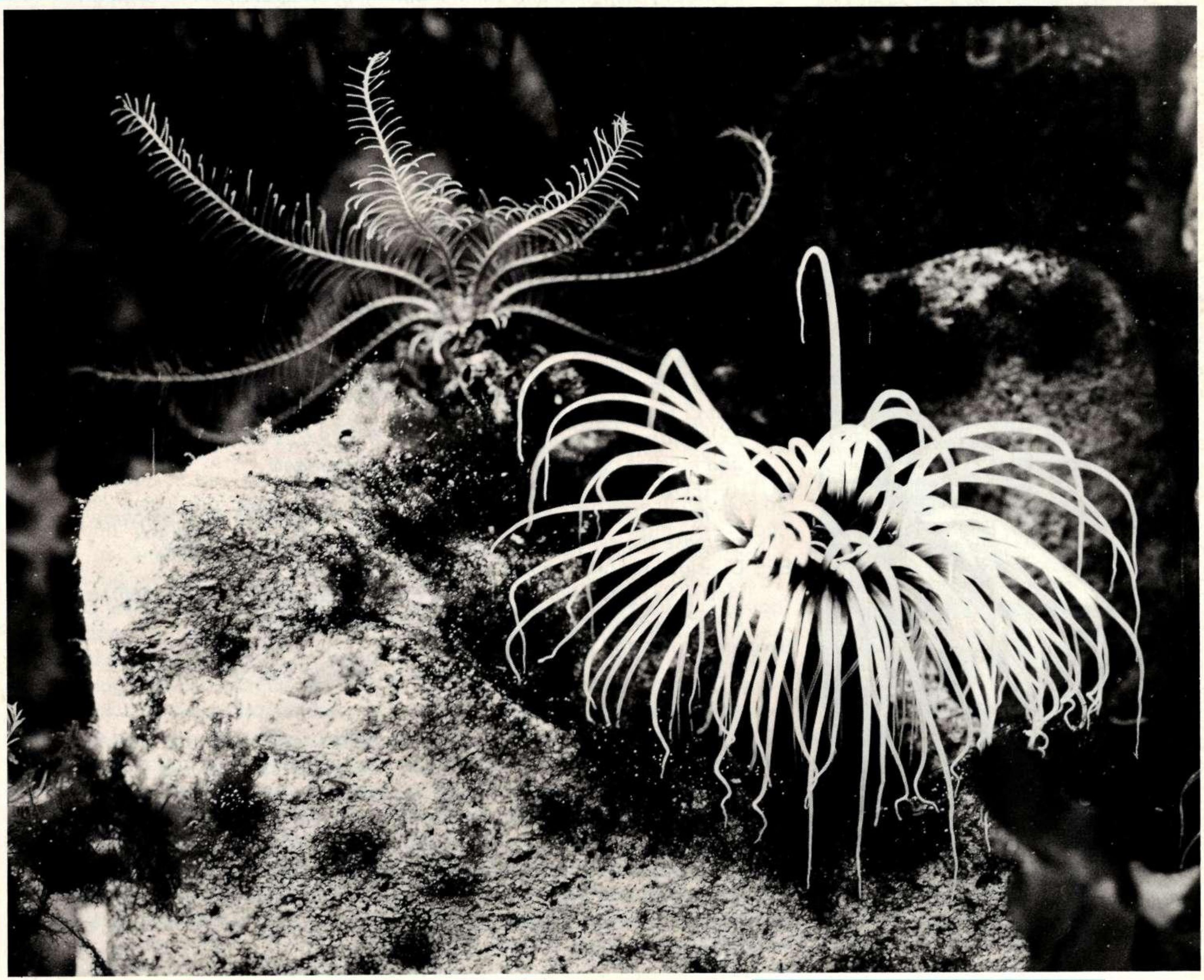
CERN COURIER

NO. 3 VOL. 13 MARCH 1973



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 3000 people and, in addition, there are about 850 Fellows and Visiting Scientists. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 382.9 million Swiss francs in 1973.

CERN Laboratory II came into being in 1971. It is supported by eleven countries. A 'super proton synchrotron' (SPS), capable of a peak energy of hundreds of GeV, is being constructed. CERN Laboratory II also spans the Franco-Swiss frontier with 412 hectares in France and 68 hectares in Switzerland. Its budget for 1973 is 188 million Swiss francs and the staff will total about 370 people by the end of the year.

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Contents

Cover photograph: Many a physicist late in the night shift may well have seen visions like this inside his detector. This time it is for real. A Wilson cloud chamber, which was among the first track chamber detectors to be used at the CERN proton synchrotron, has been rescued from oblivion by being converted into an aquarium which now graces the entrance hall of the Laboratory I Main Building. About fifty specimens of marine life (the star being a baby shark) from the Golfe de Gênes are now making different kinds of bubbles. Featured in the photograph are a comatula on the left and a cerianthid on the right. (CERN 2.2.73).

The proton at very high energies

What happens to the proton when we increase its energy? The answer, to the best of our present knowledge, is in the graph on the next page. It shows how the total cross-section of the interaction between a proton and a proton varies as the energy increases. Our task in this short article is to try to explain as simply as we can how this behaviour is interpreted. The reason for turning to the topic now is that the graph has just taken a surprising turn at very high energies with new results from two groups (CERN/Rome and Pisa/Stony Brook) at the intersecting storage rings.

The total cross-section expresses the region over which one proton affects another. Two protons will interact with each other when they come close enough that these regions overlap. The cross-section is expressed as an area — even though the region of influence of each proton is likely to be approximately spherical, protons flying at one another see an area like a disk which can affect them. It is measured in millibarns (mb) where one millibarn is 10^{-27} cm^2. As is clear from the graph, the region of influence of the proton changes in size as the energy increases.

Let us begin at the lower energies where the curve, pp, represents the information gathered over the past decade at accelerators capable of energies up to those of the Brookhaven 33 GeV and the CERN 28 GeV synchrotrons.

At low energies the protons linger long enough in the vicinity of one another for a variety of interactions to occur. In particular there is enough time for the production of resonances. The cross-section reaches a peak value of 47 mb at about 2 GeV. Then, as the energy goes up, the cross-section falls steadily. We can visualize this in terms of the wavelength which is associated with the proton at each particular energy. The wavelength dictates the region of influence of the particle — a long wavelength at low energy means that the particle spreads itself around a lot. As the energy increases the wavelength decreases, the proton keeps more to itself, the cross-section falls.

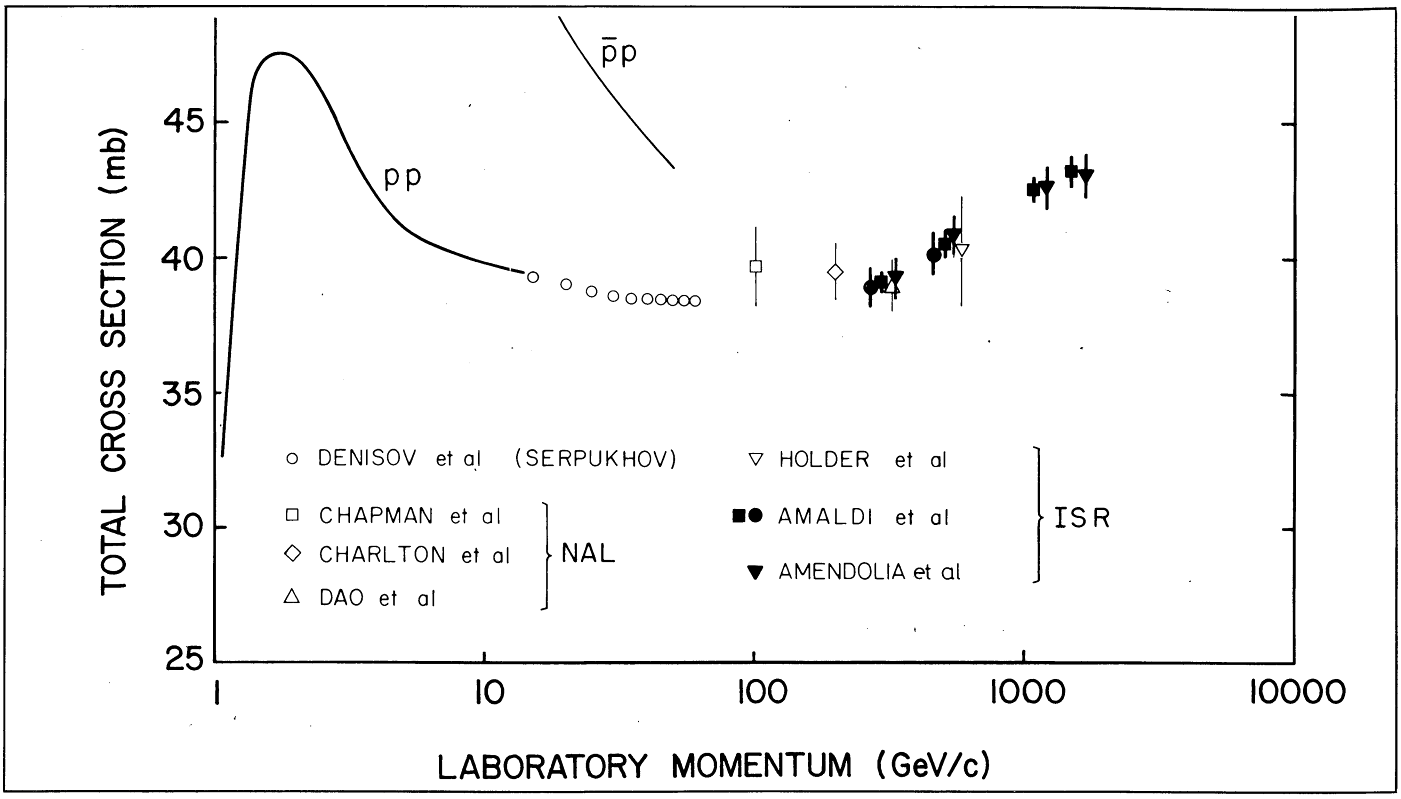
Then came the experiments at higher energies with the advent of the 76 GeV synchrotron at Serpukhov. The cross-section measurements are picked out as open circles on the graph. What they seemed to be telling us, and what was believed by most people until very recently is that at high energies the cross-section reaches a constant value independent of energy. Between 10 and 70 GeV the cross-section is almost constant at an area of about 38 mb. It was rather surprising that this happened at energies below 70 GeV but in itself the phenomenon was expected.

The majority of theorists that looked at this problem predicted that an asymptotic value of the total cross-section would be reached and that going to higher energies would see no further change in the cross-section. The reasoning behind this can be simplified by saying that beyond a particular energy the wavelength associated with the proton has become smaller than the physical dimension of the particle. Thus, from then on, increasing energy will not affect the cross-section which will always be equivalent to the physical dimension (seemingly of 38 mb). The Serpukhov results line up with this excellently.

There were some mysteries, however, about the cross-section measurements at Serpukhov (see vol. 9, page 232 for the report on the results of the first CERN-Serpukhov collaborative experiments). Some fundamental ideas about particle behaviour are built into the statement that at very high energies the cross-sections of both particle and anti-particle will be the same. The total cross-section for proton-proton should equal that for antiproton-proton; the total cross-section for negative kaon-proton should equal that for positive kaon-proton and so on. Essentially this is because the properties which distinguish between particle and anti-particle pale into insignificance at high energies when compared with all the other properties where particle and anti-particle are the same. At low energies, for example, the fact that the antiproton can annihilate with a proton results in the antiproton-proton cross-section being much bigger than the proton-proton. As the energies become very high it is expected that the annihilation property will add insignificantly to all the other possible ways of interaction and that the two cross-sections will be the same. The full formulation of this idea is usually associated with the name of I.Y. Pomeranchuk.

When it was observed that some of the cross-sections flattened out sooner than anticipated it was realized that the coming together of particle and anti-particle cross-sections looked less feasible. This was particularly true of the positive kaon when the first measurements were completed — it did not look as if its cross-section would join the negative kaon unless it somehow grew with increasing energy. In 1971, such a growth of the positive kaon-proton total cross-section was reported from Serpukhov but the idea of a cross-section growing again with energy did not, in general, sink in.

The latest measurements on the proton, however, mean that we have somehow to come to terms with a growing cross-section and abandon the comfortable explanation of a constant value which we had. Higher energies have become available with the 400 GeV proton synchrotron at NAL, Batavia and with the ISR at CERN where near-head-on collisions



Results from the ISR have revealed that the total cross-section of the proton-proton interaction increases at very high energies. This has come as a surprise since a few years ago, at the highest energies then available (at the Serpukhov synchrotron), it seemed that the cross-section had reached a constant value independent of energy. The ISR data have overthrown this picture. Dramatic changes are now expected in the proton-antiproton cross-section, also picked out on the graph up to energies investigated so far, since it should not fall below the proton-proton values.

between proton beams produce conditions equivalent to those obtainable at conventional accelerators of up to 2000 GeV.

An inkling of trouble came from some measurements at the ISR and from three preliminary results from NAL, which all gave values of the proton-proton total cross-section higher than the Serpukhov value. However, these measurements were not hot on precision and they were all consistent with the constant cross-section.

The CERN/Rome, Pisa/Stony Brook experiments now being published are very solid evidence that after passing through the 38 mb minimum the cross-section climbs again. By 1500 GeV, for example, it has reached 43 mb. The climb appears to go logarithmically with energy.

Is there any possible explanation for this new observation? Well, when we used the phrase 'most people' concerning the acceptance of the constant cross-section picture it was because some theorists had predicted other variations with energy. In fact the theorists were well covered — there were predictions of a rise, of constant cross-section and of a fall! The first prediction of logarithmic rise was in the work of W. Heisenberg twenty years ago and there have been several other similar detailed predictions since.

The idea behind the mathematics concerns the nature of the strong force operating between two protons (or any two hadrons). The successful Yukawa theory, which describes the interaction as involving the exchange of a meson, describes a force which falls off exponentially. Its influence therefore does not extend much beyond the dimension of the particle itself. There is nevertheless an 'exponential tail' — the force does extend but, at low energies, there is not enough strength in this tail to affect other particles. But at high energies, perhaps the jolt from the tail becomes significant and interaction takes place over a wider range.

Just to touch the mathematics — supposing we consider a minimum force, F, which will result in interaction. This is related exponentially in the Yukawa theory to a range r. The total cross-section, πr^2, is then proportional to $\log^2 1/F$. If this minimum force is related to the energy (i.e. a smaller force will induce interaction at higher energy) then we can expect the total cross-section to increase logarithmically in some relation to the energy.

Such a logarithmic rise is what is being seen and is particularly intriguing because it could give a new way of looking at the force acting between two hadrons. Another consequence is tied up with the particle anti-particle ideas we mentioned above. As can be seen on the graph, the proton-antiproton cross-section is dropping like a spent rocket at the energies investigated so far. If the two curves are to come together, the $\bar{p}p$ measurements must pass through a sharp U-turn at higher energies. This is a severe check on the correctness of the Pomeranchuk theory.

Members of the two ISR experimental groups are — Instituto Superiore di Sanita, Roma/CERN: J.V. Allaby, U. Amaldi, W. Bartel, R. Biancastelli, C. Bosio, G. Cocconi, A.N. Diddens, R.W. Dobinson, G. Matthiae and A.M. Wetherell; Instituto di Fisica dell'Universita and Scuola Normale Superiore Pisa/Stony Brook: S.R. Amendolia, G. Bellettini, P.L. Braccini, C. Bradaschia, R. Castaldi, V. Cavasinni, C. Cerri, T. Del Prete, G. Finocchiaro, L. Foa, P. Giromini, P. Grannis, D. Green, P. Laurelli, A. Menzione, R. Mustard, L. Ristori, G. Sanguinetti, R. Thun and M. Valdata. Their results are being published in Physics Letters.

CERN News

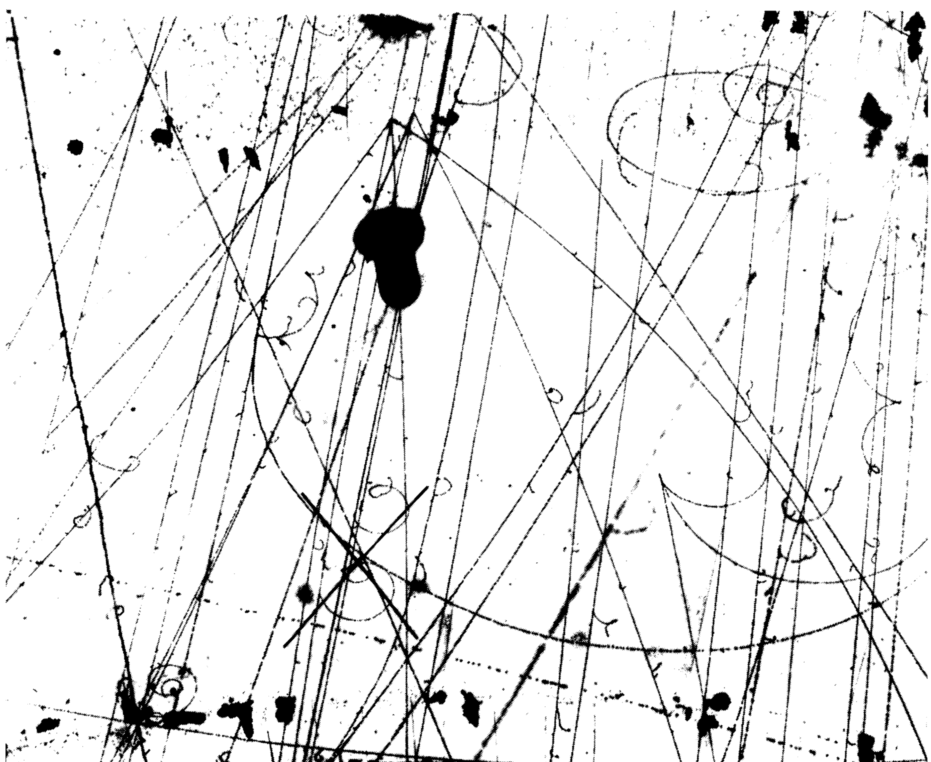
Tracks in BEBC

During the night of 3-4 March, the first photographs of charged particle tracks were taken in the 3.7 m European bubble chamber, BEBC. At the time of writing, tests are continuing but all the major components have already been taken through their paces very successfully. Work has started on optimizing chamber performance and photograph quality.

The present series of tests began mid-January with the cool-down of the huge superconducting magnet. The chamber was not at that time filled with hydrogen so that the operators could master one system at a time. The cool-down was done slowly over nine days to avoid thermal stresses which could damage the magnet cryostats. The helium refrigerator, where trouble had been experienced earlier, worked well. The cryostats were filled with 20 000 l of liquid helium and, when operating temperatures were reached, current was fed to the superconductor increasing in steps towards the design level. This enabled safety devices and instrumentation to be checked progressively. The optical and expansion systems were also operated so as to detect any effects due to the fringe field of the magnet. Small effects were noticed as peak field was approached but they can be cured fairly straightforwardly by extra magnetic shielding.

On 24 February, the current fed to the coils reached 5 kA and the magnetic field in the useful volume of the chamber climbed to 3.1 T. This current corresponds to 550 MJ of stored energy. A map of the field was taken (as at each current level on the way up) using 180 Hall probes linked to a computer. These give a relative precision of 0.05 %; absolute calibration using a nuclear magnet resonance probe will be done later. The effect of frozen flux fields (the superconductor is not of the 'intrinsically stable' type) was observed but the magnet has not yet been powered for long enough at one stretch to measure their long term effects.

Helium was then drained from the magnet cryostats (but the magnet was kept cold) while attention switched to filling the chamber with hydrogen. The chamber was cooled in three days and, on 3 March, 38 000 l of hydrogen were pumped in without problem. Expansion tests began and as soon as sensitive conditions (correct temperature, pressure and piston stroke) were established, tracks were photographed. A beam of particles was available from the proton synchrotron — not yet a tidy beam but adequate to make the observation of tracks possible. The track quality was good from the beginning and distortions due to turbulence were quickly eliminated.



Charged particle tracks recorded for the first time in the 3.7 m European bubble chamber, BEBC, at the beginning of March. In this photograph of part of the chamber volume a beam of positive particles of energy about 6 GeV arrives from the top and several interactions can be seen. Note that the chamber uses bright field illumination, the walls being lined with Scotchlite. With a large chamber volume, cosmic ray particles are also likely to be recorded. The heavy track on the left and the track of low bubble density crossing the photograph are cosmic rays passing through the chamber not synchronized with the operation of the pressure system. The central black mark is a vapour pressure monitor and other marks are from boiling at seams on the Scotchlite which will be cured.

The huge assembly hall at Laboratory II which has a floor area of about 11 000 m^2. The hall was brought into use in February when the prototype magnets were wheeled in. Some Lab. II staff have moved over from their temporary accommodation in Lab. I to the first office block to be completed, which is alongside the assembly hall.

During this time the magnet, cooled with helium gas, was fed with low current (1kA corresponding to 0.6 T in the chamber) so as to have some magnetic force pulling the two coils together. This avoids possible damage by preventing them from bouncing around when the expansion operates. Some curvature of the tracks was thus achieved as a by-product.

The remaining step in the tests is to operate the chamber in the highest possible magnetic field. This might however be postponed until the next run, because there is trouble with a hydrogen leak.

Mole in the hole

February 19 was the second anniversary of the authorization of construction of the SPS by the CERN Member States. The anniversary was celebrated by a start on boring of the ring tunnel by the 'mole'.

The tunnel for the new proton synchrotron will be 4.8 m in diameter with a circumference 6.9 km and its average depth will be 40 m below ground. Boring this tunnel is probably the most impressive part of the civil engineering programme of Laboratory II.

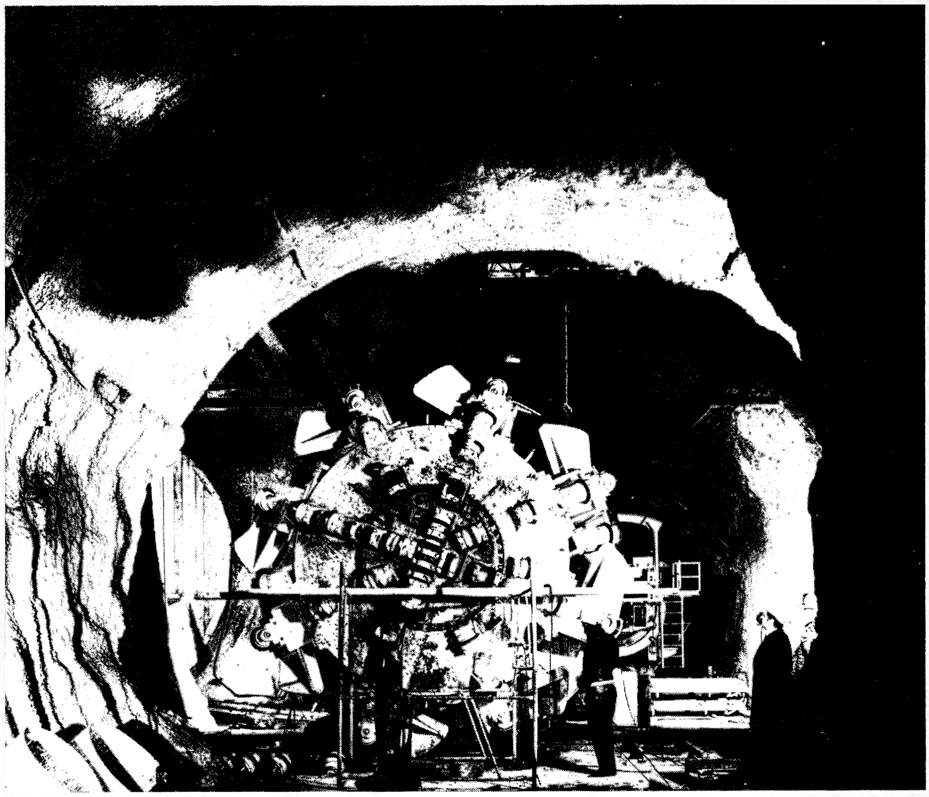
Among the reasons for selecting a tunnelling scheme (rather than 'cut and fill') was a desire to avoid changing the character of the countryside in a major way so that agricultural and forestry activities can continue much as previously. A second reason is the variation in altitude over the site (45 m between the lowest and highest points) which would have made 'cut and fill' very difficult. To retain a minimum earth shield of 20 m for radiation protection, the tunnel will be bored at a depth which is 65 m below the highest point on the surface. A final point is that the molasse bedrock is solid enough to allow the tunnel to be bored reasonably easily.

A detailed description of the boring machine, known as the mole, can be found in vol. 12 page 124. The machine is a conventional Robbins boring machine built for CERN in a factory in Seattle, where it underwent pre-delivery tests. It came by sea from the Pacific coast of the USA through the Panama Canal to Rotterdam and up the Rhine to Basel, whence it was brought to Geneva by lorry. It arrived at the end of last year.

The head of the mole has 35 cutters. Behind the head on each side, two lateral hydraulic rams push supporting pads against the wall of the tunnel to form the supports for the machine as the head grinds into the molasse. The head is pressed against the rock by means of four axial rams with a stroke of 120 cm and an effective pressure of 480 tons. After boring these 120 cm the machine stops, a foot is lowered beneath the operator's cabin behind the head to keep the whole machine

CERN 15.2.73

The mole being installed underground at the point where boring of the tunnel is beginning. The mole has a 7 km journey confronting it around the circumference of the ring which is expected to be completed by Autumn 1974. The head shown here is 4.8 m in diameter. It was lowered into the tunnel in January and the whole machine was assembled below ground. In addition to the head, the machine comprises pressure and supporting pads, an operator's cabin, electrical equipment, conveyor belts, tunnel lining system, skip changer and spoil removal train. Its total length is 80 m.



CERN 18.2.73

in balance, and the two lateral supporting rams are retracted so that the four axial rams can pull the supporting system with them. After this the head can start work with 120 cm of travel in front of it again.

The 14 ton lift of the PGC (civil engineering shaft) could not be used for lowering components of the mole because of the bulk and weight of certain items. They were lowered down the nearby shaft PP1 (45 m deep) using two automatic cranes which could take loads of 30 and 100 tons. The heavy components, weighing more than 10 tons, were assembled at the bottom of PP1, while other less bulky ones were taken to the assembly region from which the tunnel boring starts.

The mole platform (9.5 m long and weighing 32 tons), which carries a 750 kVA transformer, electrical cubicles, oil tanks and the operator's cabin, was lowered in a vertical position by the large automatic crane. It was swung horizontally by means of the second crane and parked at the assembly point. The main shaft, forming the connection between the boring head and the platform and containing, among other things, the lateral support system, was parked in the 'neutron trap' at the back of the access tunnel from PP1. Then the head itself (total weight 53 tons) was lowered after some prior assembly at the surface. It was coupled to the main shaft at the bottom of PP1 and the whole was transported on small Caterpillar trucks to the assembly point. The various assembly operations, which began on 11 January, took about a month.

The 'train', which immediately follows the boring machine and which has the tunnel lining system and the skip changer for the spoil extraction, was set up at the same time. Tests on the complete installation began in the second half of February and the machine was ready to start on its way at the beginning of March.

The problem of removing the spoil is solved in the following manner. It is carried on conveyor belts from the scoops on the boring head to a hopper (a funnel of about 2 m^3). This is the first component of the skip changer located behind the tunnel lining system (shoring erector). The skip changer is a two storey affair—empty skips on the top railway track, full skips on the lower track. The hopper pours the spoil into a skip on the lower level of the changer. Once the skip is full, a ram pushes it on to a railway, still on the lower level, allowing an empty skip to be brought down from the upper level. This empty skip, in its turn, is pushed backwards beneath the hopper, and so on.

The changer can take twelve full skips on the lower track and twelve empty skips above. Once twelve skips at the lower level are full, a train pulls them to the PGC lift, which takes them to the surface two at a time. From there, they are taken to a device which tips their contents into a hopper. Then the spoil is taken on a conveyor belt to an intermediate store from which it is picked up by lorries and taken towards the centre of the site to a little dell which will be filled in.

The mole will operate 24 hours a day, six days a week. Out of these 24 hours, eight are for maintenance of the machines. When half the final length of the tunnel has been bored (about 3.5 km) the shaft PP4 will take over the task of PGC for spoil extraction. Working at a rate of 20 m per 24 hours, the boring of the tunnel will take 18 to 20 months to complete.

The firms involved in the tunnelling programme are grouped in the ACCEL consortium: Losinger (Switzerland), Prader (Switzerland), Les Grands Travaux de Marseille (France), Forgal (France), Cuénod (Switzerland), and SELI (Italy). The shoring erector and skip changer (Grandori system) were built by SELI and three German firms (Zurnieden, Wolff and Vetter) supplied the spoil extraction system (installed at the PGC and PP4 shafts).

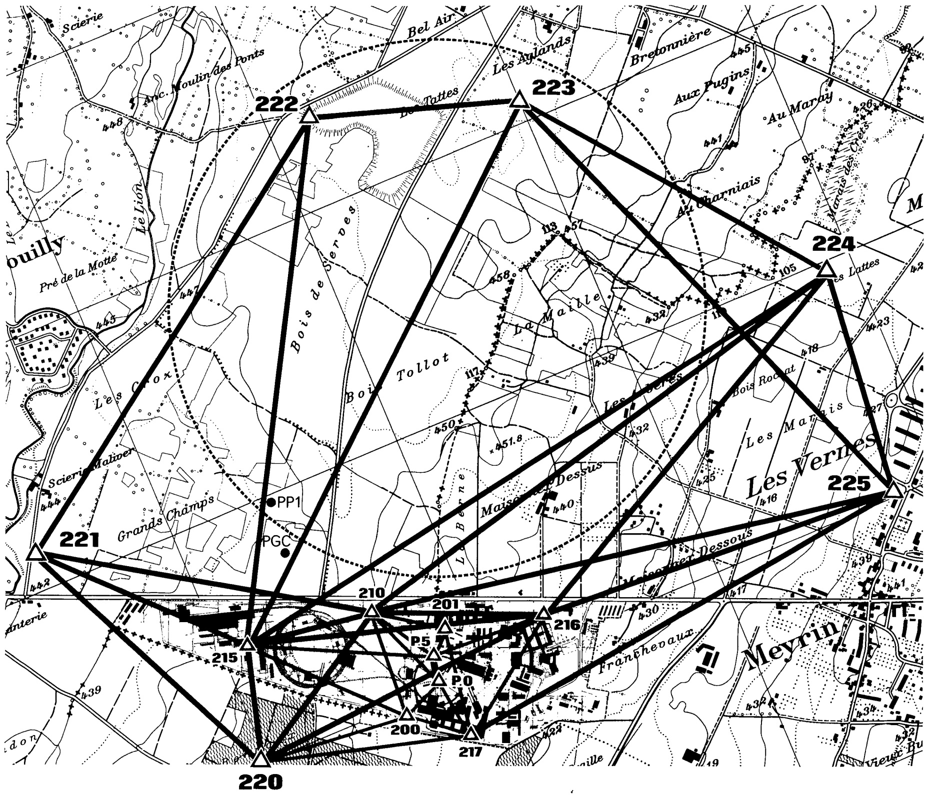
Telling the mole where to go

The survey problems at the SPS are different to those encountered in building the PS or the accelerator at Batavia. These machines were installed in a trench (the 'cut and fill' method) in open flat land. The different problems at Laboratory II are:

- installation of the magnet ring in an underground tunnel;
- links with existing installations at Laboratory I (mainly using the PS as injector and the experimental facilities associated with the West Hall);
- a difference in altitude around the circumference of the ring of about

CERN 37.1.73

Geodetic measurements are often taken under an umbrella sheltering the surveyors from the sun. But an umbrella has other uses — here, a gyro-theodolite and its operator are being protected from water seeping in at the bottom of the PP1 shaft some 40 m below the surface, while preparing the survey points below ground which tell the mole where to go.



Positioning components of the large CERN machines calls for extreme precision and the most advanced survey techniques are used. In the case of the SPS, triangulation and trilateration studies were necessary. Datum points were established over the whole site, and even beyond it. This illustration shows the geodetic network. Position locations have then to be transfered to the tunnel underground. Boring of the tunnel began in March from a position between the PGC and PP1 access shafts (to the right of monument 221).

45 m between the highest and lowest points on the surface;
– wooded land which interferes with the line of sight in survey measurements.

To solve these problems, the surveyors had to resort to triangulation (angular measurement) and trilateration (distance measurement). Datum points are located on high buildings at CERN (ISR Laboratory, Laboratory 5, SB Building, etc). Other points have been set in the ground at a height of about 1.5 m and one of them (monument 223) at a height of 8 m. It was impossible to use the top of the ISR water tower, which is the highest point at CERN, as a survey point because it is subject to movements of up to 2 cm.

The results give an accuracy of 2 mm between all the points. The base line is provided by two of the survey points of the PS (see the triangulation-trilateration figure).

In subterranean surveying, one of the most difficult problems, which is often rather poorly solved, is the dropping of a perpendicular line within a shaft in order to transfer the surface co-ordinates to the tunnel level. Various methods were used for this operation, giving results to better than 0.5 mm for depths of 60 m. It is amusing to note that the curvature of the earth requires a correction of about 8 mm for the deepest shafts in order to ensure that the SPS has the same diameter underground as that calculated at the surface.

The first underground survey, which was needed to guide the mole, consisted in laying out the line of the tunnel between the shafts PGC and PP1, some 200 m apart. After the tunnel had been pierced, metal brackets with reference sockets containing an automatic centring system were fitted to the walls and the distances were measured with invar wire and the directions with a gyro-theodolite.

This underground alignment compared with the surface alignment, was accurate to 2.4 mm, which is a very satisfactory figure since no external orientation was available for any of the survey operations in the tunnel except for locating the geographical north by gyro-theodolite. This result is important because it shows that the methods used are more than adequate for the job in hand.

The first survey monument, together with its reference socket and the support for the laser which will be used to guide the boring machine, is already in place in the tunnel. Such a monument will be built every 32m as the mole progresses. The survey team have considerable confidence that the mole will arrive back where it is starting from.

Shuffling computers

At the end of February a CDC 6200 computer arrived at the new computer centre on loan from Control Data Corporation to help CERN in some intricate shuffling of its central computers. The need for the shuffle has arisen because the new 7600 is taking longer than anticipated to settle down with CERN's normal central computer work load.

We last discussed the 7600 at the time when its hardware acceptance tests were successfully completed in

1. M. Toussaint, Belgian Minister of Education (on the left) visited CERN again on 12 February. After being shown around Laboratory II by the Director General, Dr. J.B. Adams, Mr. Toussaint toured part of Laboratory I that has been built since his first visit in 1967. In the photograph he is shown at the ISR with (from left to right) W. Schnell, G.H. Hampton and the Director General of Laboratory I, Professor W.K. Jentschke.

2. G. Charpak has received the 1973 'Grand prix de physique Jean Ricard' from the French Physical Society. The prize was awarded particularly for his work on particle detectors. Charpak led the development of multiwire proportional chambers which have found wide application in particle physics and in medicine. In the photograph Charpak, on the right, is in conversation with V.P. Dzhelepov appropriately at the Dubna Instrumentation Conference.

(Photo Yu. Tumanov)

July of last year (see vol. 12, page 232). At that time it was running for 1 ½ shifts six days per week. This has been increased to two shifts seven days per week and the 7600 is now processing over a quarter of CERN's computing. However, some of the software weaknesses apparent at the time of the acceptance tests have been aggravated in extending the work load. Conversion of user's programs to the 7600 (involving changing from programs written for CERNSCOPE, which is the software of the 6600/6500 system, to programs written for SCOPE 2, which is the new Control Data software of the 7600) has proved more troublesome than anticipated. There are two main reasons for this — firstly, there are serious shortcomings of the software in the way it handles data on magnetic tape and, secondly, there is an abnormally high number of interruptions to the computing service because of software 'bugs'.

The result is that the day when the CDC 7600 can confidently be assigned almost all CERN's central computing has been moved further into the future than had been hoped. It is thus important to keep available the capacity of the 6600 and 6500 using CERNSCOPE. However, it is inconvenient and wasteful to have the computers in different locations and it is intended to bring them all under the roof of the new computer building. To move both computers and to revamp them would take about five months which is considered far too long to be without either machine using CERNSCOPE.

This is where the manœuvres with the loaned 6200 come in. It is being installed alongside the 7600 and a hardware conversion will build it up to a 6500. This involves an extra processor and some central memory (partly coming from the existing 6500 where the amputation is planned to be carried out over Easter). It will

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CERN 204.2.73

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1. *Drawing on their experience, the CERN 'pompiers', part of whose duty involves the transport of any injured personnel, have designed and built a new kind of ambulance in collaboration with the first-aid staff. Compared to the traditional types used at CERN, it is better adapted to our needs and has cost much less to build. For example, it is possible to move freely around a central stretcher, which is intended for serious cases and can be used as a rudimentary operating-table. Also better distribution of equipment inside the ambulance means that conditions for giving cardiac massage are excellent. The CERN ambulances are on call in case of accidents on the site but are also often in action in response to urgent calls from the surrounding regions in France and Switzerland. The photograph shows the inside of the CERN-built ambulance with its centre stretcher and two further stretchers on the left available for use.*

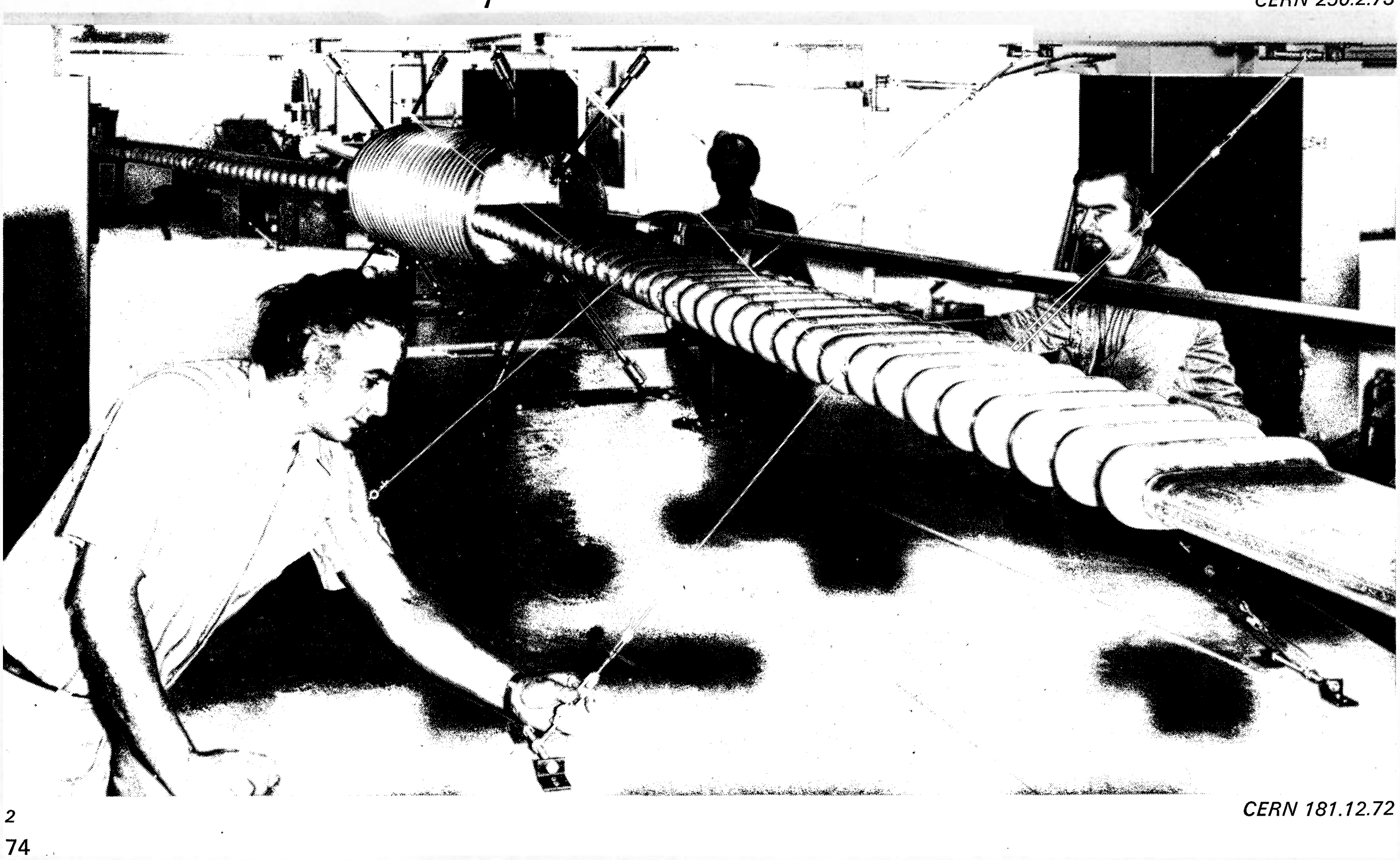
2. *Installation tests of a vacuum chamber in a full-scale model of the ISR split field magnet (SFM) destined for intersection I-4 of the ISR. The final version will be a scaled-down chamber designed to match the beam geometry and to give maximum space for positioning detectors close to the interaction region. The chamber is located on the centre plane of the magnet aperture which has a height of 1.10 m. A first series of magnetic measurements was completed in February. From the data, settings were optimized to give the precise fields which will keep the ISR beams on the closed orbit. A second series of measurements is now in progress over the whole useful volume of the SFM (approximately 55 m^3), measurements being taken on a grid 5 × 5 × 10 cm. This series is being carried out with compensator magnets powered and magnetic channels in place.*

still leave the 6600 untouched together with the equivalent of a large 6400 in the other computer centre. When this has been accomplished and the 6500 in the new centre proved to work satisfactorily, the 6600 can be moved while the computing service is assured by the 6500 and 6400. Finally the, by then amputated, 6500 can be dismantled and returned to CDC.

The automatic film measuring machine HPD1 which has been linked to the doomed 6500 is being dismantled for transfer to the new computer building where it will join the new 6500. This will take several months during which time HPD2, linked to the 6600, will take the film measuring burden. When HPD1 comes into action again, HPD2 will shut down for ever.

Thanks to the loan of the 6200 by CDC there will be only a few weeks during which only one machine is available for operation with CERNSCOPE.

1 CERN 250.2.73



2 CERN 181.12.72

Electron-positron colliding beams

Results from electron-positron storage rings were among the most interesting presented at the Chicago conference in September last year. Here are recent reports on research at the storage rings of Frascati and Cambridge.

Research at ADONE

The Frascati 1.5 GeV electron-positron storage ring, ADONE, has been successfully operating since the beginning of 1970. The Frascati Laboratory was the birthplace of storage rings for it was there, in the early 1960's, that the first small electron-positron storage ring, called AdA, was built and operated. AdA moved to Orsay and was used there for the first colliding beam experiment. AdA and a small Stanford-Princeton machine were the first to demonstrate the potential of storage rings for particle research.

During the past two years, the performance of ADONE has been improved and it has successfully reached and (in the case of the luminosity at energies higher than about 1 GeV) even exceeded its design parameters (total collision energy of 3 GeV with a luminosity of 0.6 × 10^{30} cm^{-2} s^{-1} in each experimental section). Results from the first series of experiments were presented at Chicago and played a dominant role in the sessions concerned with the electromagnetic interactions of the hadrons.

Besides the QED tests at high momentum transfer (reactions $e^+e^- \rightarrow e^+e^-$, $\mu^+\mu^-$, $\gamma\gamma$) and the limits on the electromagnetic production of heavy leptons, where results have been extensively reported on the literature, considerable effort has been devoted to the problem of the electromagnetic structure of the hadrons in the time-like region. On this subject the latest ADONE results have confirmed the fundamental role of the electron-positron interactions as a unique tool for extending the investigation of the structure of the hadrons.

The importance of this kind of research is clear since it is very likely that a thorough knowledge of hadron structure will be the first step towards complete understanding of the hadron-hadron interactions. This explains the interest in the experimental results on multi-hadron production and form factors coming from ADONE and from the Cambridge bypass.

One of the first exciting results to emerge from ADONE at total centre of mass energies above 2 GeV was that the production of hadrons in electron-positron collisions is much more abundant than expected. The most recent results have further clarified the features of the production process (among the main achievements has been a separation of the partial reaction channels which, though not complete in the case of the neutral component, has made it possible to determine the pion multiplicity of the multibody final states). The number of charged particles is found to be about 3.3 and the total number about 4.4 varying slowly in the energy range 1.2 to 3.0 GeV. Furthermore, the existence of a new vector meson, the rho prime, with a mass of about 1.6 GeV has been found by looking at the interaction giving four charged pions. The decay of the rho prime into rho and epsilon mesons has been indicated. (Identification of the rho prime in a Berkeley/Stanford experiment is described later in this issue.)

The total production cross-section for hadrons varies with energy and shows a broad increase around 1.5 GeV where values of the order of 70 nb are reached. At higher centre of mass energies (up to 3 GeV at Frascati and at 4 GeV at the CEA bypass) the cross-section, although decreasing, remains a factor of two to three larger than expected.

The importance of these results on multi-hadron production through electron-positron annihilation mainly stems from the fact that this kind of reaction represents the time-like mirror image of the inelastic processes in electron-nucleon scattering whose scaling behaviour has been the impetus for recent exciting theoretical approaches to hadron structure (partons, light-cone current commutators).

It is clear that, in order to get a complete picture of the situation, more data are needed and are eagerly awaited from ADONE, the CEA bypass or the more energetic and 'luminous' storage ring SPEAR now coming into action at Stanford.

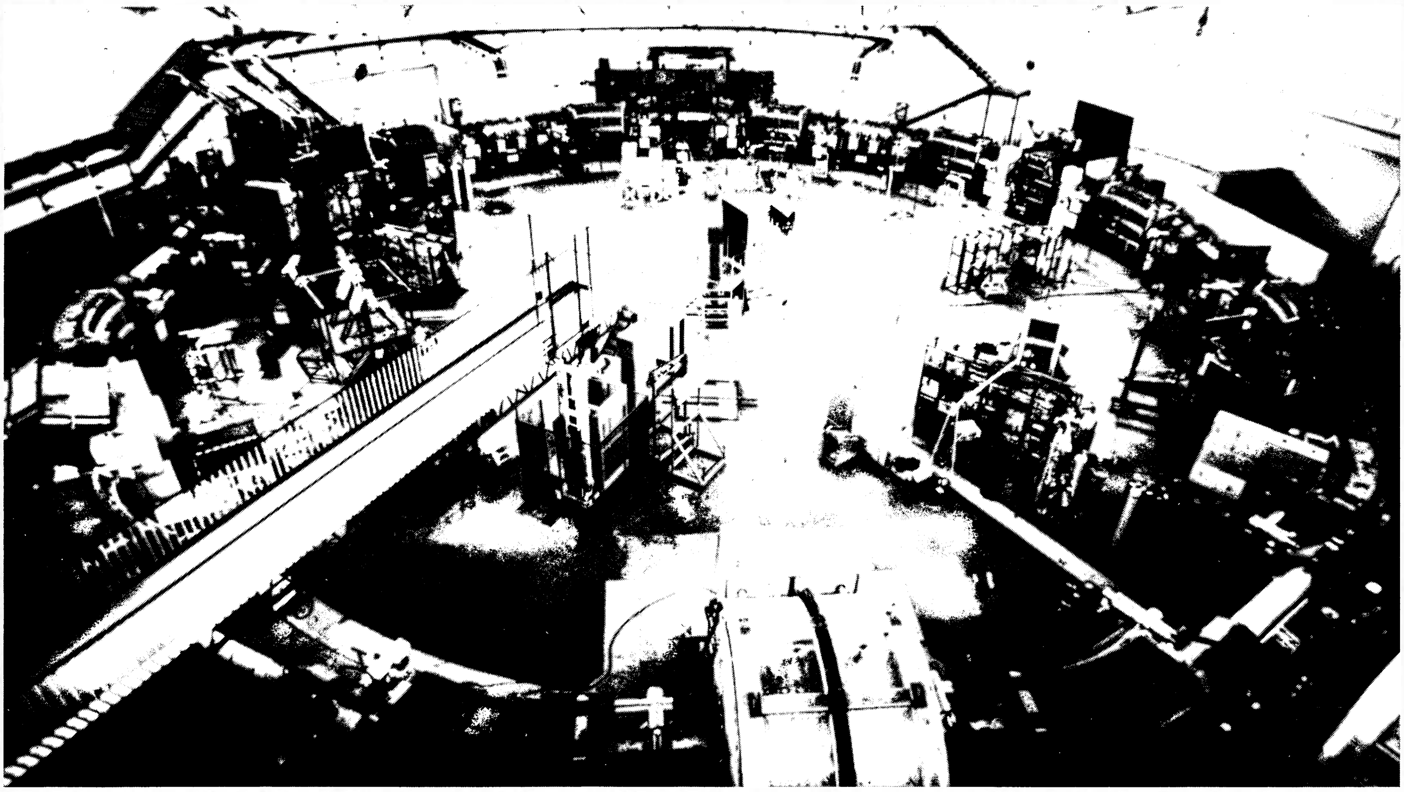
The time-like region of the form factors has now become accessible in a direct manner with the availability of the electron-positron machines and data on proton and pion form factors have been gathered.

The first measurement of the cross-section for the reaction electron-positron giving proton plus antiproton has been carried out at ADONE at S = 4.4 GeV/c^2 and a value of (0.91 $\pm$0.22) × 10^{33} cm^2 has been found. Up to this time only upper limits for the time-reversed reaction $pp \rightarrow e^+e^-$ were available. This first quantitative information about the time-like region of the nucleon form factors is the first step in a field of physics, the form factors of the stable and unstable baryons, which is expected to be thoroughly explored by electron-positron machines.

The electromagnetic structure of the pion can be investigated through the reaction electron-positron giving a positive and a negative pion. In this case, due to the one photon exchange mechanism, the isovector part of the form factor is clearly measured. New data from ADONE has extended previous measurements at lower energies performed at Orsay and Novosibirsk. Above a total centre of mass energy of 1 GeV, where the effect of the

The electron-positron storage ring, ADONE, at the Frascati Laboratory. Results from the experiments at ADONE were prominent at the Chicago Conference and are briefly reviewed in the article.

(Photo Frascati)



production of the rho meson should be reduced to a reasonably predictable tail, the observed values of the pion form factor are larger than expected and exhibit, approximately a 1/S energy dependence.

All of these interesting results from the 'first generation' experiments at ADONE call for further effort involving more sophisticated experimental set-ups. In December 1972, ADONE began a long shutdown during which, besides general maintenance on the machine, three new sets of apparatus will replace their first generation equivalents.

With these more sophisticated detection systems larger solid angles will be covered. For the first time, magnetic momentum analysis will be provided in one interaction region and a larger degree of automation will be generally achieved. The second half of 1973 should see data taking using the new equipment at full efficiency.

Further progress in this field requires higher luminosities and the development of experimental apparatus more suited to the typical 4π geometry of the events. Work is proceeding in several Laboratories and in the next decade electron-positron and, hopefully in the future, electron-proton colliding beams, will add their special knowledge to that gained at the proton storage rings and the large proton accelerators.

First results from the bypass

Analysis of the first experiment carried out at the electron-positron colliding beam facility at the Cambridge Electron Accelerator has been completed. (For a description of the facility, known as the 'bypass' since it involves an additional special loop on the synchrotron ring, see vol. 8 page 289). The experiment measured the elastic cross-section of electron-positron scattering over the angular range 50 to 130 degrees at a centre of mass energy of 4 GeV (i.e. 2 GeV per beam).

The interaction region in the bypass was surrounded by the detector known as BOLD which has a solid angle for detection of about 2π. The measured cross-section was $(2.49 \pm 0.28) \times 10^{-32}$ cm^2 which compares with the calculated value using quantum electrodynamics of $(2.82 \pm 0.02) \times 10^{-32}$ cm^2. There is thus no significant evidence of a breakdown of quantum electrodynamics at these high energies.

During the experiment, 87 events were observed which are consistent with the interpretation of hadron production in the electron-positron collisions as observed at ADONE. The total cross-section for such interactions is $(8.7 \pm 1.2) \times 10^{-33}$ cm^2 divided by the efficiency of the trigger. Two extreme approaches in estimating the trigger efficiency convert the cross-section to a value between about 1.5×10^{-32} and 2.9×10^{-32}. More accurate calculation of the trigger efficiency is now under way.

During the experiment the 1/e lifetime of an individual beam was 40 minutes while the 1/e 'lifetime' of the initial luminosity (determined by the double bremsstrahlung method) was about 20 minutes. The synchrotron was refilled about twice per hour, the refilling process taking 5 to 10 minutes (for details of beam accumulation see vol. 12 page 168). Typical initial luminosities following refilling were around 2×10^{28} cm^{-2} s^{-1} and the highest average during a twelve hour period was about a fifth of this. During 441 hours of operation for the experiment, the overall luminosity was just over 10^{34} cm^{-2}.

Since completion of this first data-taking run many improvements in the bypass and the synchrotron ring have been made to prepare for an experiment with higher beam energies (2.5 GeV per beam).

Improvements to the bypass include installation of quadrupole magnets of greater bore (10 cm) and greater length along the bypass central run. The main benefit from larger aperture is that the quality of the quadrupole field close to the axis is improved: the 12-pole and 20-pole field components, for example, are of reduced intensity. A larger diameter beam pipe has been installed in the new quadrupoles of the bypass. The larger aperture (almost a 10×10 cm^2 square, but slightly pin-cushioned in shape, as compared to the earlier circular pipe of 7.5 cm diameter) increases the pneumatic conductance and also gives room for cryogenic cooling tubes.

Improvements in the ring include extensive revision of the electrostatic plate system to keep the two beams vertically separated in a more uniform manner. The process of injection and accumulation of positrons and accumulation of electrons, then turning off the a.c. component of the synchrotron magnet power and switching the beams into the bypass, has been almost completely automated for quicker and more reliable operation.

After some machine operation to optimize performance with beams of 2.5 GeV the BOLD detector has been reinstalled in the bypass and a data-taking run at 5 GeV centre of mass is under way.

Around the Laboratories

DARESBURY
New computer

An IBM 370/165 computer has just been successfully commissioned at the Daresbury Laboratory and has taken over from a 360/65 as the central computer. Installation of the new machine was completed on schedule in spite of a building strike last summer which threatened to delay completion of an extension to the computer hall.

The new computer costs about £2 million and the central processor is about five times as powerful as its predecessor (i.e. about half as powerful as the CDC 7600). It will meet the computing needs of University and resident scientists participating in the various Daresbury physics programmes within the UK and at CERN. In the near future, data links will connect computing equipment in Universities and other centres remote from Daresbury so that users can have access to the powerful computing facilities without having to travel to the Laboratory.

The IBM 370/165 has a 2 Mbyte core store, about 850 Mbytes of disk storage, eight magnetic tape drives and a fixed head file. Several peripherals have been retained from the 360/65 including two interactive graphics terminals. The central computer not only provides a conventional batch processing service but also acts as the focus for a number of high speed data links. These data links distribute computing power to small computers in a variety of systems including: 1) high energy physics

The new IBM 370/165 computer in action at Daresbury Laboratory. It has taken over as the central computer serving the Daresbury physics programmes within the UK and at CERN.

(Photo Daresbury)

On the left are magnets of the ejected proton beam, known as Channel C, at Serpukhov. They are the last elements of the beam-line before the external target. This Channel provides particles for the 'Ludmila' bubble chamber. Channel A, which came into action a year ago, provides particles for the 'Mirabelle' bubble chamber.

(Photo Serpukhov)

experiments; 2) synchrotron radiation experiments; 3) an experimental microwave communication channel (see vol. 12, page 206). There are also about twenty alpha-numeric terminals attached via slower data links which provide facilities for remote job submission, file manipulation and interactive computing under control of the IBM Time Sharing Option.

Installation of the new equipment was a painless process for the users of the computer centre. The 360/65 was kept in operation while IBM engineers commissioned the new hardware and when the final change-over was made the Laboratory was without an internal computing service for only eight hours. The operating system and programming languages of the two machines are completely compatible and in most cases the only effect noticed by users was a dramatic reduction in running time.

SERPUKHOV Channel C to feed Ludmila

A second fast ejected proton beam was commissioned in October 1972 at the 76 GeV proton synchrotron at Serpukhov. It is known as Channel C and will serve the Ludmila bubble chamber. It joins Channel A which was launched in February 1972 through the joint work of the Institute of High Energy Physics and CERN. The successful operation of the Channel A ejection system has made it possible to tune the r.f. separator to achieve an extensive experimental programme with the Mirabelle bubble chamber using beams of separated particles.

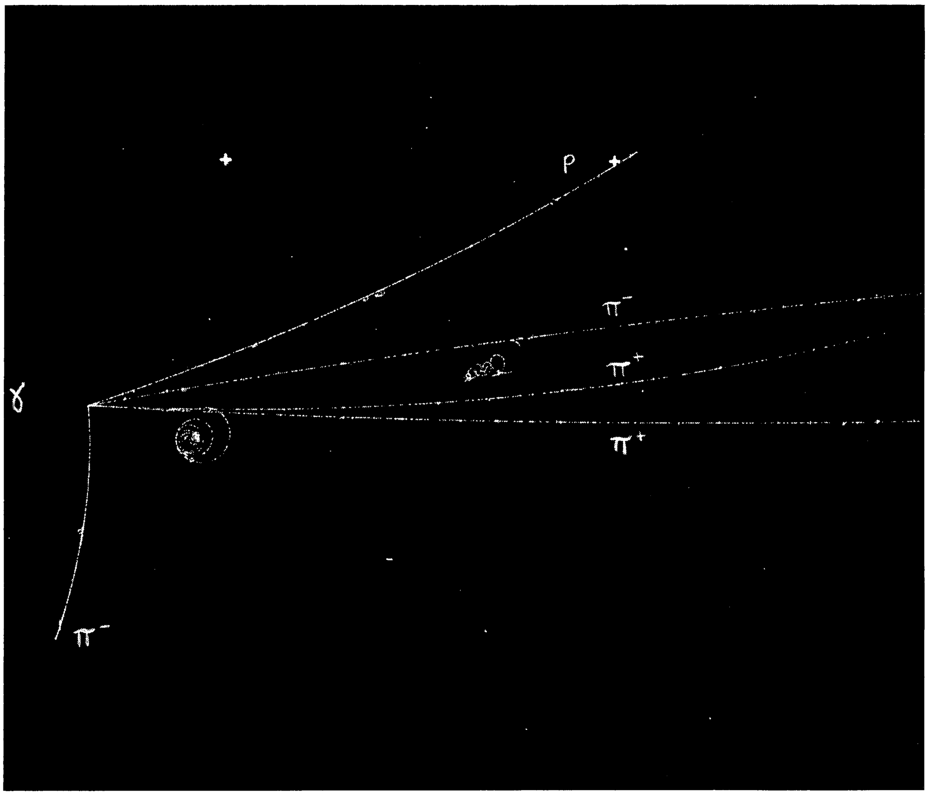
The external proton beam transport system for Channel C was designed and built at Leningrad while the kicker and septum magnets of ejection A, constructed at CERN, were used for deflecting the beam into the Channel. The distinctive feature of Channel C is that the accelerated beam is ejected at a small angle to the equilibrium orbit. This means that before it reaches the external target, situated 45 m from the accelerator, it passes through the fringing field of the main ring magnet for 20 m. In order to overcome the defocusing effect of this field and to achieve the necessary beam quality on the external target, a complex beam transport system has been constructed, consisting of pulsed quadrupole lenses and correcting magnets. The high quality of the lenses and magnets has made it possible to focus the beam on the target to a spot size of about 1.5 mm diameter and with an angular dispersion of better than $\pm$ 2 mrad.

The system has worked reliably for long periods with an ejection efficiency close to 100 %. Beam measurements at the external target indicate that highly stable operation is being achieved. Instability in beam position is less than 0.2 mm. This has enabled work to be successfully started on tuning the system in conjunction with the r.f. separator in order to provide beams for the 0.8 m^3 hydrogen bubble chamber, Ludmila, which was built at Dubna.

BERKELEY/STANFORD Rho prime results

A Berkeley/Stanford team have announced new results from an experiment at the Stanford Linear Accelerator which has been under way for several years. From two million bubble chamber photographs, they have collected around 350 events which are inter-

Bubble chamber picture (with background removed) of an event involving the creation of a rho prime meson recorded in a Berkeley, Stanford experiment. A photon, which has spontaneously converted into a virtual vector meson, has interacted with a proton. Analysis of this and other similar photographs led to the interpretation that the interaction involved a proton and a rho prime which is not itself seen since it decays in 10^{-24} s into rho and epsilon mesons (also not seen). Each of these mesons decays into two charged pions whose tracks are visible.



preted as decays of the rho prime meson.

The existence of the rho prime was predicted to explain some features of the interaction between photons and strongly interacting particles. As mentioned earlier in this issue the first evidence of its existence was unearthed at Frascati at the ADONE storage ring. The new data adds much more information on the particle.

The experiment used a laser beam back-scattered from the accelerated electrons resulting in very high energy photons (around 10 GeV) passing into a hydrogen bubble chamber. There they could interact strongly with protons via the intermediary of vector mesons. This phenomenon has been known for some time. Photons, which of themselves are not strongly interacting, can convert spontaneously into vector mesons and thus enter into the interaction as hadrons. Three types of vector meson — rho, omega and phi — have been extensively studied and the knowledge thus gained has gone a long way to explain the photon-proton interaction. The three types were not however adequate to explain all features of the interaction and more vector mesons such as the rho prime were predicted.

From the bubble chamber measurements the mass of the rho prime is set at about 1.5 GeV. It can exist in positive, negative and neutral varieties. The meson decays in 10^{-24} s giving four pions (and not two pions as expected). The photograph shows one such decay where the event is analysed as the rho prime giving rho and epsilon mesons each subsequently decaying into two pions.

Chicago Proceedings

The first two volumes of the Proceedings of the XVI International Conference on High Energy Physics, held at Chicago and NAL 6-13 September 1972, are now available.

The Proceedings, edited by J.D. Jackson and A. Roberts, are being published in four volumes: Volume 1 Parallel sessions — Strong interactions, Volume 2 Parallel sessions — Mostly currents and weak interactions, Volume 3 Plenary sessions — Strong interactions, Volume 4 Plenary sessions — Mostly currents and weak interactions. Volumes 3 and 4 are expected to be available in about five weeks time.

The price of the four volume set is $20 but separate volumes may be obtained for $7. Airmail to Europe for the complete set is $15 and surface mail $2. Cheques should be made out to 'XVI International Conference on HEP Proceedings' and forwarded to R. Donaldson, P.O. Box 500, Batavia, Illinois 60510.

WISCONSIN
Seeing the light

A fifth annual conference has been held at the Synchrotron Radiation Centre of the Wisconsin Physical Sciences Laboratory to discuss research at the 240 MeV storage ring, Tantalus, and at other synchrotron radiation facilities throughout the world.

Interest in setting up research facilities to use the synchrotron radiation emanating from orbiting electrons (in storage rings or electron synchrotrons) continues to increase. In addition to the centres we covered in the April issue last year (vol. 12 pages 130-132) research is beginning this month at Orsay using the ACO 580 MeV storage ring and there are plans to set up synchrotron radiation experiments at the 2 GeV storage ring DCI now under construction. A new

The extended experimental area at the Cornell 12 GeV electron synchrotron. The electron (e) and photon (γ) beam-lines, which feed experiments in the area, are indicated by solid and dashed lines respectively. The figures refer to experiments listed in the text.

group (known as LURE — Laboratoire pour l'Utilisation du Rayonnement Electromagnétique) has been set up under the leadership of Y. Farge.

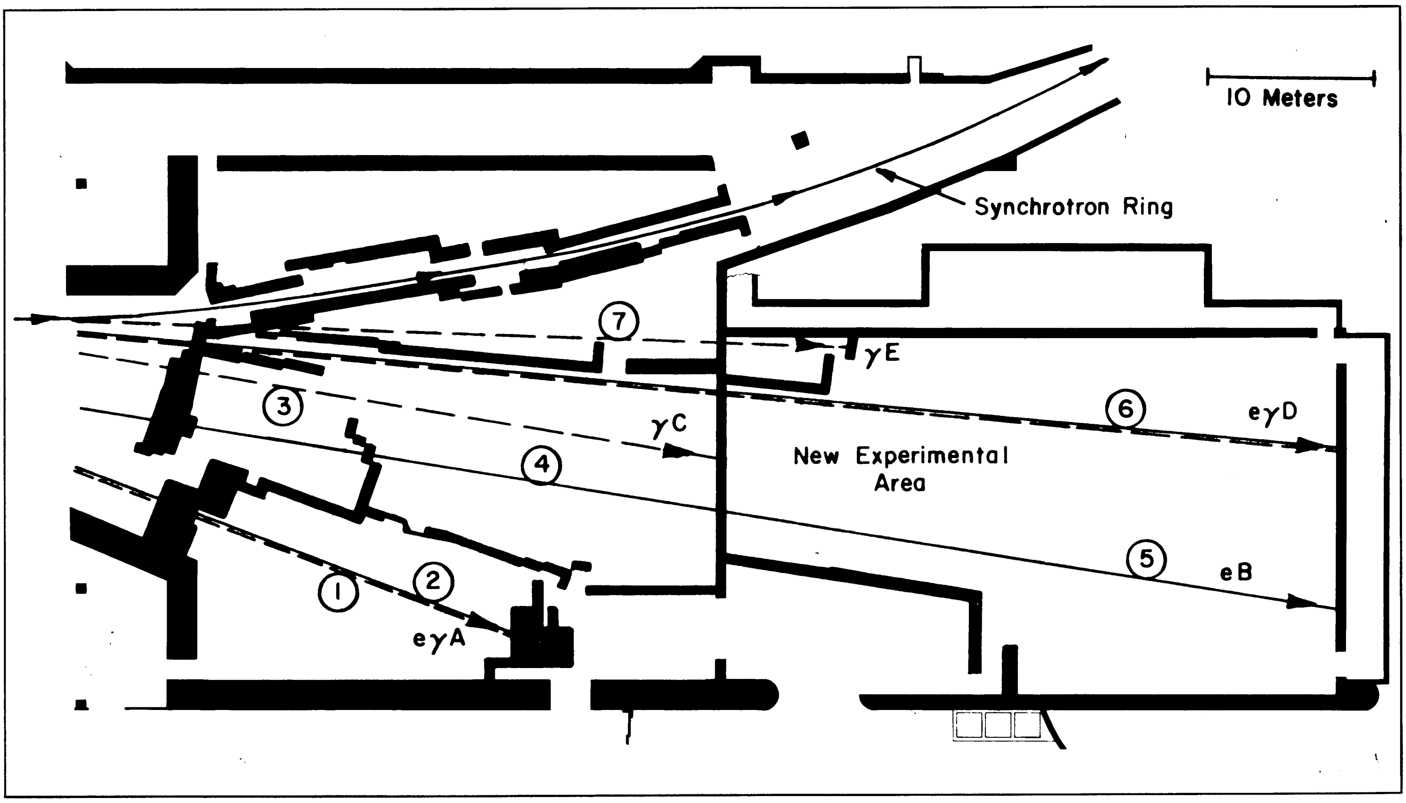
A team which has used Tantalus has moved to the Cambridge Electron Accelerator to carry out higher energy work with the bypass stored beams. Several other experiments in solid state physics and biology are using light from the CEA and the Laboratory, which in the present USA physics budget situation is fighting for its life, has proposed to the National Science Foundation that it becomes a National Synchrotron Radiation Facility.

In the Soviet Union, under the instigation of S. Kapitza, six Laboratories are proposing to build new machines or modify existing machines to serve as light sources. At Wisconsin there is a proposal to construct a 1.76 GeV electron storage ring to be used solely as a synchrotron radiation source. This proposal is now being examined by the National Science Foundation.

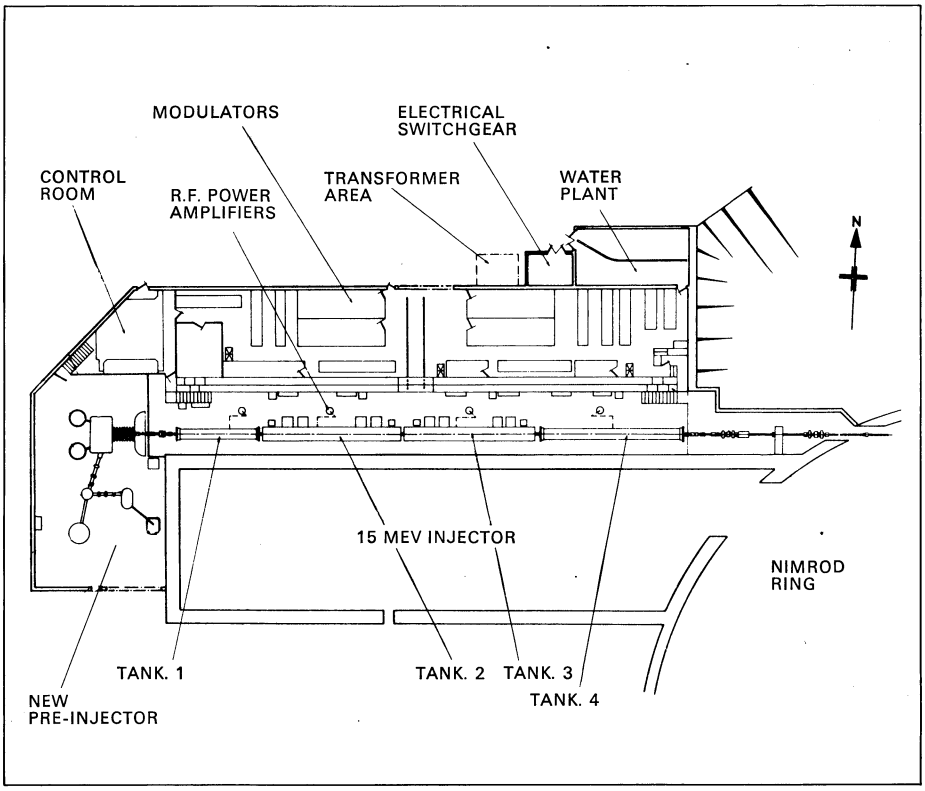
At the annual conference some topics from the research at Wisconsin attracted particular attention. A group from Illinois led by F.C. Brown has been studying the absorption of synchrotron radiation by solids and gases. They have used photon energies in the range 30 to 300 eV and have observed the absorption of thin films of solids such as silicon, alkali metals, etc., and of polyatomic gases such as silicon tetrafluoride retained in a gas cell. The spectra that they obtain are so refined by now that details can be distinguished which are due to the density with which energy states are occupied and to collective electron effects. With increasing experience, ways of identifying the different phenomena, which are producing features in the spectra, are emerging.

A Wisconsin experiment by W.M. Yen and L.R. Elias has looked at absorption spectra of trivalent rare-earth ions held in lanthanum fluoride crystals using wavelengths between 1250 and 3000 angstroms. Strong absorption bands are seen which can be assigned to electrons being lifted to higher energy levels and a lot of information on the possible transitions has been gathered. This is likely to have practical application in the development of solid state lasers in the wavelength range from 2000 to 4000 angstroms.

A surprising recent result came from the work of H.W. Ellis and J.R. Stevenson of Georgia who looked at the synchrotron radiation from Tantalus in the infra-red region. They found that the radiation intensity at long wavelengths, beyond 10 μm, was higher than from a conventional black body source (the wavelength where synchrotron radiation becomes competitive depending on the stored electron current). Particularly at the proposed



Planned location of the 70 MeV injector to feed the proton synchrotron, Nimrod, at the Rutherford Laboratory. It will take over from the existing 15 MeV linac and should increase the accelerated proton beam intensity by a factor of five.



new Wisconsin storage ring or at the higher energy machines elsewhere, synchrotron radiation facilities could better the present experimental possibilities for research at infra-red wavelengths.

Summer Institute

From 13-26 August 1973 an 'International Summer Institute on Particle Interactions at very high Energies' has been organized by the Université Catholique de Louvain and the Technische Hochschule Aachen. The Institute will be held at Louvain. Further information may be obtained from D. Speiser, Director of the Summer Institute, Institute for Theoretical Physics, Celestijnenlaan 200 D, 3030 Heverlee, Belgium.

CORNELL Experimental area doubled

The area available for experiments at the Cornell 12 GeV electron synchrotron has recently been doubled with the completion of an extension to the original area. The increase in space makes it possible to use the beams more efficiently and to have more flexibility in scheduling the experimental programme.

Four experiments are currently in progress: Electroproduction of rho mesons being carried out by a Cornell group indicated at position (1) on the diagram; Photoproduction of the omega meson using tagged photons by a Rochester, Cornell group at position (2); Eta and neutral pion Primakoff effect by a Cornell, Binghamton group at (3); Inclusive positive and negative pion, positive and negative kaon and proton electroproduction by a Harvard group at (4).

Three other experiments are setting up: A Cornell, Ithaca group will study multiplicities in deep inelastic electron scattering at (4); A Cornell group will study multiparticle final states in electroproduction at (5); A Cornell, Harvard, Binghamton group will study inclusive positive and negative pion, positive and negative kaon and proton electroproduction at (6). There will also be a test facility at position (7).

RUTHERFORD New injector for Nimrod

Not long ago the 7 GeV proton synchrotron, Nimrod, at the Rutherford Laboratory had its head on the block in the context of seeing what internal economies could be made to ensure UK participation in the 300 GeV project. But the axe did not fall. On the contrary, towards the end of last year the Science Research Council foresaw Nimrod being in operation until the end of the decade. To improve the machine's capabilities in the coming years, the construction of a new 70 MeV injector has been authorized.

The new injector will take over from the existing 15 MeV linac and the higher energy is expected to increase the Nimrod intensity to 10^{13} protons per pulse. This is a factor of five higher than the peak ejected beam intensity of 2×10^{12} which is expected to be achieved when a second harmonic r.f. system is brought into action this year. With an intensity of a few times 10^{12} at 15 MeV injection energy, the machine is bumping into its space charge limit. Hence the need for a higher energy injector.

Design work has been underway for some time. The major constraint, as usual, is money and ways of limiting effort and cost have been found. It is hoped to build the injector for around £1 million and the money will be found by internal budget shuffling rather than by asking for 'new' money.

The injector will be built alongside the existing 15 MeV linac (as shown in the diagram) and will use existing components where they are suitable. This applies in particular to tanks 2 (10 to 30 MeV) and 3 (30 to 50 MeV) which will be moved over from the PLA (50 MeV proton linear accelerator) which was closed down at the Laboratory in 1969. There will be four tanks in all. Tanks 1 and 4 will be modelled on the equivalent tanks in the Brookhaven 200 MeV linac.

The pre-injector will operate at 665 keV with a duoplasmatron ion source and a medium gradient column (16 kV/cm). Beam transport equipment will be conventional plus a phase ramping debuncher as used at Saclay (see vol. 11, page 76).

The new injector is designed to achieve an intensity of 75 mA with a

500 μs pulse length at a pulse repetition rate of 1 Hz. Commissioning is scheduled for the Spring of 1975. Until high reliability of the new machine is assured, both injectors will be available to feed the synchrotron ring.

Nimrod turned in its best year's performance in 1972 with 5400 hours of good beam time. The efficiency in the scheduled time allocated to high energy physics research was just over 90 %. Ejection efficiencies were also improved. Thin-septum, energy-loss ejection systems are now in action for all three ejection channels and during 1972 the highest number of protons per pulse ejected down channel X3 was just over 1.3×10^{12}. The machine is now having a well earned rest during a long shutdown (February to April).

EPS Divisions for high energy and nuclear physics

The February issue of the Bulletin of the European Physical Society reports the activities of Divisions of the EPS devoted to High Energy and Particle Physics and to Nuclear Physics.

The HEPP Division initially operated under an interim board chaired by A. Zichichi (after the death of P. Preiswerk) but a new board has now been elected — M. Froissart (Chairman), G. Charpak (Secretary), A. Baldin, G. Bernardini, J. Hamilton, H. Lipkin and W. Paul.

The Division organized an EPS Conference on 'Meson Resonances and Related Electromagnetic Phenomena' in Bologna and an important future activity is its involvement in the organization of the next European Conference on High Energy Physics which is sponsored by the EPS and the French Physical Society. This Conference will be held in Aix-en-Provence from 6-12 September and is expected to welcome about 600 physicists. The emphasis at the Conference will be physics at very high energies. The following Conference in this European Conference series, which will possibly be held in Italy in 1975, is already under consideration as an HEPP Divisional Conference.

Other concerns of the Division are the future developments at national Laboratories in Europe and their relationship with CERN. (This is under investigation also by the European Committee for Future Accelerators, ECFA). Also the Division is sensitive to the many rapid changes occurring in the high energy physics community and in the political background within which it works. It is intended to give more attention to assessing financial means and numbers of physicists (and perhaps of specialized technicians) available for high energy physics in Europe in coming years.

The Nuclear Physics Division is also preoccupied by a forthcoming conference — 'International Conference on Nuclear Physics' to be held at Munich from 27 August to 1 September. It is being organized by the two local Universities under the sponsorship of the EPS and IUPAP. Since the nuclear physics sections of national societies within Europe already have meetings of high standard, the Division is generally likely to help extend the scope of some meeting of this character to serve as Europhysics Divisional Conferences. International summer schools are being organized by national groups — such as in Poland (Rudziska and Zakopane schools) and Romania (Predeal).

The Division is also pressing the EPS to establish a European equivalent of the Bulletin of the American Physical Society in connection with the internationalization of national conferences.

The interim Board of the Division is L.L. Green (Chairman), C. van de Leun (Secretary), N. Cindro, A. Corciovei, H. Faraggi, I. Lovas, Th. Mayer-Kuckuk, O.B. Nielsen, S.G. Nilsson, R. Nordhagen, R.A. Ricci, A. Strzalkowski and Y. Talmi.

Sweden's route to Laboratory II

An English translation has been published of 'Sweden and CERN II — the Research Policy Debate 1964-1971'. The report was prepared by A. Hadenius from Uppsala University for the Swedish Committee on Research Economics, FEK (a sub-committee of the Swedish Atomic Research Council — the contact organization for CERN — and of the Natural Science Research Council). It charts the important stages en route to Sweden's decision to participate in Laboratory II.

The debate prior to the decision was intense especially in the early stages, with much opposition from within the scientific community itself. The report has some very sharp comments about attitudes and techniques taken up by the participants in the debate. It is also underpinned by a very interesting discussion on scientific research 'doctrines' and their relationship to the activities of society at large.

Copies may be obtained at a cost of 15 Swedish crowns from the Editorial Service, Box 23136, S-10435 Stockholm 23, Sweden.

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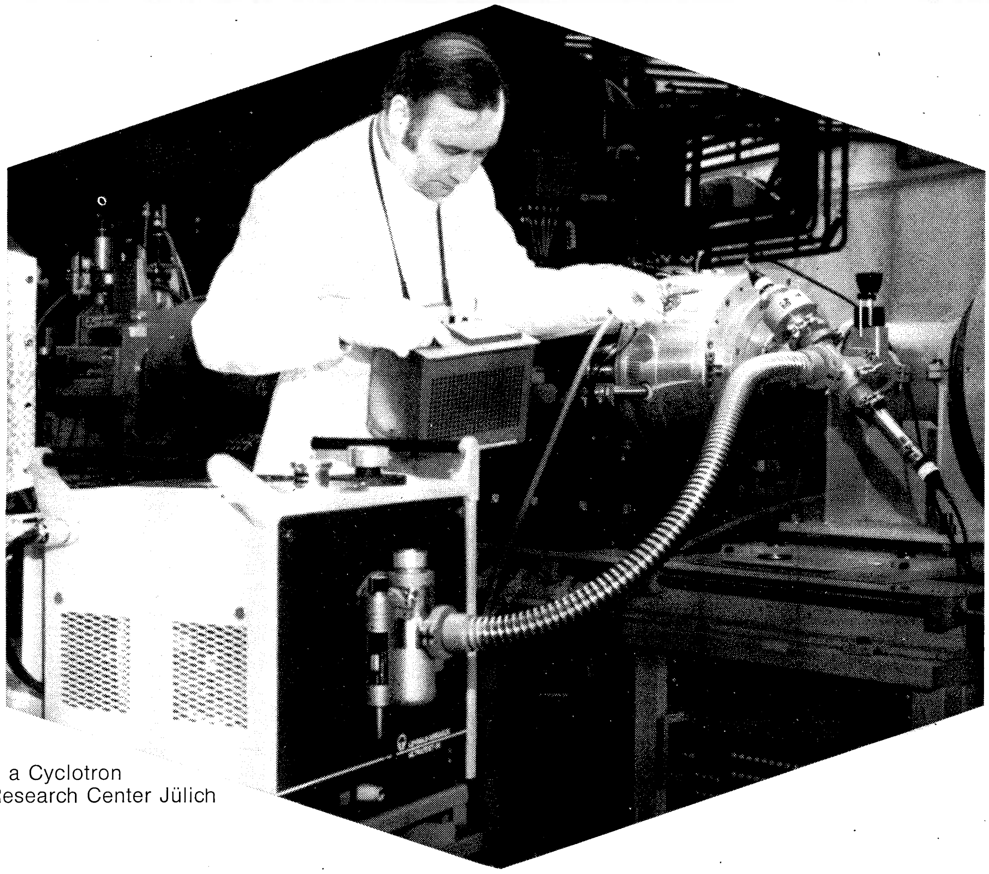

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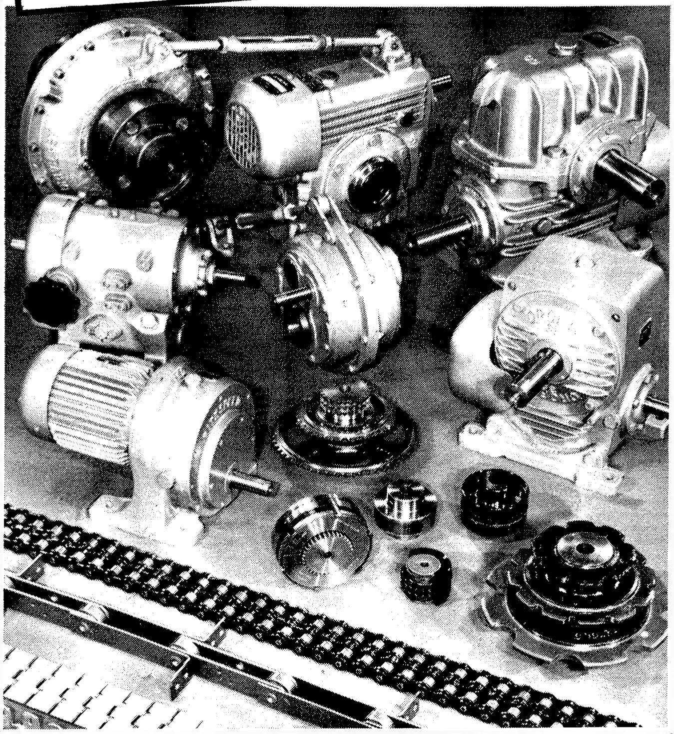

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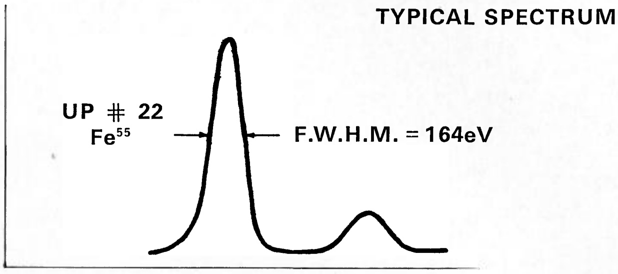

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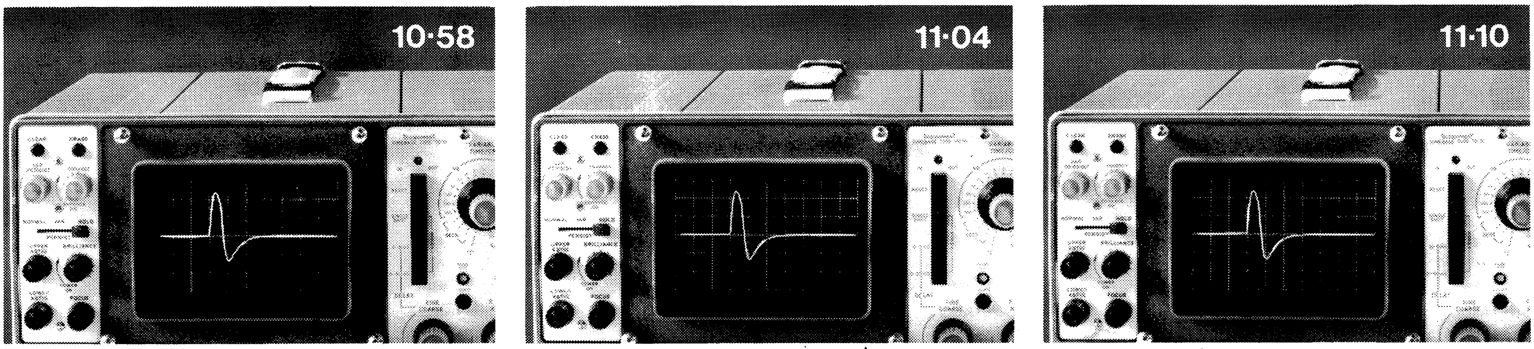

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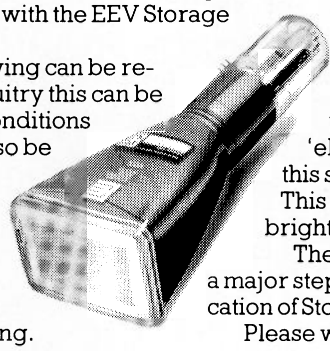

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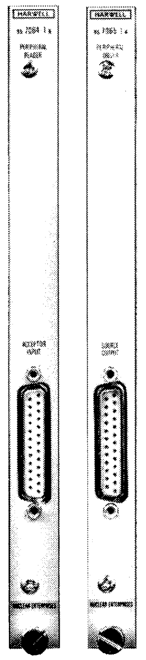
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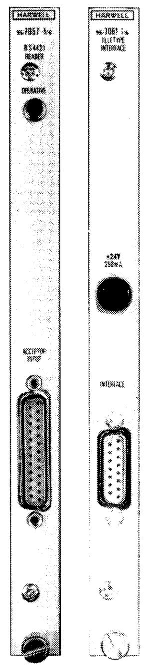
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Ces caractéristiques, auxquelles viennent s'ajouter la puissance du calculateur et ses possibilités de mise au point des programmes permettent au Modèle 30 de résoudre rapidement des problèmes extrêmement complexes. Il peut donc effectuer immédiatement la plupart des tâches qui, sans lui, attendraient leur tour être traitées par l'ordinateur central. Comme tous les autres produits Hewlett-Packard, le Modèle 30 bénéficie d'un réseau de 172 points de vente dans 65 pays, qui assurent le service après-vente.

Pour recevoir une documentation complète sur ce nouveau venu dans la grande famille des calculateurs Hewlett-Packard, remplissez le coupon-réponse ci-dessous.

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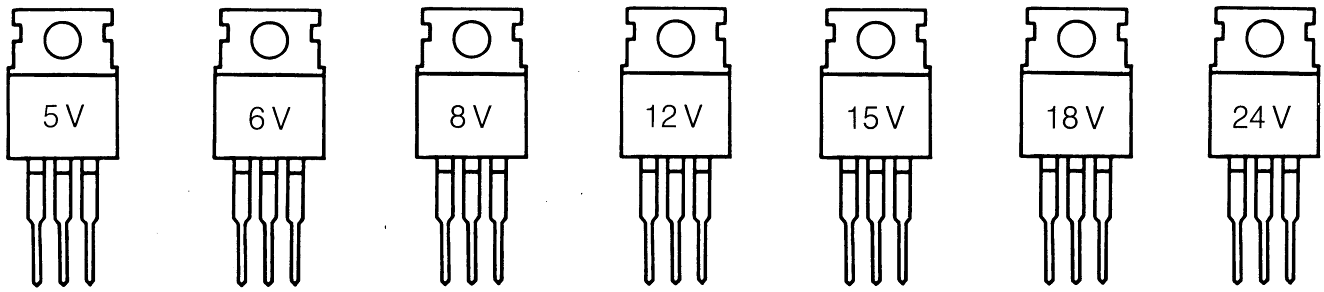

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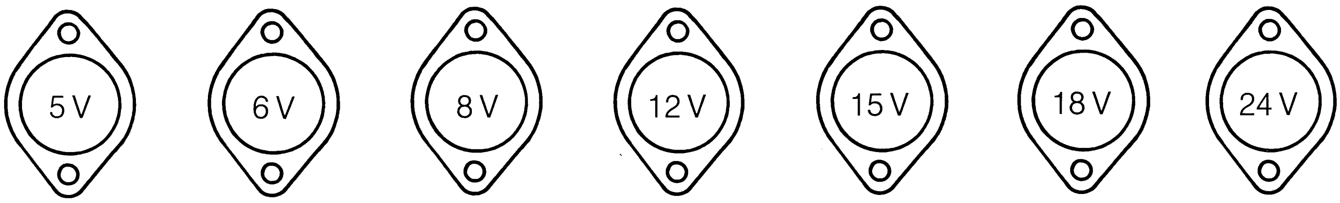

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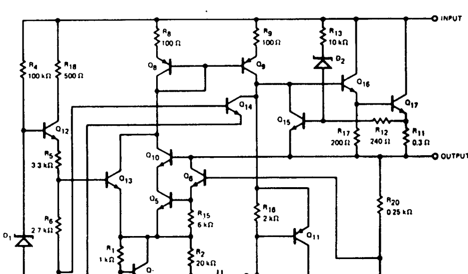

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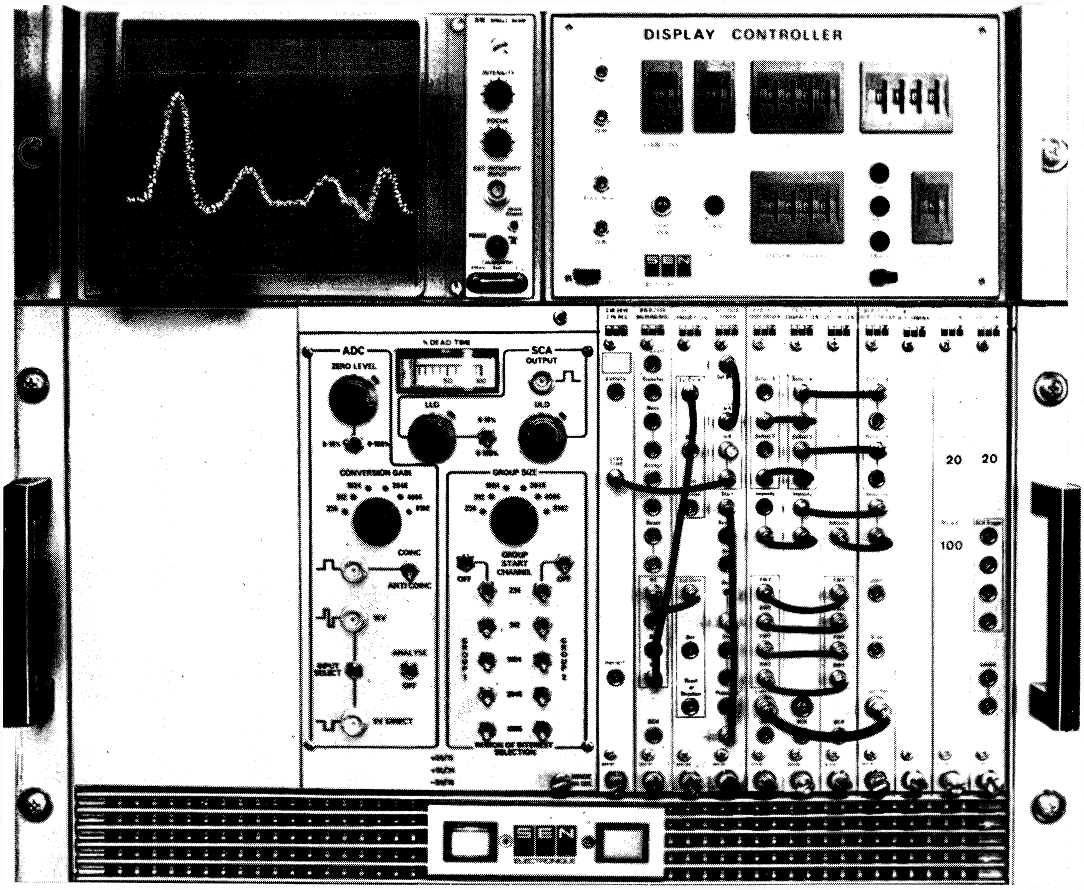
SEN SPECTRUM ANALYSER



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* *The current range of SEN CAMAC consists of 37 different modules.*

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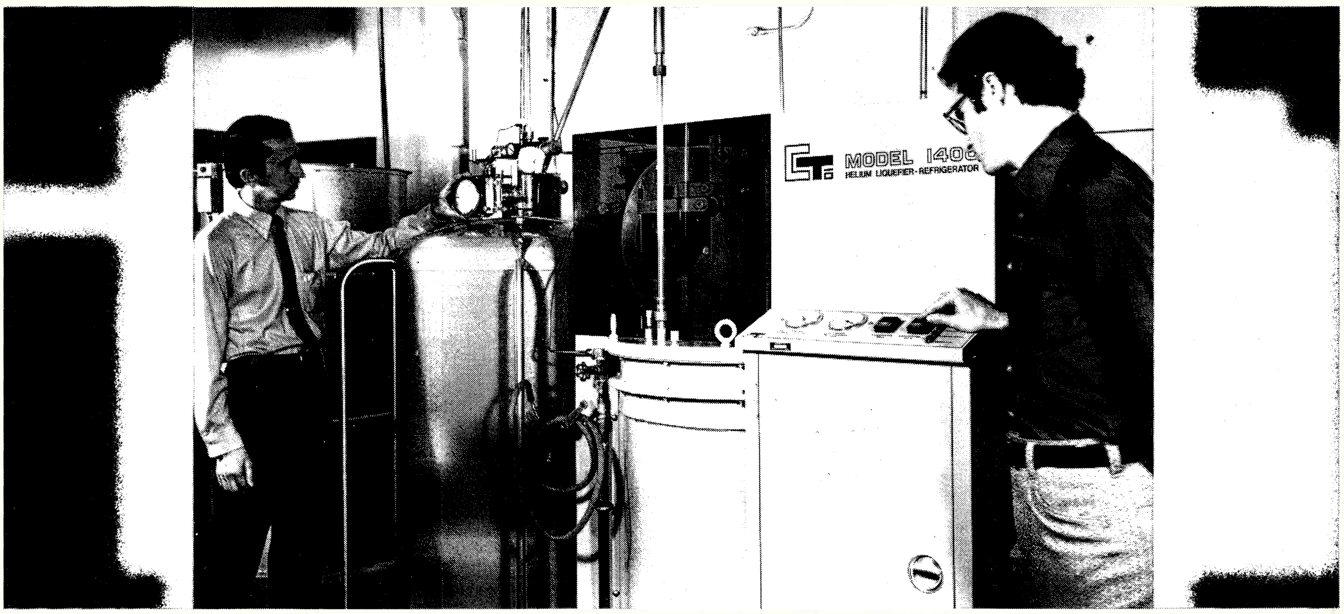

The University of Florida at Gainesville is one of a growing number of universities and research centers that have opted for an in-house capability to produce liquid helium.

Florida's Department of Physics and Astronomy, for example, has extensive research projects both in solid-state and in low-temperature physics, some involving high-field superconducting solenoids, requiring steady supplies of the "lifeblood" fluid of low-temperature research.

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