producing pulses with a 4 ns rise time and a base width of 12 ns. The streamers were photographed with a lens f = 1.4. The photographs, obtained last winter, show tracks of 1 GeV/c negative pions — the portions to the right are the direct view parallel to the applied electric field; the portions to the left are seen via a 45° mirror and are out of focus due to the rather small depth of field. The streamer density is about a factor of two to three lower than expected from the primary ionization of the particles.

Similar pictures were obtained with the chamber filled with deuterium with no marked difference in brightness of the streamers.

Unfortunately, the output voltage of the Marx generator was not sufficient to operate chambers with wider gaps, thus in the pictures the streamers extend from one electrode to the other. Furthermore, at the circumference of the electrodes, corona-induced breakdowns are visible and only with a very careful design of the electrodes can one hope to eliminate them.

At present, an effort is under way to study streamers in gases at low temperatures, beginning with neon. The aim is a high density hydrogen streamer chamber which operates as a target and as an isotropic detector at the same time.

Similar work is also under way at Dubna and it was reported at the Dubna Instrumentation Conference that V.I. Komarov and O.V. Savchenko have photographed streamers in hydrogen with an admixture of helium.

DARESBURY
Study Weekend

The first of a series of study weekends was held at the Daresbury Nuclear Physics Laboratory on 13-14 June to discuss the problem of vector meson production and omega-rho interference. The proceedings of this meeting are to be published at the end of September.

Speakers were invited from nearly all the European and USA high energy electron accelerator Laboratories as well as from CERN. The participants were all directly involved in the field under discussion, thus ensuring a lively interest in the whole proceedings. Such meetings are useful supplements to the large biennial meetings.

There has recently been theoretical interest in the study of two pion photoproduction, in order to describe the pion mass spectrum observed in photoproduction. This should put the extraction of the resonance contribution on a theoretical rather than an empirical footing. The discrepancy over the width of the rho as found in storage ring experiments on the one hand, and photoproduction and strong interaction experiments on the other, was resolved when a common formula was used to fit the experimental spectra.

Since the Electron/Photon Conference at Liverpool in September 1969, values for the vector meson coupling constant $\gamma_\varrho^2/4\pi$ obtained from rho-photoproduction off complex nuclei by DESY and Cornell groups are now in agreement, DESY giving a value 0.57 ± 0.10 and Cornell 0.62 ± 0.10. These values are also compatible with the Orsay Storage Ring value of 0.46 ± 0.02. The same degree of agreement does not exist for the omega meson, whose values of $\gamma_\omega^2/4\pi$ from two photoproduction experiments, also on complex nuclei, at Cornell by a Rochester/Cornell group and at DESY by a Bonn/Pisa group, are about a factor of two larger than the Orsay value. It is clear that further analysis and experiments are required to bring the measure of agreement over the omega parameters to the same state as the rho.

In the field of omega-rho interference, further evidence was presented from both strong and electromagnetic interaction experiments. A compilation of πp, $\bar{p}p$ and Kp experiments which have seen, or claim to have seen, effects of omega-rho interference was presented. Analysis of these experiments is considerably complicated by the lack of knowledge of the strong interaction contribution, so only a lower limit can be placed on the value of the omega-rho mixing parameter in each case.

Two diagrams of the superconducting linac as it is envisaged at present at the Stanford Linear Accelerator Laboratory.

1. A cross-section of the accelerator at a position where r.f. power is fed in, showing also how the cooling and insulation is arranged.

2. A section along the length of the accelerator.

The mixing parameter has been most accurately measured at Orsay in the reaction $e^+e^- \to \pi^+\pi^-$ and at Daresbury through the process $\gamma C \to \pi^+\pi^- C$, although in the former case there is an inconsistency between the magnitude of the effect and the relative phase. The interference phenomenon in the photoproduction reaction has been suggested as an alternative method for determining the cross-section for omega production off complex nuclei and hence $\gamma\omega^2/4\pi$ and $\gamma_{\omega N}$.

In the case of photoproduction of lepton pairs, there is a disagreement over the relative production phase between the Daresbury experiment, which gives $\Phi\omega\varrho = +100^\circ \, ^{+38^\circ}_{-30^\circ}$ and the DESY experiment which gives $41^\circ \pm 14^\circ$. This discrepancy may be resolved when the results of both groups are known on asymmetric electron-positron photoproduction. This experiment measures the real part of both the rho and omega photoproduction amplitudes and therefore the relative rho-omega phase.

Preliminary results were presented from the first experiments with Adone at Frascati. Initial experiments have observed wide angle electron-positron pairs and have shown them to be consistent with the predictions of quantum electrodynamics. The first unexpected result to emerge is the observation by several groups of a large cross-section for multipion (four or more) production of the order of 10^{-32} cm^2 for centre-of-mass energies around 2 GeV, which cannot be explained by existing models.

Future topics for these study weekends include kaon decay and pion electroproduction.

STANFORD (SLAC)

Towards a 100 GeV superconducting linac

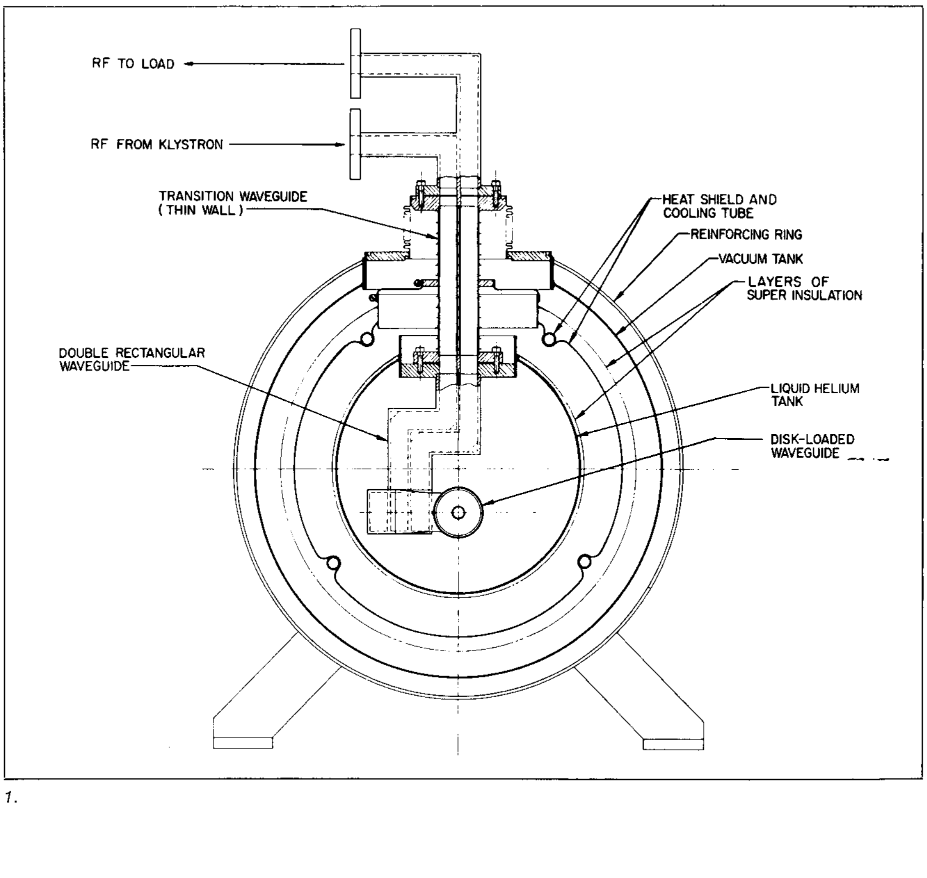
For over a year scientists at the Stanford Linear Accelerator Centre have been studying the possibility of converting the two mile 20 GeV electron linac into a superconducting machine of much higher energy and much longer duty cycle. While providing a machine which will open up physics inaccessible with accelerators in operation at present, the study has attempted to keep within the bounds of what is likely to be technically and financially feasible in the near future and has also attempted to make the maximum possible use of the existing facilities surrounding the 20 GeV machine.

The energy has been selected as 100 GeV which will imply an energy gradient along the accelerator of 33 MeV/m. To help achieve this very high gradient the present proposal is to use a 'travelling wave resonant ring' structure which could have advantages in terms of the ratio between effective and peak field gradient by comparison with standing wave structures. The operating frequency (2856 MHz) and the mode ($2\pi/3$) would be the same as for the existing machine and parts of the existing waveguide system could be retained.

In addition to higher peak energy, the second great advantage of the superconducting linear accelerator is the possibility of a long duty cycle (the percentage of time for which the machine is providing beam) when the power losses drop dramatically due to the use of superconducting cavities. How far it is possible to go in this direction is limited by the demand on the refrigeration plant which has to absorb power losses and retain the superconducting temperature. To keep refrigeration costs acceptable, a 6 % duty cycle (about a hundred times longer than with the existing machine) at full 100 GeV energy will be possible. When the converted machine is run at lower energy, the duty cycle could be increased (to 100 % at 25 GeV, for example) while still staying within the capacity of the refrigeration plant (14.2 kW at 1.85° C with a liquid helium refrigeration system).

The proposed beam current is 48 μA peak, 3 μA average, at 100 GeV. A peak r.f. power of 4.8 MW will be needed and, using 240 klystrons as on the existing machine, each klystron will need to supply only 20 kW peak power which is a thousand times less than from the present klystrons.

It is estimated that five years would be necessary for the final design and construction of the superconducting accelerator. Of this time only the last two years



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would bring an interruption to the physics programme at the Laboratory while installation and testing took place. The tentative cost estimates are put at between $ 70 million and $ 80 million.

The superconducting accelerator with its much higher energy and longer duty cycle would greatly extend the range of research which is possible with electron and photon beams and would push the study of quantum electrodynamics much further. As a bonus, intense beams of hadrons could be produced from the high energy electron beam and, in particular, neutral kaon beams uncontaminated by neutrons, which is a problem at proton synchrotrons, would be available.

Research programme
Project Leapfrog

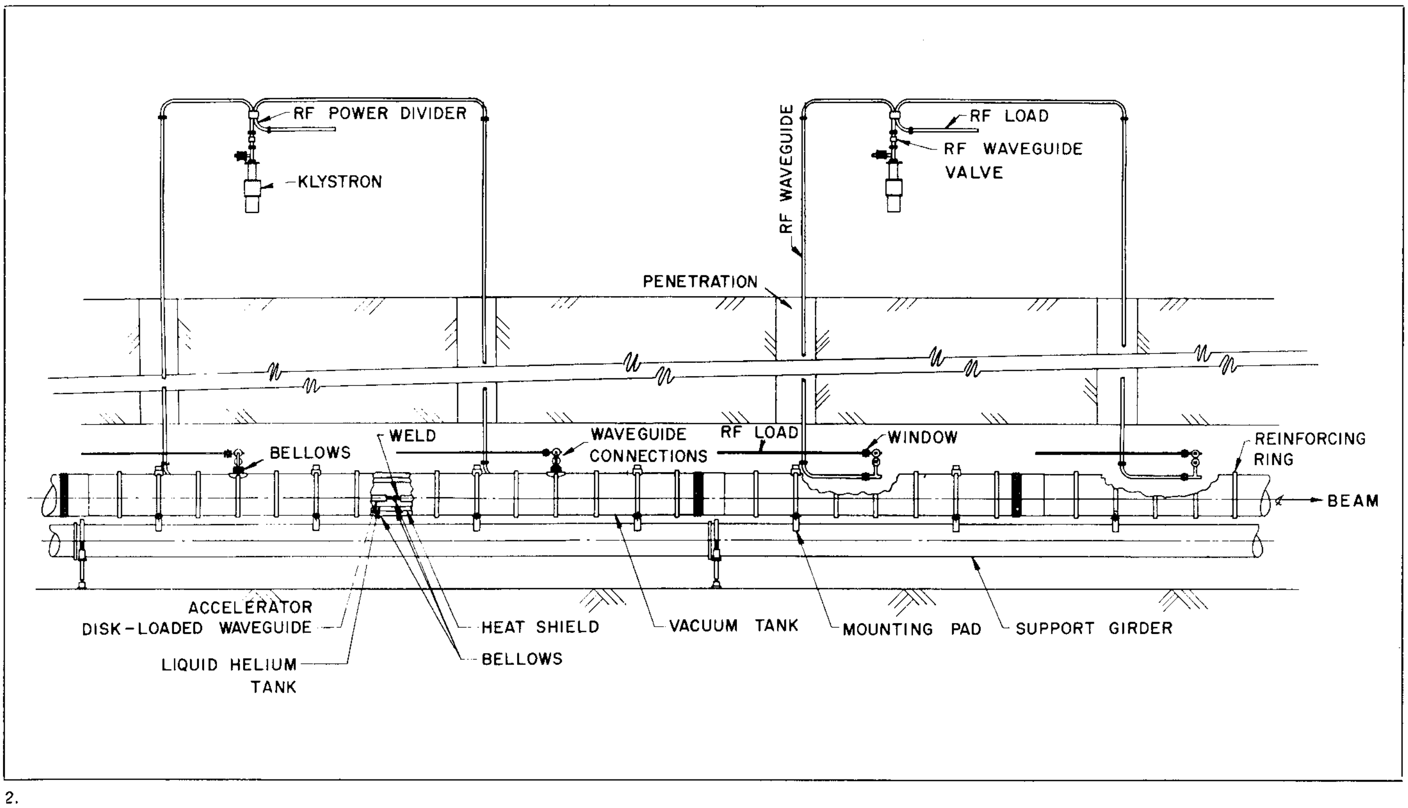
However, before the stage is reached where a solid proposal can be formulated and money sought for a superconducting conversion, a variety of technological problems will have to be thoroughly mastered. To this end a two-pronged attack is being launched at SLAC.

The first prong is a systematic study of the properties of superconducting materials as applied in linac cavities. Experiments are being carried out with material samples and single cavities, studying such things as — maximum voltage gradient which can be sustained, optimization of structure shapes, susceptibility to radiation damage, thermal properties and fabrication techniques. The aim of an energy gradient of 33 MeV/m (implying a peak electric field of 55 MV/m and a magnetic field of 1 kG at the superconducting surface) will be no picnic to achieve in a large accelerator which has to operate with a high degree of reliability.

The second prong is known as 'Project Leapfrog' since it aims to jump over some of the basic research stages in tackling immediately the construction and operation of what is effectively a small piece of the proposed superconducting accelerator. A section of 15 cavities, 52.5 cm long, is to be built by the end of 1970 and it is intended to operate it with an electron beam (giving an energy of 17 MeV) next year. Most of the parameters for Project Leapfrog are the same as for the proposed 100 GeV accelerator. This will meet many of the difficulties head on and may reveal construction or operation problems which cannot be predicted with such a new type of machine.

During the first stage of tests with Leapfrog (before it is used with a beam) it will be installed in a vertical dewar (about 2 ft in diameter and 5 ft high) for ease of construction. The effectiveness of the resonant ring method of operation will be tested to decide whether to persist with it for the 100 GeV. Important information will also be gained on techniques of r.f. field control.

A new horizontal dewar will later be built for operation with an electron beam. A modified SLAC electron gun capable of 1 mA continuous current (to work with very long duty cycles) will feed in the beam via a prebuncher and, possibly, a chopper. Beam analysis equipment will receive the electrons at the output end and will be used to study energy, beam loading



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effects, etc., and, possibly, beam break-up instabilities.

A more thorough description of this research programme can be found in a paper by P. B. Wilson, R. B. Neal, G. A. Loew, H. A. Hogg, W. B. Herrmannsfeldt, R. H. Helm and M.A. Allen to appear in the journal 'Particle Accelerators'.

The SLAC team have benefited from close contact with their neighbours at the Stanford University High Energy Physics Laboratory (HEPL) where many pioneering contributions to the development of superconducting linacs have emerged. HEPL have a programme for the construction of a 2 GeV electron linac (which could be extended to give 8 GeV electrons by arranging for the particles to pass through the linac several times). Their work has been reported in CERN COURIER vol. 8, page 239 and vol. 9, page 261.

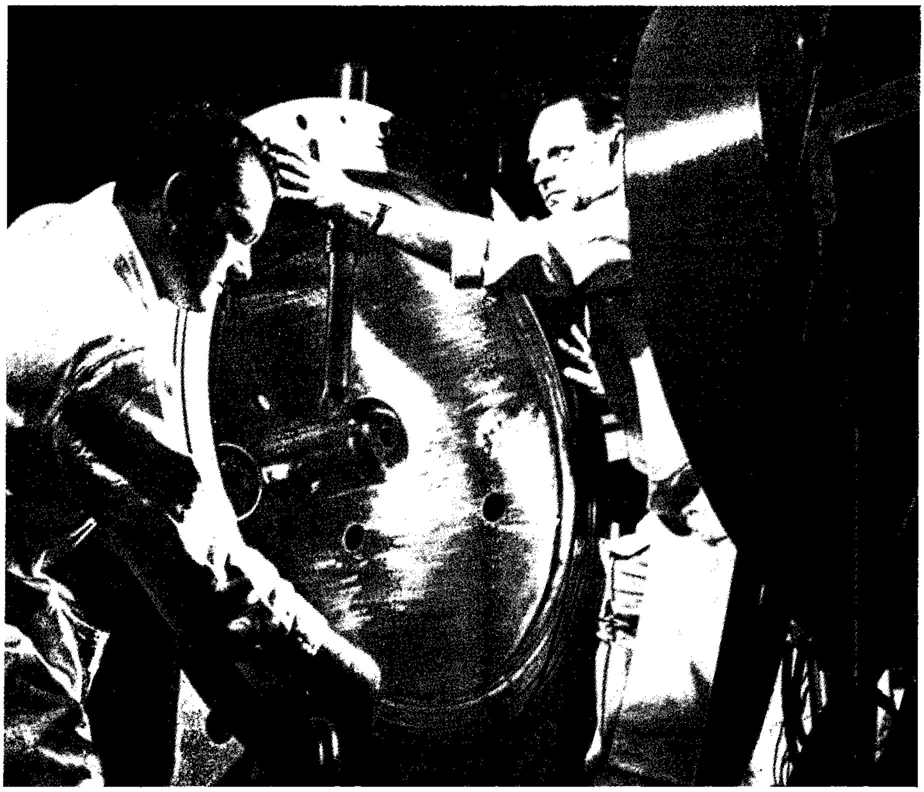
The 500 foot tunnel, 30 foot underground, to house the machine is complete and the experimental area and the recirculation tunnel are under construction. They too hope to have a section of the accelerator in operation by the end of this year.

BROOKHAVEN
Linac gives 210 mA

As part of the Conversion Project at the Brookhaven Alternating Gradient Synchrotron the energy at which protons are injected into the main magnet ring is being raised to 200 MeV by means of a new linear accelerator. This higher injection energy should make possible the acceleration of at least 10^{13} particles per pulse to peak energy of 33 GeV.

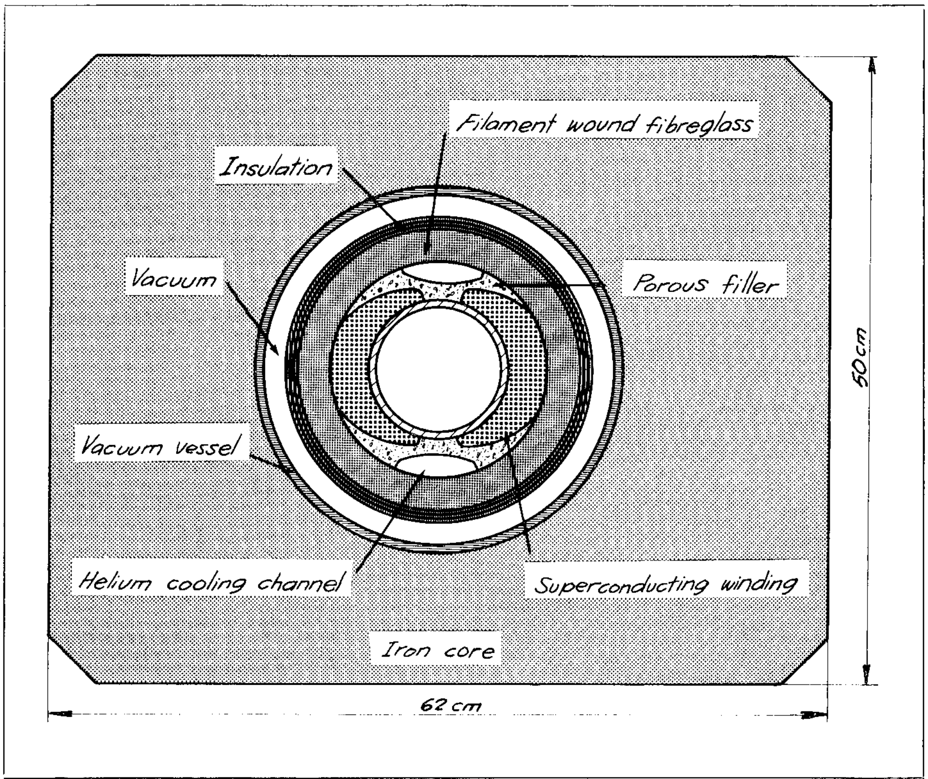
Protons were first accelerated to 10 MeV through tank 1 of the new linac in March of this year. In August the performance of this first section was improved to yield beams of 210 mA at 10 MeV (a proton linac intensity exceeded only by the mighty MTA accelerator in the 1950s). The linac is designed to cope with a peak intensity of 200 mA with a guaranteed intensity of 100 mA.

The achievement of such a high current not only increases confidence in the success of this part of the Conversion Project but also looks very encouraging for the



A section of tank 2 of the Brookhaven 200 MeV linac being manoeuvred into place in August. A beam of 210 mA has been accelerated to 10 MeV in tank 1.

(Photo BNL)



The Berkeley conceptual design of a pulsed superconducting magnet such as could be used in a proton synchrotron.

off-shoot project to use nine out of ten linac pulses for radio-chemistry experiments and isotope production (BLIP - Brookhaven Linac Isotope Producer).

Tank 2 of the linac was being installed in August and tanks 3 to 7 are already in place. There are nine tanks in all. It is hoped to have a 200 MeV beam by the end of the year but the link to the magnet ring will await the next AGS shut down in May 1971.

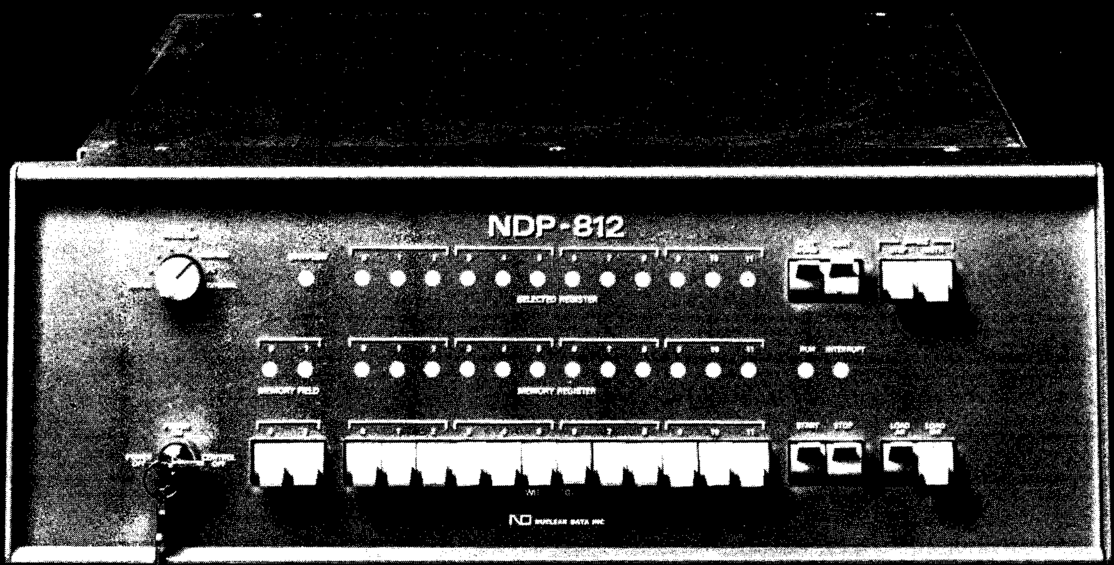
BERKELEY
Superconductivity studies

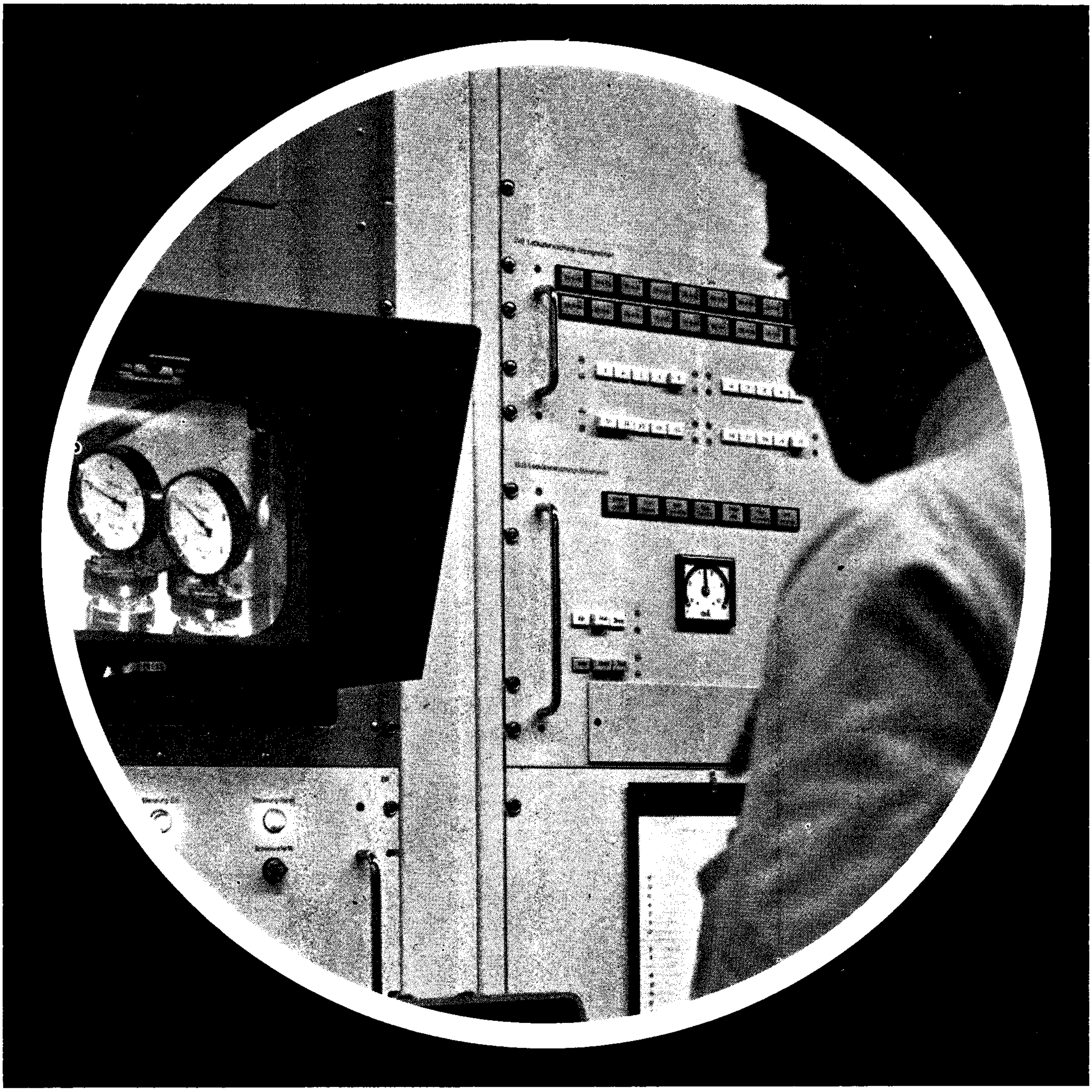
As mentioned several times before in CERN COURIER a small group at the Lawrence Radiation Laboratory, Berkeley (led by W.S. Gilbert and R. Menser) is one of the teams studying the application of superconductivity at high energy physics Laboratories both for experimental area equipment and for pulsed synchrotron magnets. The following gives a few details of their work.

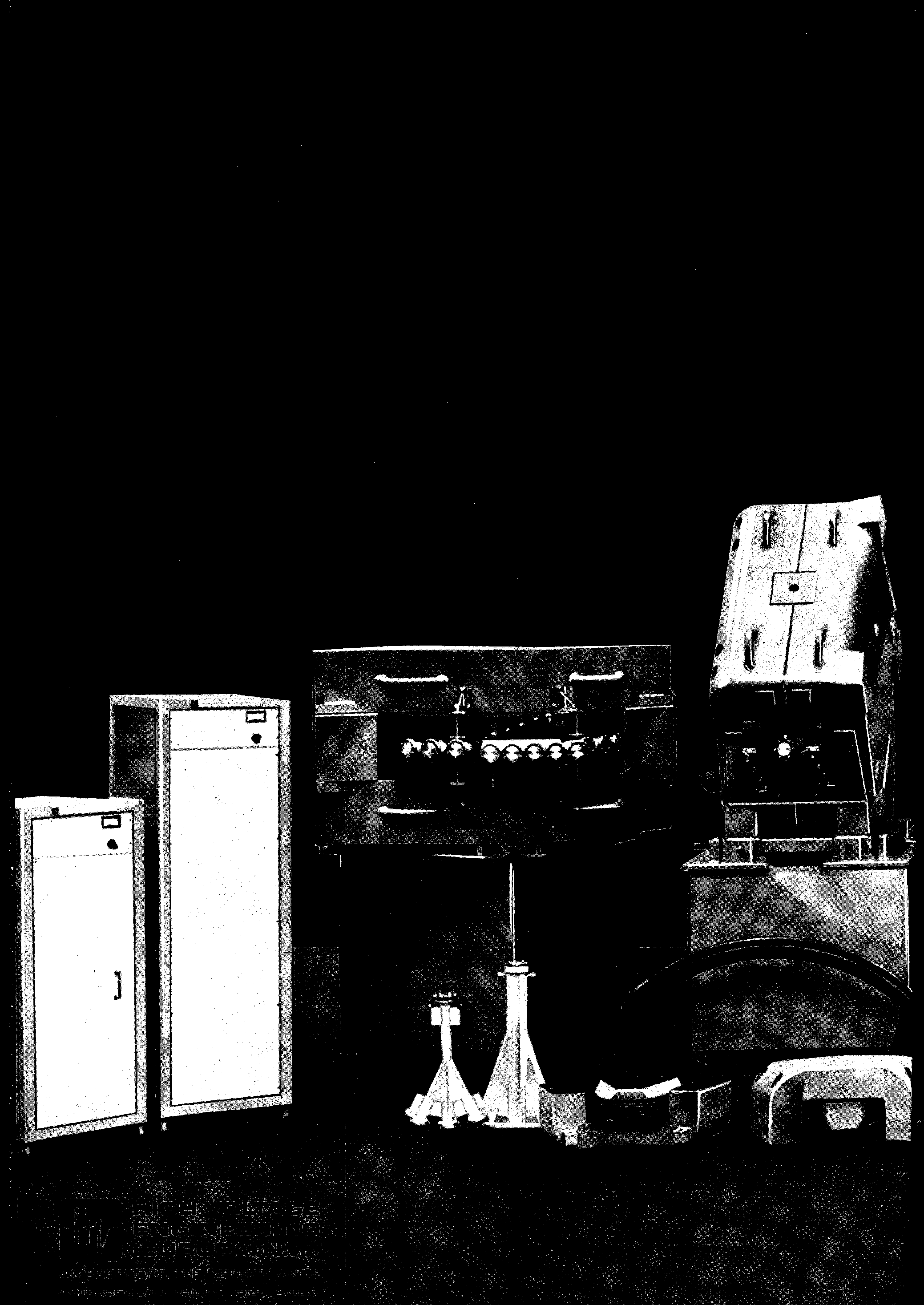
The group participated in a collaborative programme with Batavia (carried out at Berkeley) to develop superconducting magnets such as could be used in the beam transport lines for very high energy beams (200-500 GeV range). A typical dipole was built and successfully operated having a 10 cm internal diameter and a field of about 30 kG (27 kG without iron core, 35 kG with iron core added). The magnet was 45 cm long and constructed of flat pancakes of rectangular twisted multicore conductor bent into shape. Previously a 90 cm solenoid with an axial field of 60 kG was constructed to gain experience of operation in a physics experiment. It operated successfully for $5\,{}^1/_2$ months at the 184 inch cyclotron.

For use in the experimental area of the 6 GeV Bevatron, magnets with larger internal diameter are needed and a bending magnet and a quadrupole doublet are now under construction. The bending magnet is a dipole, 130 cm long in its cryostat, with an internal diameter of 20 cm. It is designed to produce a field of 40 kG. The doublet has the same internal diameter, each quadrupole being 75 cm long both mounted in the same cryostat. The design field gradient is 2.4 kG/cm.

Fundamental studies on the behaviour of superconductor of various types under pulsed conditions, related cryogenic problems, etc., are under way with a view to achieving pulsed superconducting magnets for use in a synchrotron. At present the conceptual design of such a magnet is as shown in the diagram. The internal diameter available for the beam is 10 cm and the design field is 50 kG. Multifilament (filament diameter $7\ \mu$) niobium titanium superconductor is used. Several magnets based on these design concepts are being developed.


NDP-812

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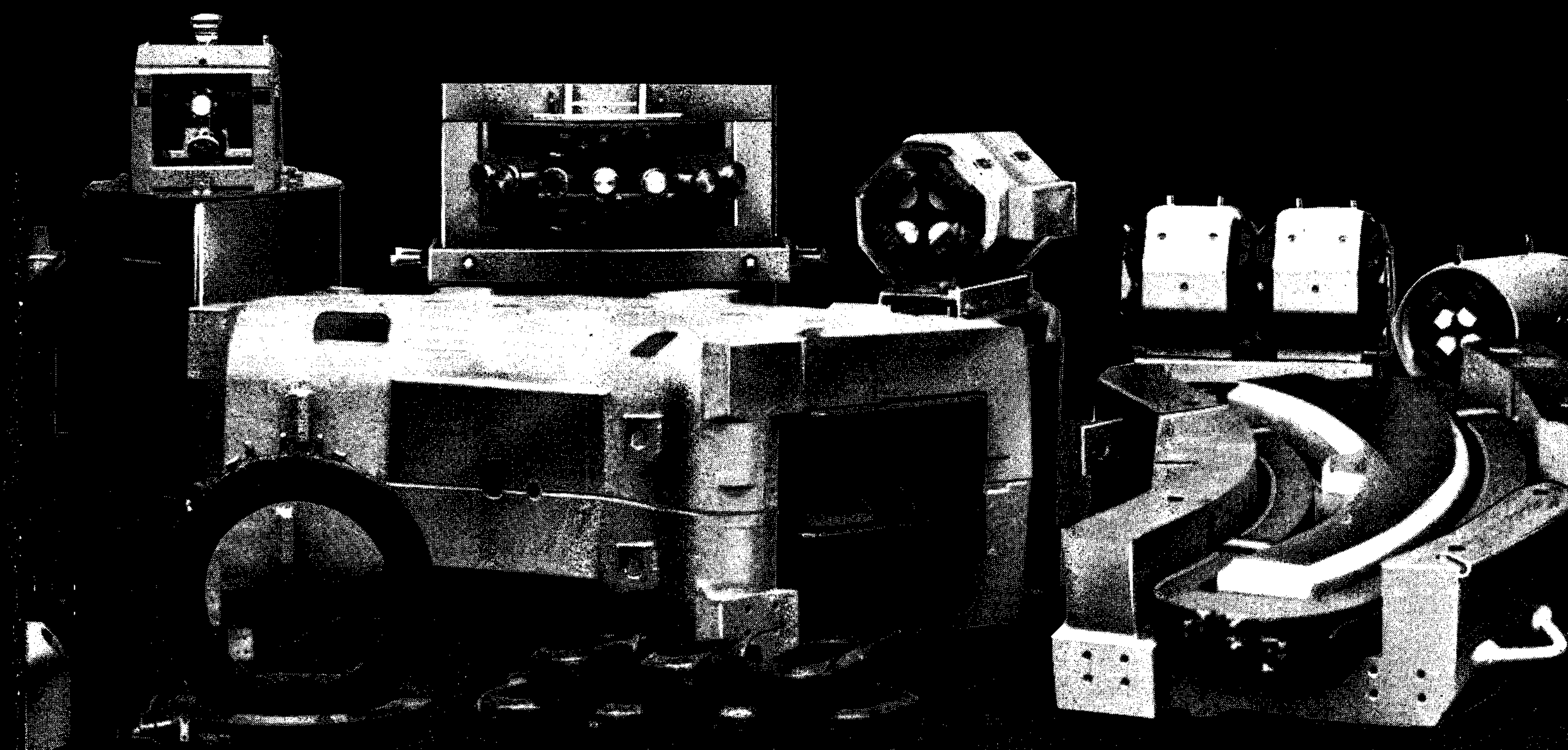
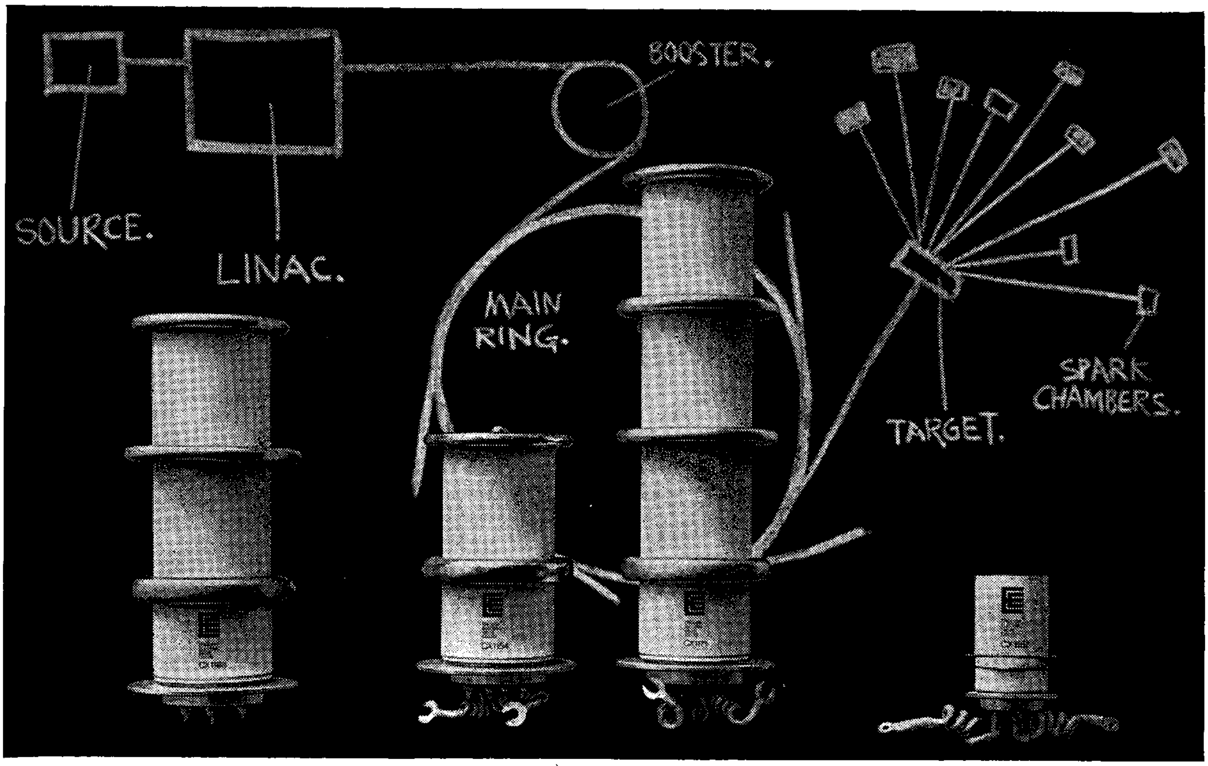


EEV thyratrons give greater accuracy and better performance in three major nuclear physics applications:



Linear accelerators

☐ EEV thyratrons can withstand peak inverse voltages up to 20 kV following a pulse.
☐ Their operation is unaffected by small reservoir voltage variations.
☐ EEV thyratrons need no servicing and give trouble-free operation in oil-filled equipment.

Particle accelerators

☐ EEV thyratrons ensure reliable firing. They give nano-second accuracy.
☐ There are very few missing pulses.
☐ They require no external gas supply.
☐ Because they have an annular current flow EEV thyratrons can switch peak currents very rapidly without risk of arc extinction. When fitted into coaxial housings rates of rise of current up to 100kA/μsec are possible.

Spark chambers

☐ Long life is important for spark chamber operation – and EEV thyratrons have given 10,000 hours service in some cases.
☐ Spurious firing is virtually eliminated.
☐ Jitter is kept as low as 1 ns.
☐ They make possible repetition rates of up to 50 kHz due to very rapid deionisation characteristics.
☐ EEV thyratrons operate over a wide range of H.T. voltages at currents up to 10 kA without change in characteristics – so drive units may be used with different chambers.
☐ The low trigger voltage means that simple firing circuits are possible.

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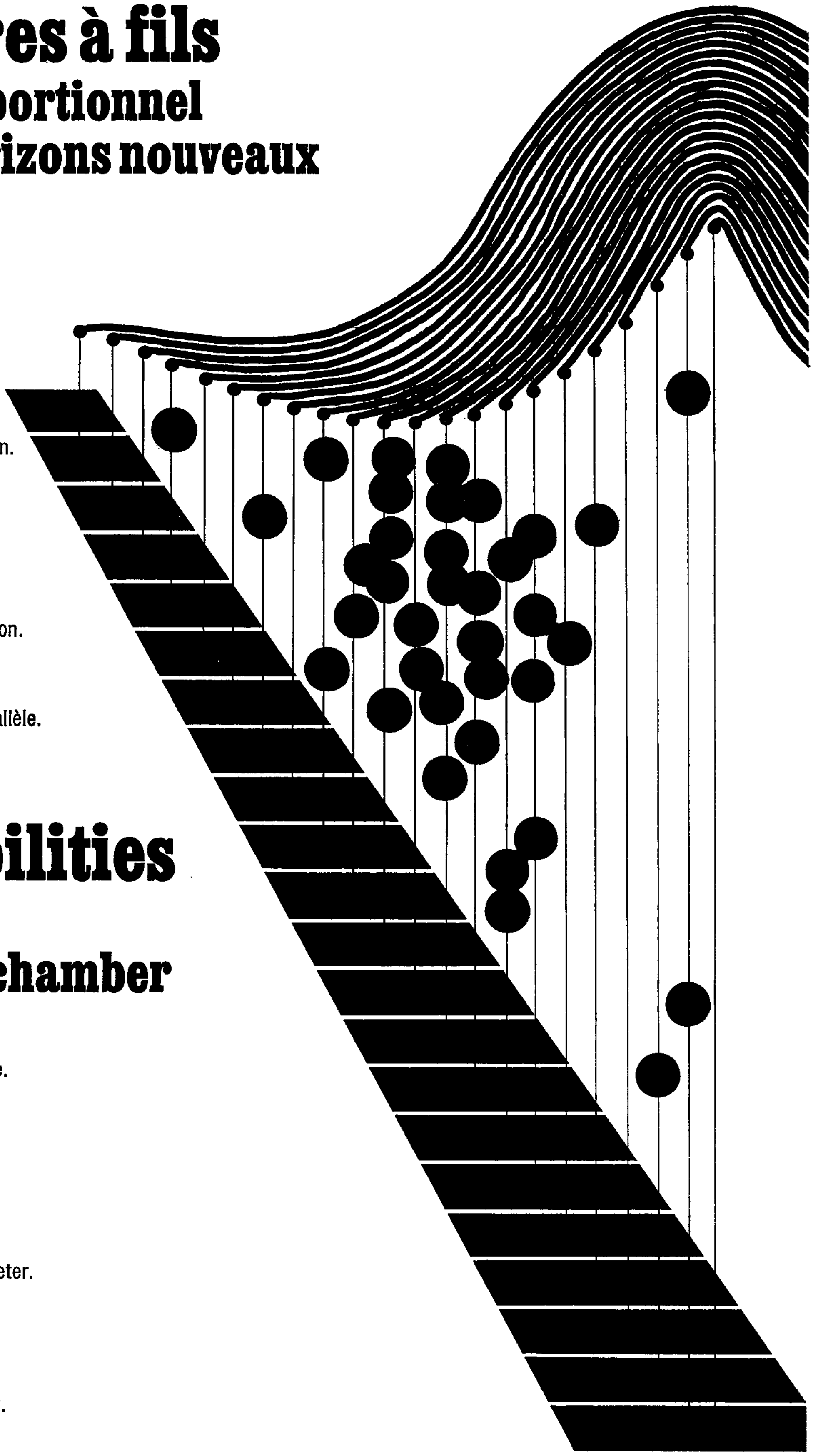

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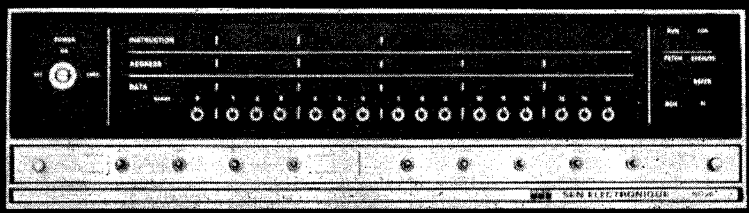

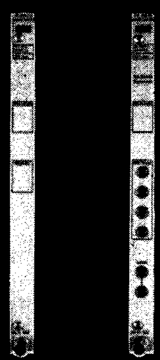

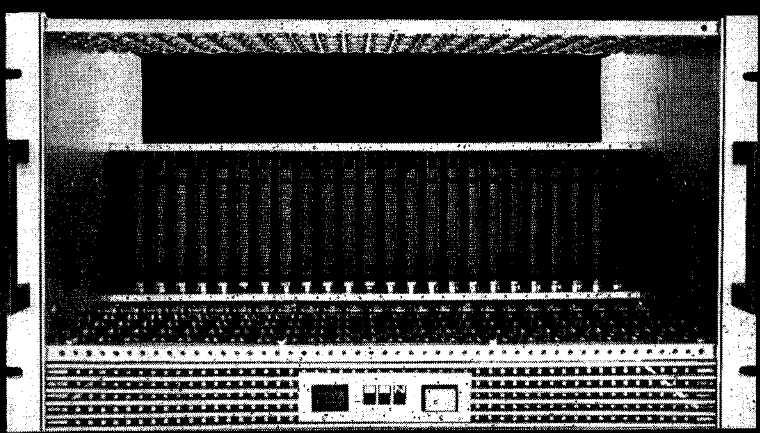

CAMAC PROCESSOR, NOVA OR SUPERNOVA

Two I-O and software compatible 16-bit machines. Four accumulators, two of which may be used as index registers. Basic memory 4 k, expendable to 32 k. Every 4k block can be replaced by 1k read-only memory. Automatic interrupt-source-identification. Four mode data channel is standard: data in, data out, add to memory, increment memory.
Many peripheral devices available, extensive library includes relocatable assembler, Basic interpreter.
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A two station controller providing the best link between the Camac bus and the NOVA I-O bus. Each crate uses one I-O channel.
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200 W available output power. Extensive protection against overcurrent, overvoltage and overheating. Multi-fan cooling.

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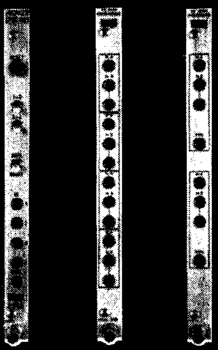
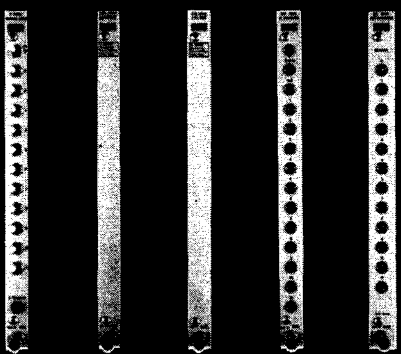
CAMAC SYSTEMS



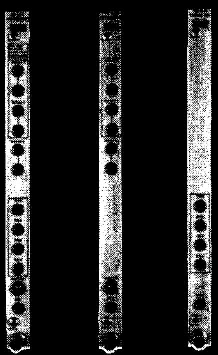
SCALERS

4 S 2003	Four fold 16 bit scaler meets CERN 003 specs.
4 S 2004	Four fold 16 bit scaler, 30 MHz, convenient input gating, L-mask, really low cost.
2 S 2024	Dual 24 bit 150 MHz scaler, the fastest Camac scaler available, surprisingly low cost.



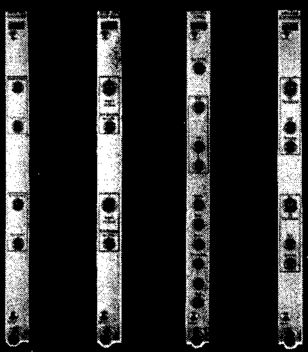
IN/OUT REGISTERS

P 2005	12 bit switch register with L-request.
2 OR 2008	Dual 16 bit output register, provides 32 bits as TTL levels.
2 IR 2010	Dual 16 bit input register, samples and stores 32 TTL levels.
SIR 2026	Strobed input register, accepts 12 narrow NIM pulses.
OR 2027	12 bit NIM output register, the way to control fast NIM electronics at about $15 per control variable.



CRT DISPLAY MODULES

A truly modular and expandable system: DD 2012 for random or sequential point plots, CD 2018 for ASCII character generation, VG 2028 the vector generator for the ultimate in graphics convenience. DD 2012 and CD 2018 can be used alone or coupled, DD 2012 is prerequisite for VG 2028. Provision for light pen or joy stick.



CONVERTERS, TIMER

2 DA 2011	Dual 10 bit D-to-A converter.
2 DVM 2013	Dual digital voltmeter, integrating converter, ± 100 mV range.
RTC 2014	Real time clock, to be used as computer clock, time interval meter or preset scaler.
2 IPE 2019	Dual Incremental Position Encoder, digitizes X-Y motion with any type of incremental transducers.

Ask for data sheets and descriptive literature.

Other modules are available or in the development stage: A-crate controller, Five-fold scaler for magnetostrictive spark chambers, "Busy-Done Module"...

Leasing facilities available.

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ELECTRONIQUE

Olivetti P 203

Programmation, logique, mise en mémoire, grande vitesse de fonctionnement, impression alphanumérique: toutes ces caractéristiques sont alliées dans le P 203 Olivetti à une simplicité d'emploi, à des dimensions qui permettent de l'installer dans tous les bureaux.
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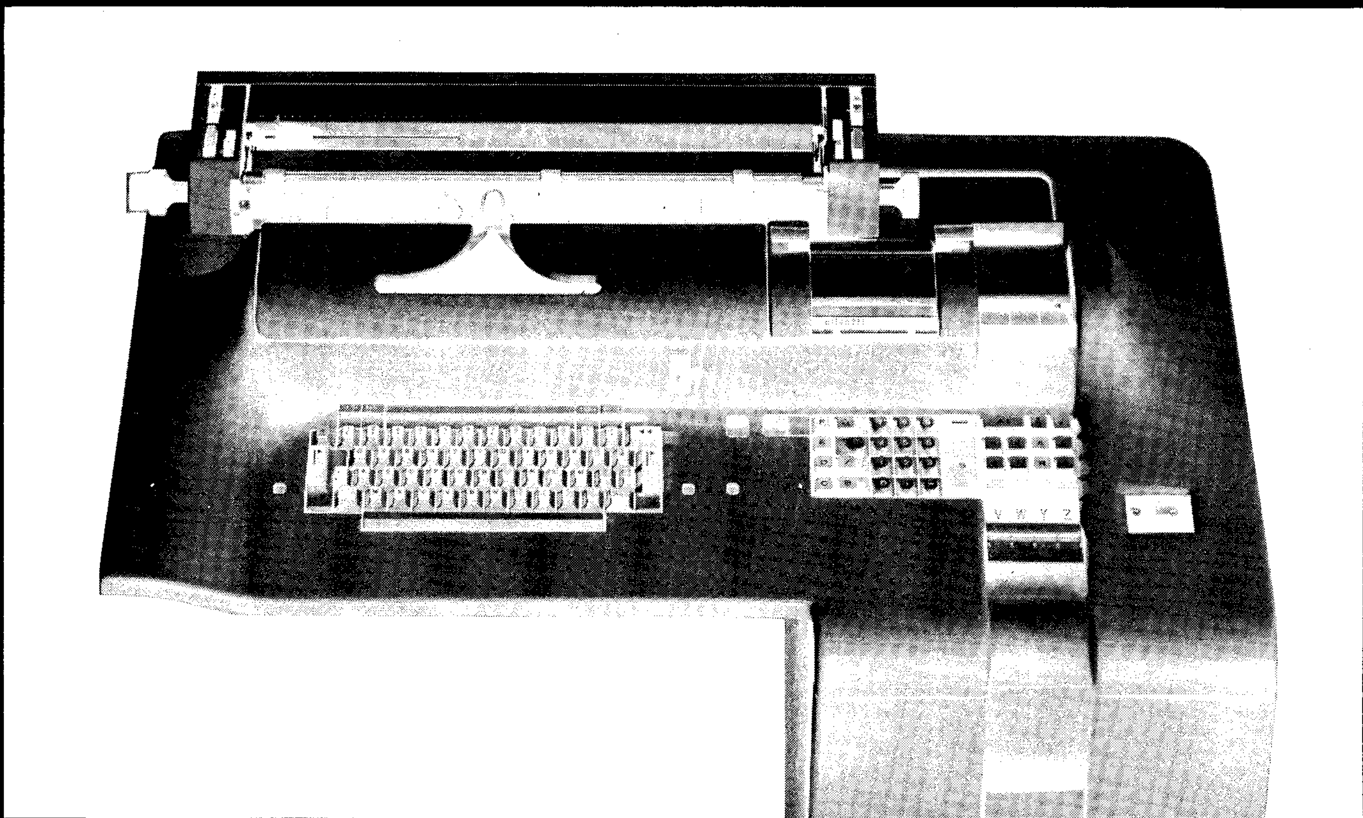

Ce n'est donc pas uniquement un calculateur électronique mais un appareil qui élabore des documents définitifs: le P 203 Olivetti met à la disposition de tous les bureaux, au centre ou à la périphérie, des prestations qui par leur importance et leur variété sont celles d'un grand ordinateur.
L'administration et la comptabilité, les finances et les statistiques, l'enseignement et le secteur technique: voilà les domaines du P 203 Olivetti.
Ses dimensions, son prix — ceux d'un simple appareil qui se suffit à lui-même — les multiples possibilités de la logique électronique alliées à la souplesse de l'intervention humaine prennent une nouvelle signification et se trouvent valorisées.

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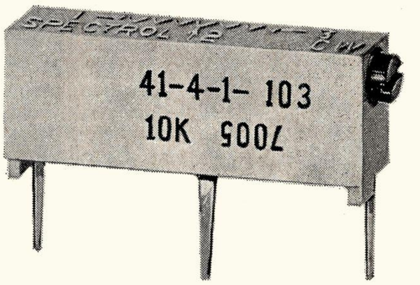
Tips + Topics

Spectrol

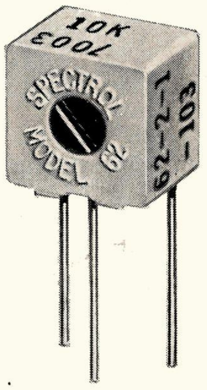
Have a close look to these Cermet Trimmers

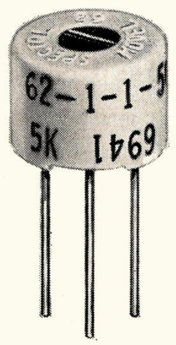


Model 41

10 Ohm - 1 MOhm
0,75 W at 25° C
—65° C at 125° C

The narrow housing of this popular trimmer allows tighter side-by-side installation and closer board socking - you save space and money.





Model 62

10 Ohm - 1 MOhm
0,75 W at 25° C
—65° C at 125° C

Top and side adjust versions.
The model 62 is a high performance single turn cermet trimming potentiometer, ideally suited for applications requiring subminiature size coupled with low cost and dependable service.

Almost infinite resolution, a resistance from 10 Ohm up to 1 MOhm, stability under severe conditions, and 'last but not least' the price. These are good reasons to have a close look to these Cermet trimmers. For further details ask for data sheets and the price list 14TR870. Call or write us and we will tell you more about the advantages of SPECTROL trimmers.

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