CERN COURIER

No. 6 Vol. 12 June 1972

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. The Organization has its seat at Meyrin near Geneva in Switzerland. There are two adjoining Laboratories known as CERN Laboratory I and CERN Laboratory II.

CERN Laboratory I has existed since 1954. Its experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). Large intersecting storage rings (ISR), are fed with protons from the PS for experiments with colliding beams. Scientists from many European Universities as well as from CERN itself take part in the experiments and it is estimated that some 1200 physicists draw research material from CERN.

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

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

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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Annual Report

The CERN Annual Report for 1971 has recently been published. Copies are available, on application, from the Public Information Office (CERN, 1211 Geneva 23, Switzerland) stating clearly — name, address, number of copies, language version (English or French).

CERN COURIER next edition

The next edition of CERN COURIER will cover the months of July/August and will appear at the end of August.

Cover photograph : Professor A. Petrosiants (left) and Professor W. Jentschke (right) cut the ribbon giving access to the fast ejection building at the 76 GeV proton synchrotron at Serpukhov. This inauguration ceremony for the CERN-built equipment installed at the Soviet Institute was held on 8 June. Professor A.A. Logunov, Director of the Institute of High Energy Physics, is in the centre holding the ribbon. (CERN 138.6.72)

48th Session of CERN Council

The Council met on 15, 16 June under the Presidency of Professor W. Gentner.

Progress Reports

Progress at both CERN Laboratories was covered in reports from Professor W. Jentschke and Dr. J.B. Adams.

At Laboratory I the 28 GeV proton synchrotron has been in fine form and further refinements of its abilities have been achieved. Within recent weeks running in of the Booster has been going smoothly and a new ejection scheme has been successfully tested (both these topics are amplified later in this issue). Performance of the Intersecting Storage Rings has continued to improve and luminosities only a factor of four lower than the design value (4×10^{30} per s per cm^2) have been reached. Peak currents are now 11 A in Ring I and 9 A in Ring 2 and physics runs are possible with sufficiently stable beams in the 6 to 7 A region. No basic limitation on performance has yet been reached. The 600 MeV synchro-cyclotron is supporting a very full research programme and has developed a technique for sending very short bursts of particles needed for an experiment on the mu-mesic Lamb shift in helium. The improvement programme on the machine is still, unfortunately, in abeyance waiting for the rotary condenser. It is hoped to start final tests on the condenser late summer.

Major detection systems are nearing the time when they will be involved in their first experiments. The Omega spectrometer has one superconducting coil operating and has received its first particles. The Split Field Magnet at the ISR is coming together and should be ready at the end of this year. The large proportional chambers wich will be installed in the magnet aperture are being manufactured and a lot of work is going into developing the analysis programmes which will be needed to understand the information that the chambers collect. The large European bubble chamber, BEBC, is now in the midst of its initial cool down. (This is being done very carefully over a fourteen day period in this first test.) A leak of oil into the helium cooling circuit has caused delays in the commissioning of BEBC and the project is running four or five months behind schedule. It is not now expected to start physics until the middle of next year. The heavy liquid bubble chamber, Gargamelle, has, of course, already had many physics runs with both freon and propane fillings and has yielded some preliminary results of great interest. In particular there is clear evidence of the production of strange particles (such as lambdas and sigmas) in neutrino interactions. Total neutrino cross-section measurements are in line with the simple quark model.

At Laboratory II the number of staff involved in the construction of the SPS

An important event at the Council Session was the approval of the revised Agreement between CERN and France concerning the legal status of the Organization in France. The initial Agreement was signed in 1965 when land was made available to CERN by the French government for the construction of the Intersecting Storage Rings. This land is enclosed with access only from Switzerland. The revised Agreement takes account of the fact that Laboratory II, where the SPS is being built, is largely in France with, of course, access from France. In essence, the Agreement is designed to protect the international status of CERN in all matters relating to its efficient and independent functioning.
After the Council Session the Agreement was signed by M. G. Curien (left) representing France and the CERN Directors General Dr. J.B. Adams and Professor W. Jentschke.

CERN 160.6.72

Not strictly related to the latest CERN Council session but very much an affair of Council was a farewell dinner held at the end of May for two of Council's most celebrated delegates who now no longer participate directly in its work. Edoardo Amaldi from Italy and Gösta Funke from Sweden have both contributed a very great deal to the success of CERN. We have already recorded appreciations of their work (Professor Amaldi vol. 12, page 5, Dr. Funke vol. 9, page 377). At the dinner they were presented with albums of photographs which traced major events in the life of CERN and incidents in which they were personally involved during the past twenty years. The presentations were made by Professor W. Gentner, the present President of the Council:

1. To Edoardo Amaldi (on Amaldi's right is Dr. J.B. Adams, Director General of CERN Laboratory II);

2. To Gösta Funke (on Funke's left is Professor W. Jentschke, Director General of CERN Laboratory I).

has now risen to about 200 and is expected to reach 300 by the end of the year. Two full-size (over 6 m long) model magnets have been built and field measurements are starting. Offers to build the bending magnets have been received from European industry and are now being analysed. It is hoped to adjudicate the contracts in July. Tenders for construction of the quadrupole focusing magnets are expected soon. Work on the magnet power supplies has reached the stage where specifications for the rectifier modules, transformers and passive filters have been written and invitations to tender are being sent out.

Inquiries concerning manufacture of the r.f. accelerating system are also being made. It has been decided that the power amplifiers will be based on the use of tetrodes, contracts to be adjudicated in July. Tests on models of the accelerating structure (which will involve three cavities 20 m long) are continuing. Work on injection, ejection and beam transport has progressed to the stage where design of many components is complete. Some decisions, which are necessary to finalize the beam transport system design, remain to be taken (for example the energy of the beams to be fed to the West Experimental Hall and the method of supplying neutrinos to BEBC). These important decisions will be taken at the meeting of the ECFA Working Group on the SPS experimental programme to be held in Tirrenia in September.

Preliminary enquiries have gone out to a very large number of firms concerning the control system of the accelerator which is based on a hierarchy of computers. (Since the last report on SPS design it has been decided to have the large computer at the top of the hierarchy divided into units each performing comparatively few duties.)

CERN 339.5.72 1.

CERN 344.5.72 2.

CERN News

The most visible activity is on the site itself where construction of the laboratory blocks and assembly hall has started and where the access shafts are being dug. Two of the shafts are now down 45 m and are being joined by tunnelling underground ready to take the 'Mole' — the large tunnelling machine scheduled to arrive in September. In order that the machine can be pointed in the right direction, a very precise geodetic network has been established on the site. A series of survey monuments have been set up and their positioning is remarkably accurate — a standard deviation of 2.4 mm over an area of about 10 km². Negotiations concerning the vital supplies of electricity (Electricité de France) and cooling water (Swiss authorities) are well advanced.

The most invisible activity is the administrative work. This has involved discussions with French and Swiss authorities concerning acquisition of the required land, customs and fiscal arrangements, etc. There have also been many contacts with representatives of local communities since it is aimed to cause as little disruption as possible in the region where the machine is being built. One important step in solving all these complex problems, which come from CERN's unique position of being built across an international frontier, is the revision of the Agreement between France and CERN (see photograph caption on page 195) which puts CERN's legal status in France in order.

Scales of contribution

Every three years the percentage contributions of the Member States to the budgets of CERN are adjusted in accordance with figures on net national income provided by the United Nations Statistical Office. The agreed scales for the years 1972, 73 and 74 are as follows :

	Laboratory I	*Laboratory II*
Austria	2.06 %	2.07 %
Belgium	3.71 %	3.72 %
Denmark	2.16 %	2.17 %
France	21.55 %	21.65 %
Germany FR	24.59 %	24.70 %
Greece	0.46 %	—
Italy	13.82 %	13.89 %
Netherlands	4.66 %	4.69 %
Norway	1.54 %	1.54 %
Sweden	4.78 %	4.80 %
Switzerland	3.12 %	3.13 %
U.K.	17.55 %	17.64 %

Following the decision of Denmark earlier this year to join in the 300 GeV programme the Council agreed that the total project cost should revert to 1150 million Swiss francs over the eight year construction period as originally foreseen.

Appointments

The Council renewed for three years the appointments of G.H. Hampton as Director of the Administration Department, K. Johnsen as Director of the ISR Department and C. Peyrou as Director of the Physics II Department. E. Picasso was appointed as Leader of the Nuclear Physics Division and L. Resegotti as Leader of the ISR Division. (F. Bonaudi will succeed L. Resegotti at the end of 1972.)

The mandate of the Danish 'Revisions-department' as external auditors expires with the completion of the audit of the CERN accounts for 1972. The Council appointed the Deutscher Bundesrechnungshof to succeed them.

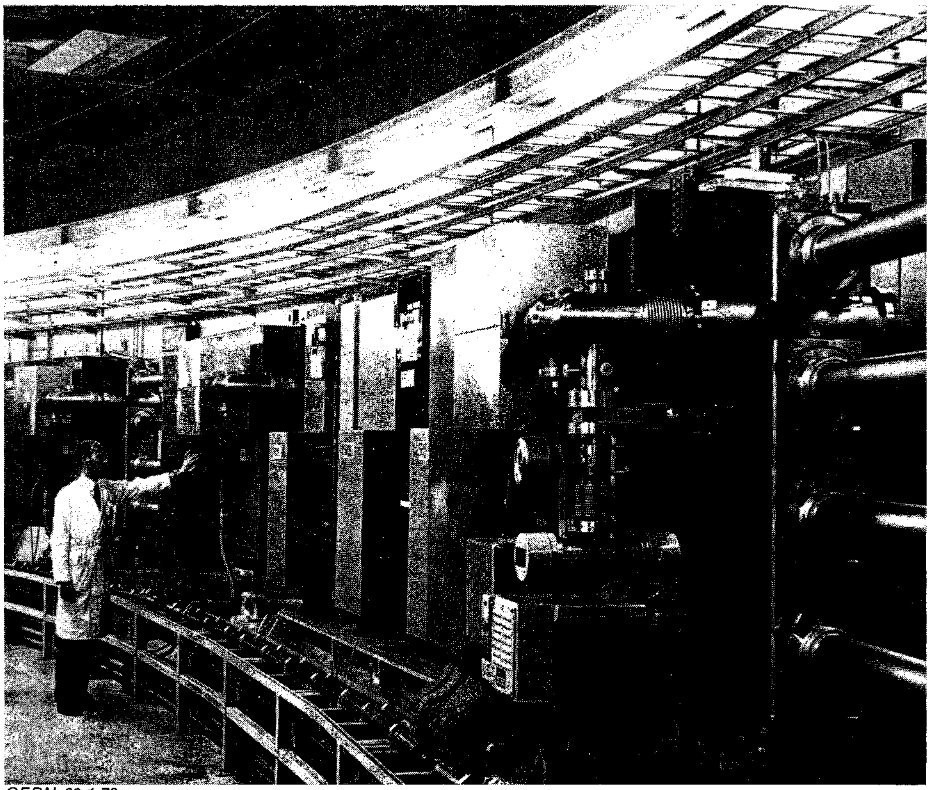
Booster coming smoothly into action

On 26 May the Booster, which is now being commissioned, accelerated protons to the design energy of 800 MeV for the first time. During subsequent runs other systems were successfully brought into play and first measurements on the beam indicate that no unforeseen problems have been encountered. The Booster is well on the way to achieving its design intensity of 10^{13} protons per pulse to feed to the main ring of the synchrotron.

The Booster has been built in the context of the improvement programme at the 28 GeV machine. By boosting the injection energy from the 50 MeV of the existing linac to 800 MeV, the 'space charge limit' of the synchrotron ring will be raised considerably so that beams with intensity in the 10^{13} protons per pulse region can be accepted by the synchrotron rather than the few times 10^{12} reached at present.

A novel design with four superposed rings was evolved. The rings are 50 m in diameter with a separated function magnet structure — bending and quadrupole focusing magnets are separate units, each magnet being in one block with apertures for the vacuum chambers of the four rings. The rings are fed at 50 MeV from the linac for a maximum pulse duration of 100 μs. A vertical kicker and septum magnets direct protons to the four levels, a 25 μs pulse feeding each ring (multi-turn injection for fifteen turns). The r.f. system accelerates five bunches of particles in each ring and, after ejection at 800 MeV, septum magnets again come into action to bring the protons to the PS ring. The bunches can be transferred sequentially to establish the twenty bunches which are normally accelerated in the PS. Also, a trick that the Booster has up

The 800 MeV Booster now being commissioned at the 28 GeV proton synchrotron. The vacuum chambers of the four superposed rings can be clearly seen on the right then comes a bending magnet, a quadrupole triplet and another bending magnet. The Booster reached design energy on 26 May and is now pushing towards design intensity.



CERN 83.1.72

its sleeve for future use is that by combining two bunches vertically, rather than transferring them sequentially, it may be possible to increase the physics potential of the ISR subsequently supplied by the PS.

Commissioning of the Booster started on 1 May with the magnets in the machine not properly aligned. The first few runs concentrated on tidying up the injection line from the linac and the injection systems. Nevertheless by the third run on 5 May, circulating beam was achieved with about a third of the machine aligned and by 16 May, with the machine fully aligned, beam was circulating for some 4200 turns. This was reported in the last issue, page 162. No acceleration was being applied at this stage and the beam was lost to the inner wall of the vacuum chamber as the magnetic field rose.

On the fifth run beams were circulating in rings 2 and 3 and measurements on the ring 2 beams were carried out. Both horizontal and vertical Q values corresponded to the design values of 4.50 within 0.05 in both planes. The results of closed orbit measurements were better than predicted — a few millimetres rather than 5 to 10 mm.

Then came problems. During the next run a leak in the water cooling system of a prototype septum magnet gave the injection line a good washing out. Septum magnets had to be removed to dry out the ferrite leaving only ring 3 (on the same plane as the linac beam and hence feedable without the septum magnets) available for filling. Tests were able to begin again three days after the accident. However, the enforced element of simplicity in the subsequent commissioning runs in having only one ring to play with was not all bad. There were quite enough complexities left to absorb the available time.

On the seventh run the r.f. accelerating system was brought on but without the feedback loops which ensure high precision of the accelerating frequency and its phase. Beam was accelerated for about 100 ms which is equivalent to an energy of around 120 MeV. The next run on 26 May first pushed this higher (450 ms equivalent to around 560 MeV) with the r.f. working well. The magnet power supply was then set for 800 MeV and the beam went all the way to peak energy. An intensity of around 5×10^{10} protons per pulse was recorded at 800 MeV.

In subsequent runs operation of the Booster has become smoother as experience has accumulated. Q shifting up to peak energy could be achieved easily by means of ramped trim supplies connected to the quadrupoles. More time per run was thus available for studying the beam behaviour. By 2 June intensities of 2×10^{11} protons per pulse at 800 MeV with single turn injection had been reached. About 5% of the beam was being lost at injection and the trapping efficiency, when the r.f. system was brought on, was 55 %.

On 9 June the intensity goal of 2.5×10^{12} protons per pulse per ring seemed really to be in sight when multi-turn injection worked successfully in ring 3. Then intensity climbed steadily as turn after turn was injected. With 15 turn injection over 2.5×10^{12} protons could be fed to the ring.

Up to this stage all the injection tests had been carried out with a 'chopped' beam — at the linac input a 3 MHz chopper cut the beam into tiny slices. This helped in beam observation in the Booster. When the chopper was switched off, multi-turn injection over 15 turns gave 5×10^{12} protons circulating. This looks very healthy for achieving design intensity of 2.5×10^{12} protons accelerated to 800 MeV in each ring.

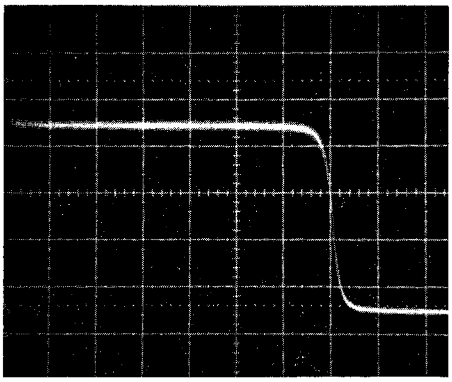
For the delight of accelerator specialists - four scope pictures illustrating the behaviour of beams in the Booster :

1. Signal from a beam transformer showing single turn injection which is practically loss-less. The beam circulates, without being accelerated, for 7 ms until the rising magnetic field drives it against the vacuum chamber. The steepness of the loss when this happens indicates the small size of the beam. (Scale - horizontal 1 ms per division, vertical 8 mA per division.)

2. Signals from 16 pick-up stations are acquired by a computer on two successive turns shortly after injection. The closed orbit distortions are so small that no use is made of the correcting dipoles.

3. Acceleration to 800 MeV. The signal from the beam transformer increases in amplitude as the particles gain speed and thus represent a higher current. The intensity at design energy is 2×10^{11} protons. (Scale - horizontal 100 ms per division, vertical 8 mA per division.)

4. Multi-turn injection over eighteen turns is demonstrated by the signal from a fast beam transformer. The individual spikes result from the use of a chopped beam. (Scale - horizontal 5 μs per division, vertical 80 mA per division.)



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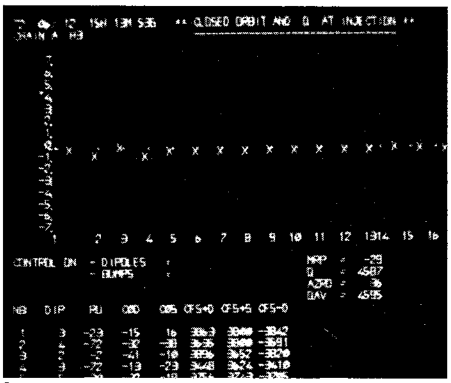

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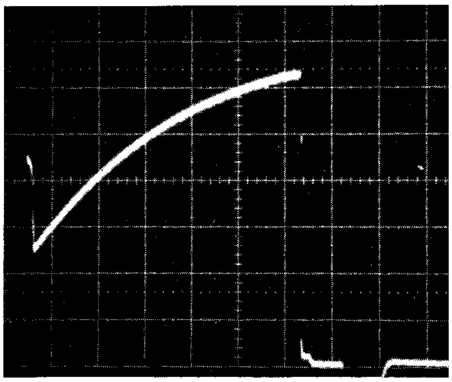

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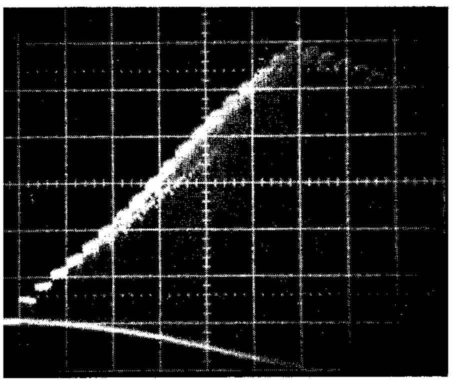

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Computer simulation of beam behaviour carried out before commissioning started, has proved an invaluable help. It has made it possible to understand rapidly what is happening and to adjust conditions quickly and appropriately. Adiabatic trapping is now being tried to increase the fraction of particles which can be captured by the r.f. accelerating fields. By the end of the month the final septum magnets should be in place so that all four rings will be in action.

The five year project has been carried out to schedule. The Booster team have carried through design, construction and commissioning excellently.

CERN-Serpukhov Experiment No. 3

On 1 June equipment set off by rail from Geneva en route to the Institute of High Energy Physics, Serpukhov, to be used in the third collaborative experiment on the 76 GeV proton synchrotron. The experiment involves groups from Karlsruhe, CERN, ITEP (the Institute of Theoretical and Experimental Physics, Moscow, under the direction of I.B. Chuvilov) and, possibly, a few scientists from Moscow State University. It is concerned with studying neutron-proton charge exchange at high energies.

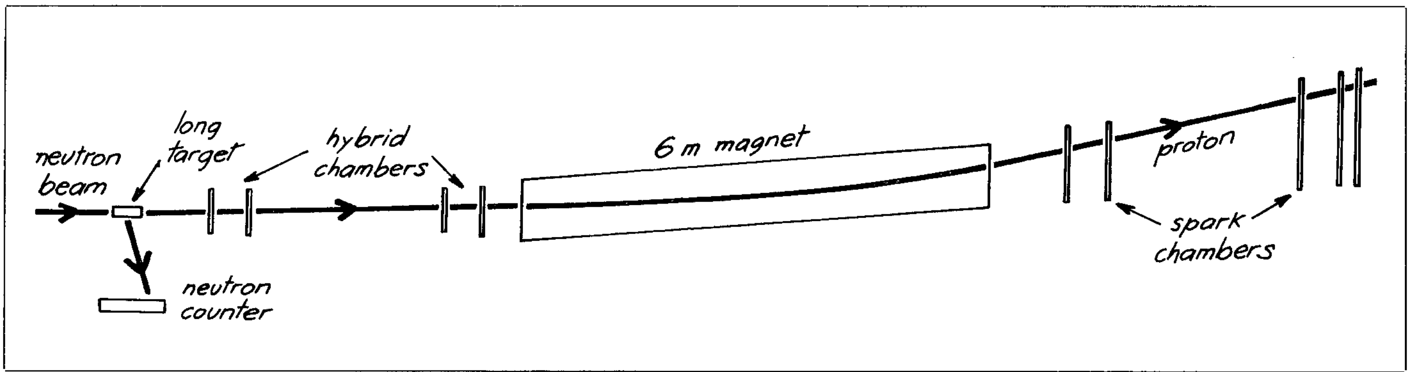
A lot of data on the phenomenon of charge exchange has been collected at lower energies. What happens is that a neutron is fired into a target and a proton emerges in the forward direction, a neutron coming off at the side. The simple interpretation is that a pion, carrying a positive charge, has hopped from the 'stationary' proton in the target to the neutron as it hurtled by thus converting it to a positively charged proton (leaving a neutron in its wake). This simple interpretation gains weight, at first glance, from looking at the graphs obtained at all the energies investigated so far — they all show a very sharp peak at small t values (i.e. when little momentum is transferred from the incoming particle to the target particle). The slope of this peak (which is much sharper than that observed in any other scattering cross-section) is of the order of magnitude of the inverse of the pion mass squared — a seemingly clear pointer that the pion is involved.

However when the detailed calculation is done concerning the results which should be obtained with a simple one-pion exchange, a dip should be found rather than a peak. It is still probable that the pion is involved but its effect must be superimposed on other things which go on during the charge exchange (superimposed on a more complicated background).

One of the main aims of the new experiment at Serpukhov is to try to learn more about this background — for example, whether it has to do with pomeron-pion exchange (Regge cuts) or rho and A2 exchange. The way in which the phenomenon is dependent on the energy should settle this question.

A second aim is to try to get more information on whether the pion is 'Reggeized'. Regge theory has been one of the most successful theories in linking particles together and in linking the existence of particles with the observed scattering amplitudes. When only spin and parity are changing, particles lie on so-called Regge trajectories in orderly fashion and the slopes of the trajectories are parallel. The pion however is isolated and is not linked with other particles — a trajectory for the pion cannot be drawn. The indications from the latest measurements at CERN are that the trajectory may have zero slope — the pion may not be Reggeized at all. Extending the measurements to higher

Schematic diagram of the layout of the detection system for the third collaborative electronics experiment at the 76 GeV proton synchrotron at Serpukhov. The experiment will study neutron-proton charge exchange using a neutron beam from the accelerator and detecting the proton and neutron emerging from the interaction.



energies should clinch this question.

A schematic representation of the experimental set up can be seen in the diagram. The neutron beam emerges from the synchrotron at a tangent where the accelerated proton beam (about 5×10^{11} protons per burst) strikes an internal target. Magnets and lead blocks take out the charged particles and the gamma rays, respectively, leaving a neutron beam which strikes a hydrogen target about 60 m away. The experiment can cope with all neutrons with a momentum between 20 and 70 GeV/c.

Since the probability that the charge exchange interaction will take place goes down as the energy increases, a long target (25 cm) filled with liquid hydrogen is used to put more protons in the way of the neutrons. However using a long target would mean that the point of interaction would not be known to adequate precision unless special measures were taken. Therefore a system to measure the amplitude of the Cherenkov light emitted by the emerging proton was developed with the group of L. Mazzone. The amplitude of the photomultiplier signal from the Cherenkov light gives the point of interaction.

The neutron emerging from the target with low momentum is detected in a neutron counter (four vertical scintillator blocks). The angle and time of flight can be measured and neutrons with momentum between 1 and 250 MeV can be detected. (This corresponds to studying t values, or momentum transfers, between 0.001 and 0.6 $(GeV/c)^2$.)

The outgoing proton is detected and measured in a spectrometer involving hybrid chambers (described in vol. 11, page 231) which are used near the target to take advantage of all the intensity possible, a 6 m magnet (a standard Serpukhov bending magnet), and spark chambers with core read-out. The detectors are all linked with an on-line computer, a CDC 1700. We will not describe the various tricks such as the use of anti-counters and shields which ensure that only the events of interest are being recorded.

All the equipment, with the exception of the large Serpukhov magnet, has worked at CERN in an experiment covering a lower energy range. It is scheduled to arrive at Serpukhov on 22 June and to be set up ready to receive its first high energy neutron beam on 18 August. The experiment will be at Serpukhov for about a year. The people who will go for varying lengths of time are V. Bohmer, J. Engler, W. Flauger, B. Gibbard, H. Keim, F. Monning, G. Novellini, K. Ratz, K. Runge, H. Schopper and K. Pack. Their Soviet colleagues will be led by V. A. Ljubimov and one of the Vice-Directors of the Institute, V. G. Shevchenko will participate.

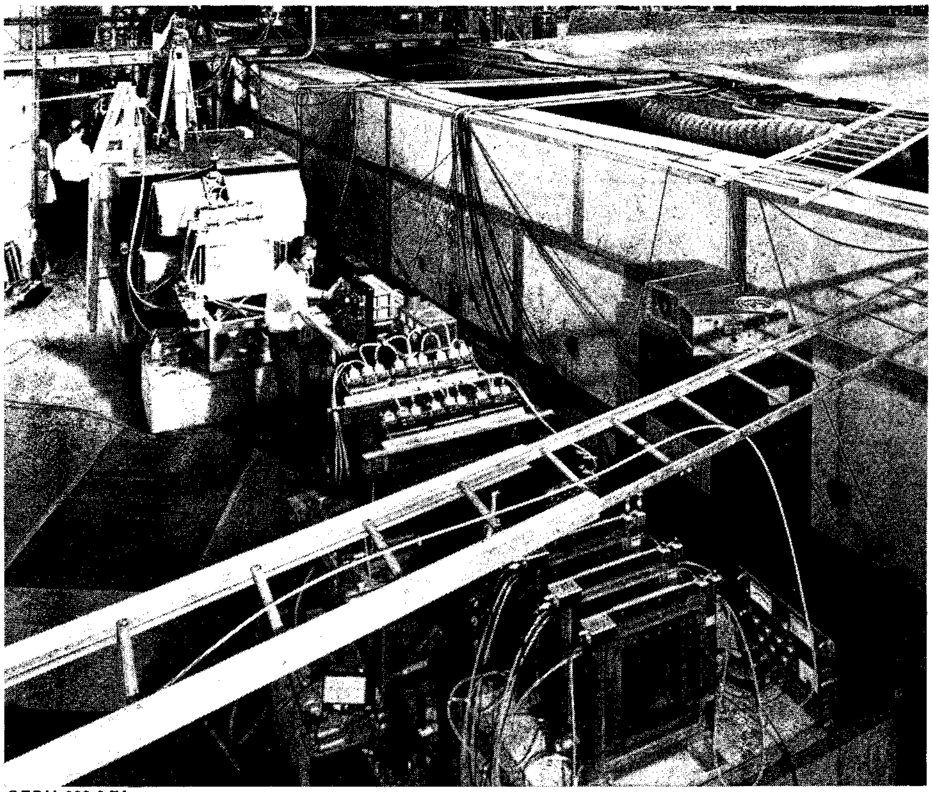
A fourth collaborative experiment involving a Karlsruhe, Pisa, Serpukhov and Vienna team will study negative pion-proton charge exchange and neutral meson resonances. They will be using some of the equipment of the second experiment (described in vol. 10, page 78) which finished earlier this year. The fourth experiment will start only a few months after the neutron-proton experiment we have described above. Thus two collaborative experiments will be under way at the same time. This goes beyond the terms of the initial Agreement and is yet another indication of just how well the CERN-Serpukhov collaboration is working.

On the way to Omega experiments

Two more important steps have been taken en route to the start of experiments in the Omega spectrometer. One coil of the superconducting magnet has been successfully tested and beam has been brought from the 28 GeV proton synchrotron to the Omega target in the West Experimental Hall.

The magnet of the spectrometer is designed to give a 1.8 T field at the centre of a large aperture (3 m diameter, 2 m high between the magnet poles where detectors can be installed). It

Setting up the detection system of the Karlsruhe, CERN experiment on neutron-proton charge exchange at the 28 GeV proton synchrotron last year. This equipment (minus the bending magnet) left for the 76 GeV machine at Serpukhov on the 1 June to extend the experiment to higher energies.



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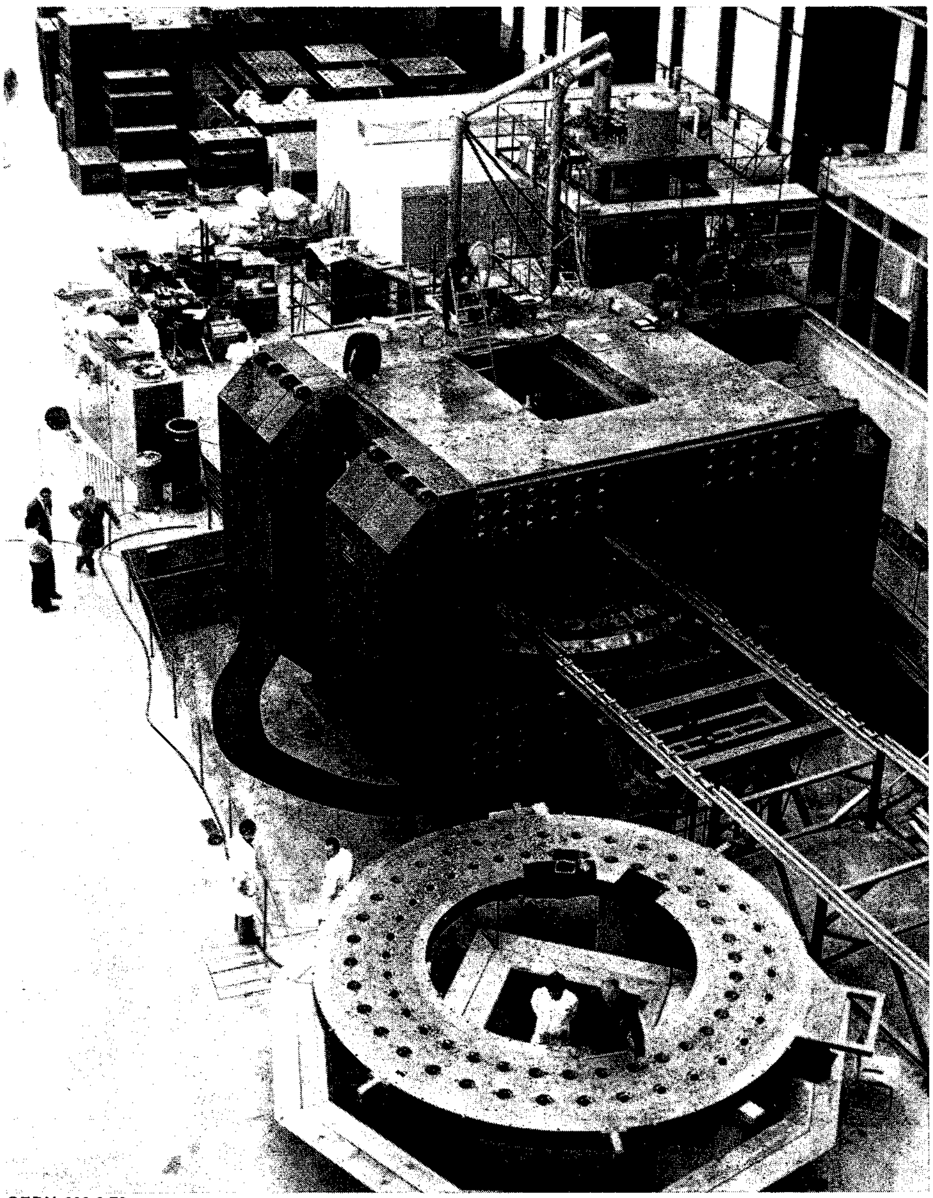
Assembly of the Omega spectrometer. Top right is the refrigerator which furnishes the helium to maintain the magnet coils at superconducting temperature. In the centre is the magnet yoke (note the demountable sides) with its very large aperture and with one coil in place. In the foreground the second coil is being made ready.



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uses superconducting coils which are special in that they are made of hollow conductor force-cooled by liquid helium. The first tests were carried out towards the end of May with just one of the two coils in position (problems at the manufacturers' have delayed installation of the second coil).

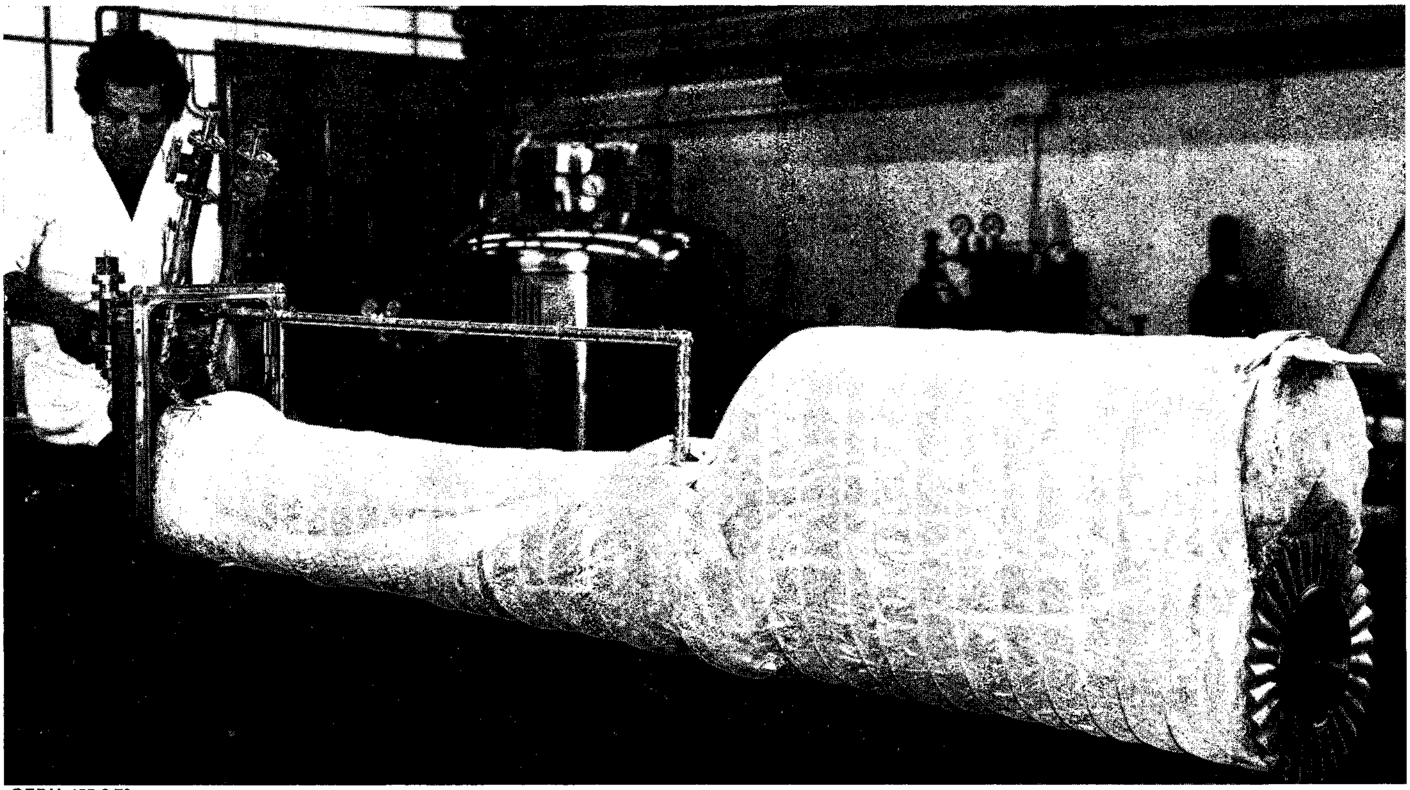
During three days the current through the superconductor was gradually taken higher, safety devices, etc., being checked as currents and fields increased. On the third day within three hours of starting from zero field the design field of 1.05 T was reached with 4.9 kA in the coil. (The peak field at the coil was about 3.3 T.) When the two coils are in action, this will yield 1.8 T at the centre of the magnet aperture.

There has been trouble with the refrigerator and with insulation of the helium transfer lines and this is not yet completely cleared up. Nevertheless it is hoped that the coil will be in action around the end of June for testing the detection systems which are now being installed in the magnet aperture. The second coil is being assembled near the magnet and will be ready in October for installation at a suitable time in the experimental programme.

On 25 May a proton beam was taken all the way to the Omega target. The beam was slow ejected from the PS using the new system, SQUARE. Slow ejection efficiencies of 95 % have been recorded from this system on previous tests. It was guided along the tunnel towards the ISR, deflected towards the West Hall and, finally, steered through a shielded channel in the Hall to the target.

The beam spot size was as predicted and the beam could be steered as designed. Beam intensity monitors had not been calibrated so the intensity at

The superconducting field shield (with its vacuum tank removed) which will allow low momentum particles to be fed to the 2 m bubble chamber. It was successfully tested at the end of May and will be used in experiments scheduled to start in October.



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the target is not known precisely. From now on, beginning in the first week of June, the teams preparing to use Omega will intermittently receive beam to help in the setting up of their detection systems.

Field-free path into 2 m chamber

At the end of May, a superconducting field shield was moved into position at the entrance to the 2 m bubble chamber for a brief series of tests. The chamber magnet was powered and field measurements within the shield showed that (except for inevitable field penetration for a short distance at the open end of the shield) a field-free path into the chamber could be achieved even at full magnetic field (1.75 T).

We wrote about field shields in vol. 11, page 155 because development work has been going on at CERN with the immediate aim of building a shield for the 2 m chamber. It will allow low momentum particles to pass through the region of the fringe field of the magnet so that they enter the photographable volume without being bent off too quickly. Briefly, the shield works because of Nature's tendency to resist change. When a magnetic field is applied in the presence of a conductor, currents will flow in the conductor in such a way that they set up opposing fields so as to maintain the status quo. Normally the conductor's resistance causes these currents to die away quickly but a superconductor, with zero resistance, can sustain them as long as the superconducting state is maintained.

The shield for the 2 m chamber has been developed in the Low Temperature Laboratory of the Track Chamber Division, the work being led by M. Firth. It consists of a cylinder 2.3 m long and 15 cm in diameter. Inside the bore of the cylinder is protected from external fields. The cylinder is built in two half shells using alternating layers of aluminium strip, niobium-titanium superconductor and mesh (to allow the passage of helium cooling). This is surrounded by radiation shields, superinsulation and a vacuum tank. The whole unit can slide easily into position at the chamber so that changing from low to high momentum beams can be done quickly.

The tests, carried out in rather hectic conditions, were entirely satisfactory. The shield has now been removed to finish the insulation and will be installed again at the end of September ready to be used in physics runs with low momentum beams scheduled for October.

(The story of a superconducting field shield which is now in operation at the Stanford Linear Accelerator Centre appears later in this issue.)

1. Schematic diagram of the 'continuous ejection' system successfully tested in the 28 GeV proton synchrotron at the end of May. By programming the currents to magnets A and B the orbiting beam can be peeled off and ejected over eleven turns as is required for the SPS.

2. Scope trace of the ejected beam intensity as recorded by a beam current transformer outside the PS. For such an early stage of the game, a remarkably steady intensity is achieved over the eleven turn ejection. The trace is a sum over twenty PS pulses.

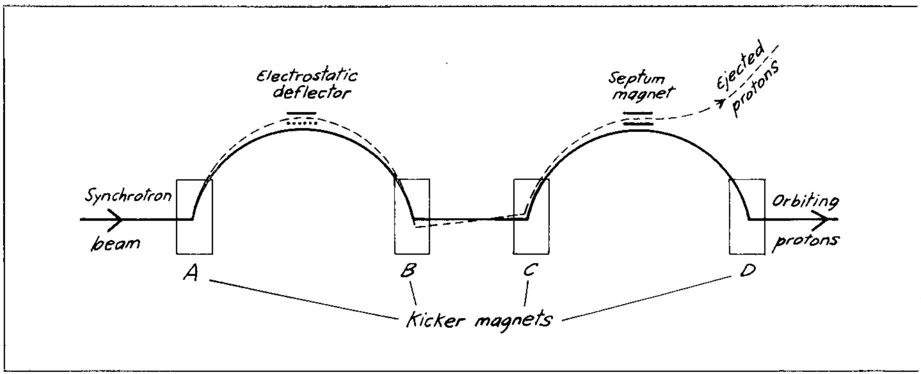
3. Meanwhile back in the PS .... a scope trace from a beam current transformer monitoring the intensity of the beam orbiting the ring. It shows the fall in intensity as beam is peeled off during eleven turns.

A peeling ejection system

In addition to success with the Booster, the 28 GeV proton synchrotron showed its paces in other ways at the end of May. Slow ejection and beam transport right through to the Omega target in the West Hall was achieved for the first time (see next page) and 'continuous transfer' was tested with very promising results. Continuous transfer is one of the two schemes which are being studied ready for the day when the PS will feed beams to the SPS.

The problem is to distribute the PS beam, which is accelerated in twenty bunches spaced around a ring of 200 m diameter, evenly around the SPS ring of 2.2 km diameter where the SPS r.f. system can take over in its own way to accelerate the beam further. One solution is to take single bunches from the PS and space them around the SPS — this is the 'bunch-by-bunch' method. Time is then allowed for the beam to debunch (smear out into a ribbon) before the SPS r.f. is switched on. Given the ratio of the diameters, it requires an eleven bunch interval between kicking successive bunches out of the PS and a clever system for implementing this has been developed (see vol. 10, page 310).

The second solution is 'continuous transfer' where the beam in the PS is debunched and then peeled off towards the SPS during eleven turns. This is done by nudging the beam, which is orbiting the PS, progressively across an electrostatic deflector



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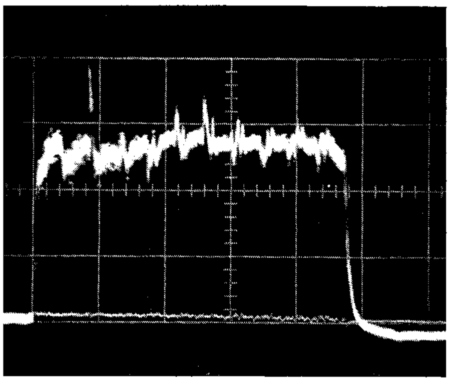
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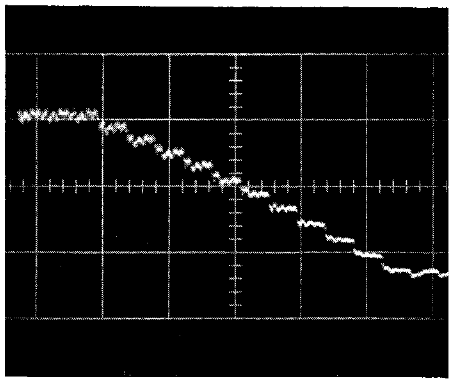
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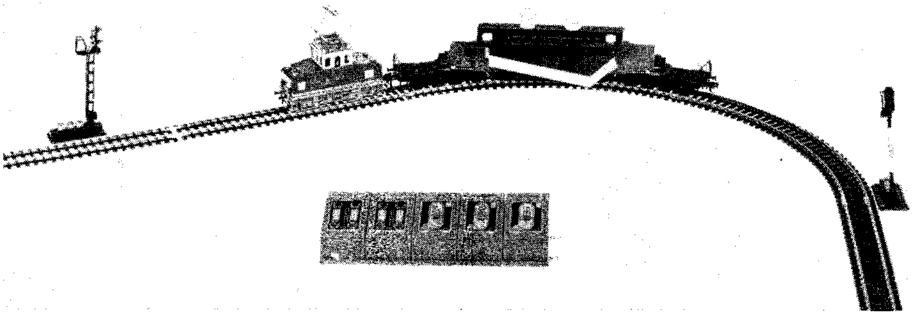
CERN 467.5.72

On 30 May the French Minister of Industrial Development and Science, M. François-Xavier Ortoli, visited CERN. He is seen here (left) examining samples of the superconducting magnet coil used in the construction of the 3.7 m bubble chamber, BEBC. This large chamber has been built as a collaboration between CERN, Federal Republic of Germany and France.

A Bombay/Bucharest/CERN/Cracow team have carried out a nuclear emulsion experiment in intersection region I1 of the ISR studying charged particles produced in the proton-proton collisions. The experimental method was checked in a preliminary experiment in I4.
Since the emulsions collect tracks from charged particles regardless of whether or not they emanate from the situation which is under study, it was important to keep them shielded when the conditions in the ISR were not stable.

A model railway proved a reliable and inexpensive way of doing this in the preliminary experiment. The emulsions were kept outside the shielding wall until conditions were right and then a train pulled them into the intersection region on a goods wagon. The use of an automatic signalling system also proved a very simple way of stopping the emulsions at precisely the required position.
In addition, the use of the model railway increased the fun of doing the experiment by a factor of two.



CERN 54.4.72

during these eleven turns. When this happens the deflector takes a fresh slice of the beam on each turn so that they are ejected out of the machine and travel off to fill the full circumference of the SPS.

The continuous transfer system is illustrated in the diagram. Initially, two 'bumps' are introduced in the beam by powering the magnets A, B, C, and D, the purpose being to locally adjust the path of the beam so that it travels close to an electrostatic deflector and a septum magnet. Magnets A and B are then programmed so that their currents increase sharply in steps. The time for which each step is held corresponds to the time taken for one turn around the PS. Thus, during eleven turns the beam sees progressively increasing fields and is nudged progressively into the electrostatic deflector, and hence the septum magnet, and ejected from the machine. Quadrupoles (not shown in the diagram) are used to increase the beta function locally and reduce losses at the deflector. Beam losses of about 3 % are anticipated.

All the equipment necessary to test continuous transfer from the PS has been constructed at high speed, including a pulse generator of a new type. Some of the components are those of the SQUARE slow ejection project (see vol. 12, page 33). During the recent tests a bunched beam was used and tuning of the system (setting the current steps at the magnets in order to peel one eleventh of the orbiting beam off during each turn) was done by hand. Also a mismatch of the kicker magnet settings introduced coherent oscillations in the beam so that the peeling was not being done on an 'even' beam.

Despite these comparatively primitive conditions for the tests, excellent results were obtained as can be seen from the photographs and it is now probable that this method will be selected for SPS injection. It will save debunching time in the SPS and will also reduce the horizontal emittance of the beam. (Thinking superficially about the ejected beam — a string of sausages each smaller in diameter than the parent sausage in the PS are being sent along the transfer line.) This will ease the aperture requirements in the SPS and give more room to breath when high intensity beams are around.

Theoretical work on continuous transfer for the SPS has been carried out mainly by C. Bovet. The hardware was developed by the group of D. Fiander and preparation for the tests was in the hands of A. Krusche.

Around the Laboratories

LOS ALAMOS
LAMPF all the way

On 9 June, a proton beam was taken all the way along the 850 m of the linear accelerator at Los Alamos reaching the design energy of 800 MeV for the first time. LAMPF (Los Alamos Meson Physics Facility) thus becomes the first of the 'meson factories' (the others being TRIUMF in Canada and SIN in Switzerland) to come into action.

The project was described in vol. 8 page 132. LAMPF is a high intensity accelerator designed to provide 900 μA average proton current and 100 μA average negative hydrogen ion current (accelerated simultaneously). The design involved several new approaches, such as the use of side-coupled cavities and unusually extensive computer control. All the more credit is therefore due to the LAMPF team for bringing the machine into operation on schedule.

Research at LAMPF will cover nuclear and particle physics and there will also be extensive programmes of solid state physics, biology, medicine and isotope production. Over sixty experiments have already been assigned beam time.

Design and construction has been under the leadership of Louis Rosen who handled the job so skilfully that it just never seemed possible (at least to outsiders) that the project would not go well. In particular, Louis Rosen showed great skill and awareness in securing and sustaining support for LAMPF in hard times. He has always shown his concern about the social climate in which the project has come to life and has taken care to present the broad range of potential research at the accelerator in both its intellectual and 'applied' aspects. We congratulate him and his team on their

Happy faces clustered around the controls at Los Alamos on 9 June when the 800 MeV proton linear accelerator, LAMPF, produced its first full energy beams. Louis Rosen, leader of the project, is on the right in the photograph justifiably clapping his hands.

A huge sign (each letter taking a gallon of paint) on the cliff facing the road leading to the accelerator site told it like it is.

splendid achievement and hope that LAMPF will enjoy many years of top class research.

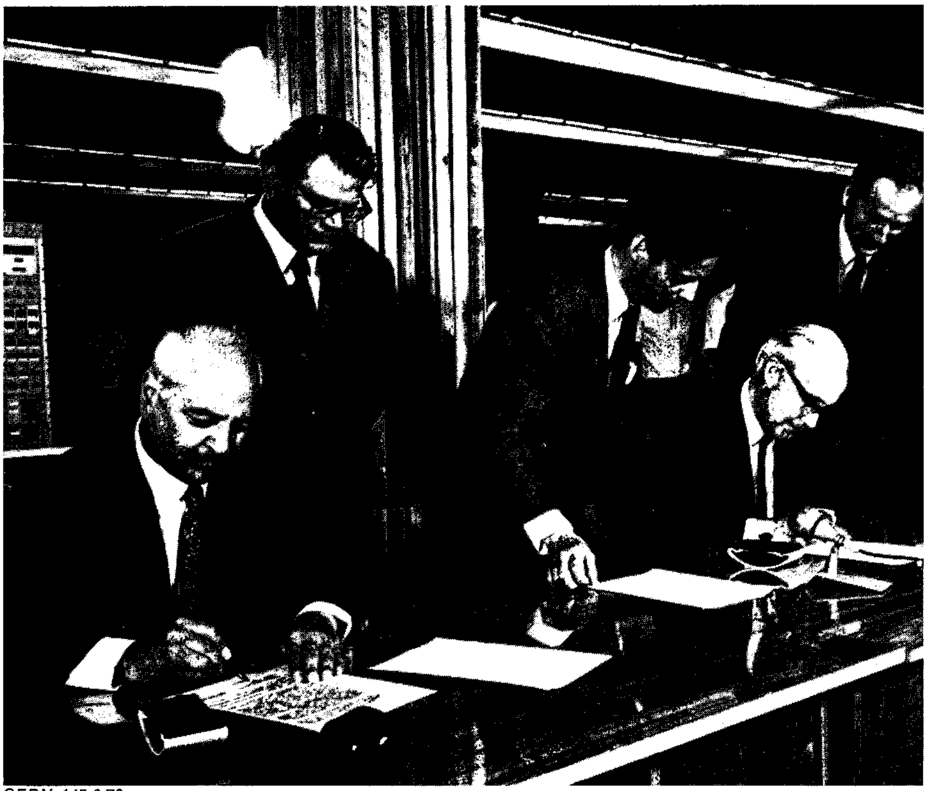
SERPUKHOV Inauguration ceremony

On 8 June, the completion of an important stage of the CERN-Serpukhov collaboration was celebrated at the Institute of High Energy Physics. An inauguration ceremony for the CERN-built equipment (fast ejection system, beam transport and r.f. separators) now in action on the 76 GeV proton synchrotron was held. Professor A. Petrosiants (Chairman of the State Committee of the USSR for the Utilization of Atomic Energy) and Professor W. Jentschke (Director General of CERN Laboratory I) together cut a ribbon giving access to the new building where fast ejection equipment is installed.

The two ribbon cutters then moved to sign a protocol recording the date of coming into operation of the equipment. As specified in the initial documents signed in July 1967, the Agreement remains in force for five years from this date (taken as 8 June 1972 — the day of the inauguration ceremony) and is renewable from then on.

The collaboration has involved the provision by CERN of a fast ejection system, beam transport and radio-frequency particle separators. (Technical details can be found, for example, in vol. 11, pages 212-218.) Western European physicists have been participating in electronics and bubble chamber experiments at the 76 GeV machine, until recently the highest energy accelerator in the world. (Stories of the experiments have appeared frequently in CERN COURIER in recent years and there are two more in this issue.)

The ceremony was attended by leading personalities from the Soviet



CERN 145.6.72

Signing of the protocol giving the date (8 June) of acceptance by the Institute of High Energy Physics, Serpukhov, of the CERN-built equipment. The Agreement concerning collaboration with Serpukhov will continue for five years from that date and is renewable thereafter. In the photograph, left to right, are A. Petrosiants, A.A. Logunov, Y. Goldschmidt-Clermont, W. Jentschke and G.H. Hampton.

Laboratory and from CERN and attracted a large group of journalists from Eastern and Western European countries. All were able to tour the Institute seeing the accelerator, experimental hall, the 'gallery' where the CERN-built equipment is installed and the large Mirabelle bubble chamber supplied by Saclay. Among the Soviet scientists were M.A. Markov from the Academy of Sciences and A.A. Logunov, Director of the Institute. Among the CERN people were P. Germain (Director of the Proton Synchrotron Department in 1967 when the projects began), Y. Goldschmidt-Clermont (involved in bubble chamber collaborative experiments), G.H. Hampton (Director of the Administration Department), H. Schopper (Assistant to the Director General for the co-ordination of the experimental programme) and the leaders of the groups who had built the equipment — B. Kuiper, B. Langeseth and H. Lengeler.

In their formal speeches later in the day Professors Petrosiants and Jentschke both expressed their great satisfaction in the progress of the collaboration. Professor Petrosiants in recording his pleasure at the successful completion of this part of the collaboration said, 'It is a significant achievement in international science and a help in reducing international tension'. Professor Jentschke added 'It is a marvel that these highly developed instruments are made to work together with remarkable stability and reliability. This achievement demonstrates that the techniques of the East and of the West, even at their highest degree of sophistication, can be made to work together in perfect harmony. We are still only at the beginning of our scientific collaboration and I look forward to its long and fruitful continuation'.

DARESBURY
Computing at a distance

There is a seemingly inevitable tendency to centralize in high energy physics because of the scale and cost of the most advanced research facilities. At the same time, there is a generally recognized need to keep the roots of the research embedded in the Universities and research centres sprinkled through the countries involved. The problems that this poses have often been discussed in broad terms. We pick out just one of them here — how can widely dispersed groups of physicists lock in, easily, on a large central computing system. A novel piece of work relevant to this has been successfully carried out at Daresbury.

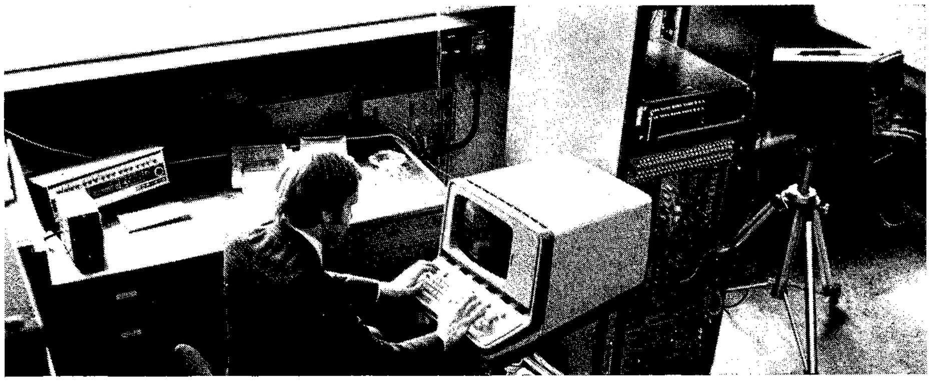
For several years now, users of the 5 GeV electron synchrotron, NINA, have been accustomed to the on-line use of all the facilities of the central computer, an IBM 360/65, by means of a network of high-speed (10^6 bits/s) wire links. In this way, use of local magnetic tape buffering or storage at counter experiments has been entirely eliminated and data acquisition is performed instead by means of the fast links to the central computer which terminate at the many small local computers. The complex computing and link system between any terminal equipment and the central computer is completely 'transparent' to the user — in terms of what he is required to do, he is unaware of the intricate manœuvres going on behind the panel immediately confronting him and he can write all his programs, for example, in FORTRAN.

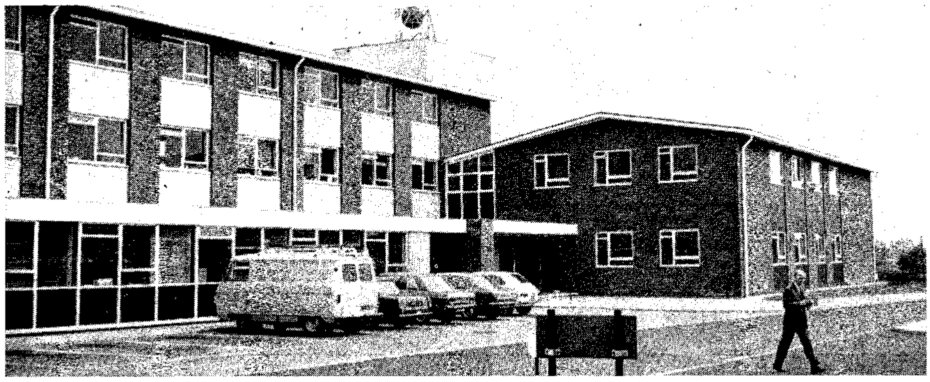
Over the past three years, there has been a further development in that experimentalists, using the same high-speed wire links in the reverse direction, are able to feed back computational results to running experiments. This facility is now extensively used for the graphical presentation of the results of sample calculations, experimental system checks and even partial physics analysis.

But in addition there is a desire on the part of the users, a significant fraction of whom are visitors from neighbouring Universities, to extend the comprehensive and centralized computing facilities of the Laboratory in such a way that they could perform interactive computations at a terminal situated an arbitrary distance away from the central computer system (for example, back in any University) as if they were within the Laboratory itself. In particular, there is the ambitious wish not only for remote job entry and batch processing but also for full interactive graphical computation.

An experiment in remote high-speed linking was therefore set up and has recently been completed. The aim was to demonstrate the feasibility of using

Interactive computing under way at Daresbury with keyboard and screen as it might be at almost any high energy physics research centre. But the photograph below reveals an antenna on one of the Laboratory buildings via which the data was being beamed to a T. V. repeater station 35 km away and collected back. The experiments on this microwave link proved very successful.





the full facilities of the central computing system at a distance. The way in which this was done was to take, arbitrarily, a sizable block of the computer's normal work-load, broadcast it from an antenna installed on a Laboratory building, bounce it back from a T. V. repeater station at Winterhill (35 km north-east of Daresbury), pick it up again with the antenna and see whether the user would notice.

Standard Post Office equipment was used where possible (for convenience, cheapness and, most important, to ensure complete compatibility with networks anywhere in the country). The external high-speed link used a standard Post Office microwave video link without modifications. The only new equipment to be built was an interface between the video link and the Laboratory's computing network. This was assembled from CAMAC units (Daresbury being amongst the most highly CAMACized of Laboratories). A small Honeywell 516 computer was used to organize the data at the interface and to correct errors. Both hardware and software for the microwave link is modular and again 'transparent' to the user, who can use the link with standard FORTRAN or PL-1 language programs.

With the microwave link, a data transfer rate of 10^7 bits per second is attained with a corrected error rate of better than 1 bit in 10^9 (which is a performance at least as good as that achieved when shunting information around on magnetic tape, for example). For the tests the distance of the link was 70 km including one regenerator at carrier frequency. No difficulty is foreseen in going to much greater distances by means of many repeaters.

As part of an Open Week exercise in May, the microwave link was demonstrated to visitors. It was performing interactive graphical computation on data from a counter experiment carried out at CERN in which Daresbury physicists had been involved. Input was via keyboard and light-pen, and output returned to the graphics console after transmission over the microwave link. The information was often bounced around the link many times before it was received by the demonstrator. Thus the data could be transmitted over distances corresponding to those separating Daresbury and neighbouring Universities or other research centres such as the Rutherford Laboratory and CERN. Under these circumstances the link itself introduced no noticeable delay, and the response time to user action was set by the program in execution or by other tasks in which the computer was involved. For fun, the data was once bounced around for a distance equivalent to that of the moon and back when a few seconds delay was noticeable. We should hasten to add that no proposal for an experiment at Daresbury has yet been received from the moon.

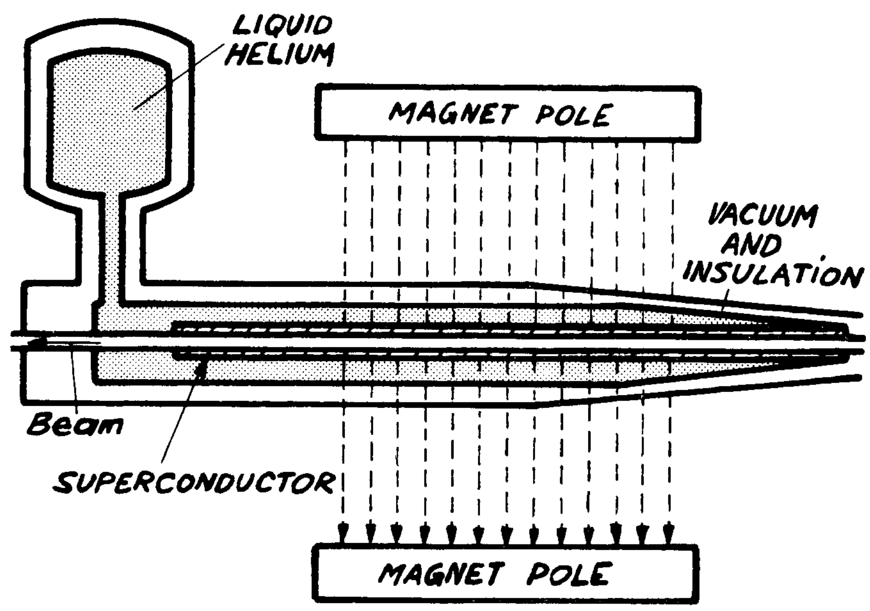
The tests were very successful and there are now ambitious plans, in connection with the 370/165 shortly to be installed at the Laboratory, to extend the Daresbury computational facilities in this way to remote users. The simplicity, speed of implementation, cheapness and ease of use could have significant implications both for the domestic needs of other high energy physics centres and for their further co-operation.

Regional collaboration extends

For several years there has been a so-called 'triangular collaboration' between research centres in Bratislava (Czechoslovakia), Budapest (Hungary) and Vienna (Austria) which has concentrated particularly on the organization of seminars in theoretical high energy physics and nuclear physics. The seminars have been held at about monthly intervals and have moved around between the three cities. Recently, the collaboration has broadened both to take in research centres in other adjoining countries and to cover experimental topics as well.

The first move in this direction came at a meeting in Zagreb on 2 October 1971 at the Ruder Boskovic Institute where there is interest in collaboration in the building and operation of a 100 MeV cyclotron for nuclear physics. It was there suggested to extend the triangular collaboration to include other centres in Yugoslavia and Italy with meetings for experimental physicists to be held about twice a year.

The first of these took place at the Central Research Institute for Physics in Budapest in February 1972 attended by about 35 physicists. There were



Drawing, not to scale, of the superconducting field shield developed at Stanford. It takes beam particles through a magnetic field and detectors without disturbing them while allowing several scattered particles to be observed travelling in different directions outside the shield.

reports on research using the electronic and bubble chamber techniques, mainly at Serpukhov and CERN, by representatives of teams based at Vienna, Budapest, Trieste, and Belgrade. The next meetings are planned for Vienna in October and Trieste next spring. Meanwhile the theoretical seminars are continuing as before.

From quite modest beginnings forms of regional collaboration like this could grow to take on bigger tasks and to cover other areas of science. In this particular case there are, of course, many common features in the cultural heritage of the regions of the countries involved, which have helped promote them grouping in this way. The initiative to set up wider forms of collaboration has the blessing of the relevant government departments in the participating countries and the interest of UNESCO. It is likely that this type of regional collaboration will become more widespread in high energy physics since the units which can carry out effective experimental work at the accelerators will probably need to be bigger.

STANFORD
Field shield working

One of the problems in particle scattering experiments is that the intense beam fired at the target can swamp the subsequent detection system with unwanted signals as the particles which have not interacted in the target travel through the region where the detectors are placed. For this reason the detection is often done off at a particular angle so that the beam itself can sail on without affecting the detectors. This can be a limitation since it reduces the quantity and range of information which is gathered. An original way around the problem has been successfully developed at the Stanford Linear Accelerator Centre. It involves the use of a superconducting field shield.

The SLAC arrangement can be seen in the sketch. The shield passes through a magnetic field and detectors over a total length of about 4 m (its container is sufficiently rigid to be suspended on wires aligned to a precision of better than a millimetre). It takes the electron beam from the accelerator safely through the experimental equipment while making it possible to catch simultaneously three or more particles scattered in different directions.

The shield is built up of an inner stainless steel tube copper plated and tinned with soft solder surrounded by an outer tube, initially made in two half cylinders, of superconducting ribbon (niobium-tin, also clad with copper and tinned with soft solder). The assembly was heated to bond it solidly together with the solder. It is then fed into a liquid helium tube to achieve the superconducting temperature and finally is surrounded by a vacuum and insulation jacket. The entire unit is only 7.5 cm in diameter.

The shield successfully holds out a magnetic field of 1.5 T. It was designed and built by the experimental group of M.L. Perl, where A. Newton developed the technique of forming the superconducting tube, and the low temperature group of S. St. Lorant, where E. Tillman designed the helium system.

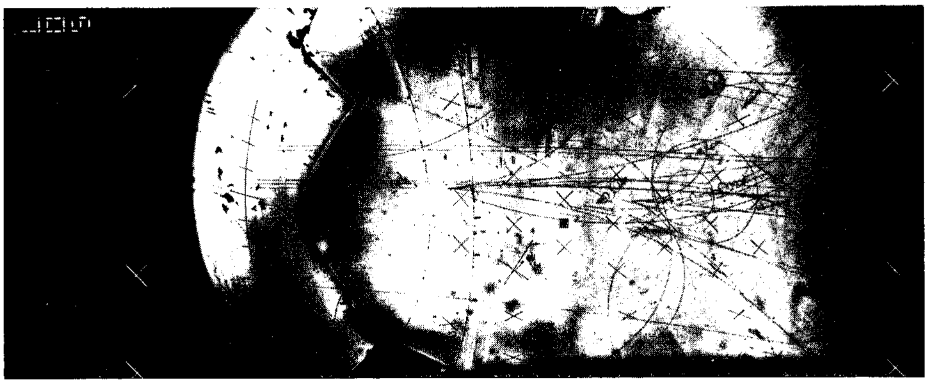
SERPUKHOV
Bubble chamber collaborations

We have already covered in this issue the inauguration ceremony for the CERN-built equipment at the Institute of High Energy Physics and the story of the third collaborative experiment using electronic detectors. In addition, collaboration between Eastern and Western European groups in the measurement and analysis of bubble chamber film taken at the 76 GeV machine is now opening up in a big way.

The collaborations concern film taken in the large hydrogen bubble chamber, Mirabelle, designed and built by Saclay for use at Serpukhov. (There is also a 2 m propane chamber in action taking pictures for Eastern European collaborations and a large heavy liquid chamber, comparable to CERN's Gargamelle, will come into operation probably at the end of 1973.)

Up to now Mirabelle has been used in two physics runs taking about 70 000 pictures of 70 GeV proton interactions in the hydrogen. These pictures are being analysed predominantly by a Saclay/Serpukhov collaboration and preliminary results on particle multiplicities were presented at Oxford in April (see last issue, page

Mirabelle bubble chamber photograph taken by Camera I (Entry). A negative kaon of 34 GeV/c from the r.f. separated beam enters through the beam window (indicated by the ladder-like marks on the scotchlite) and interacts, producing charged and neutral secondaries (some decays of neutral particles are visible downstream).



Below: On 15 June, 200 GeV protons were taken into the 30 inch hydrogen chamber at the National Accelerator Laboratory, Batavia, for the first time. The picture shows a typical event.

170). There were some problems in connection with accumulation of dust in the chamber (probably coming from friction of the pistons on the sealing rings) but the picture quality has nevertheless been improved. Since the ejected proton beam came into action last January, a small sample of 50 GeV negative pion photographs has been taken and the quality was good.

The first run with 32 GeV separated negative kaons into the chamber started at the end of May. About 30 000 pictures are scheduled and they will be measured and analysed by a collaboration of the following centres — Aachen, CERN, East Berlin, Imperial College London, Serpukhov and Vienna. 17 000 were taken by the middle of June and the picture quality was good throughout the run. The beam then switched to 32 GeV separated positive kaons for a similar number of pictures to be handled by Brussels, CERN, Collège de France (possibly), Mons, Saclay and Serpukhov. About ten Western European bubble chamber physicists from these collaborations are taking part in the beam tuning and bubble chamber exposures at Serpukhov during the runs.

Several of the collaborating centres have set up scanning and measuring systems to cope with film from Mirabelle. Saclay has six tables already in operation. Serpukhov has two in operation and others will be available soon. Collège de France is developing a powerful POLLY-type (see vol. 9, page 275) system known as Coccinelle. Brussels has SAAB tables suitable for Mirabelle and Gargamelle film. Mons has bought the Adam and Eva (see vol. 10, page 229) systems from CERN, since CERN has decided, as an economy measure, not to retain measuring systems for Mirabelle film.

Proposals from Western Europe for the bubble chamber programme with Mirabelle follow a rather tortuous path - passing via the CERN Track Chambers Committee, the CERN Nuclear Physics Research Committee, the Saclay/Serpukhov Scientific Committee and, finally, the Scientific and Technical Committee at Serpukhov. Nevertheless the path seems to be broad and reasonably smooth. Collaboration in this field also is obviously off to an excellent start.

ARGONNE
12 foot tops a million

The 12.5 GeV Zero Gradient Synchrotron at the Argonne National Laboratory is now in the midst of a long shutdown during which titanium vacuum chambers are to be installed. They will replace the damaged stainless steel chambers and will have pole-face windings installed. These will make it possible to set up the conditions in the accelerator to achieve slow ejection in both external proton beams simultaneously.

Prior to the ZGS shutdown the 12 foot bubble chamber (which has a large superconducting magnet) passed the one million picture mark. Over 300 000 of them have been taken with the chamber filled with deuterium for a neutrino experiment which has added new data to the neutrino dossier.

The 12 foot chamber began operation for physics in autumn 1970. The experiments opened with the chamber filled with hydrogen and pictures were taken with 12 GeV/c protons (for an Argonne, Illinois Institute of Technology, Notre Dame University team) and with neutrinos (Argonne). The first neutrino event ever recorded in hydrogen was published in vol. 10, page 389. There has also been an 8 GeV/c proton experiment (Tohoku University) and, beginning in autumn 1971, the neutrino run with the chamber filled with deuterium (Argonne). The run yielded about 320 000 good quality pictures.

The latest experiment, returning to a hydrogen filling, has been studying the decay of the long-lived neutral kaon (Argonne, Carnegie Mellon University). A beam of 1 GeV/c negative pions was drawn from a tungsten target bombarded by the 12 GeV/c ejected proton beam. The pions were focused on a liquid hydrogen target 1.8 m long located 3 m in front of the bubble chamber window. Neutral kaons can be produced in interactions in the hydrogen.

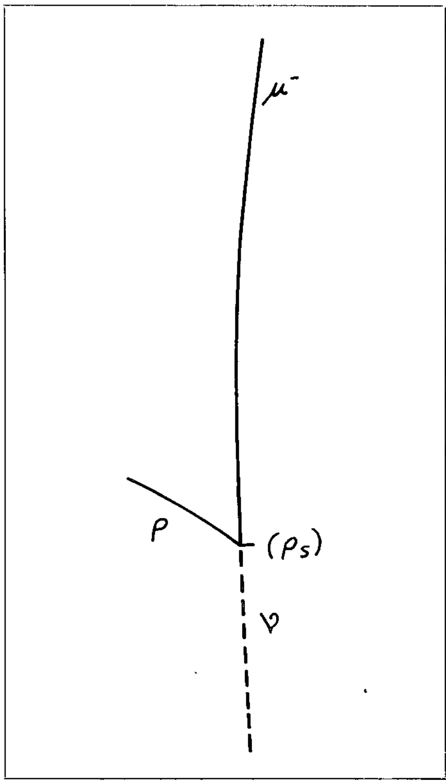
$$\pi^- + p \rightarrow K^\circ + \Lambda$$

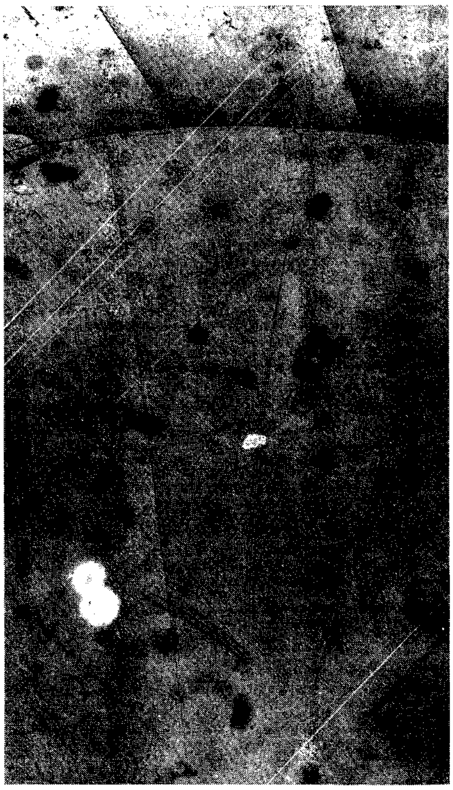
Two magnets following the target sweep most of the charged particles away so that they do not cross the chamber. But neutral kaons (with momenta around 560 MeV/c) can enter the chamber and decays occurring in the hydrogen volume can be observed. About one event of interest in every two pictures was obtained.

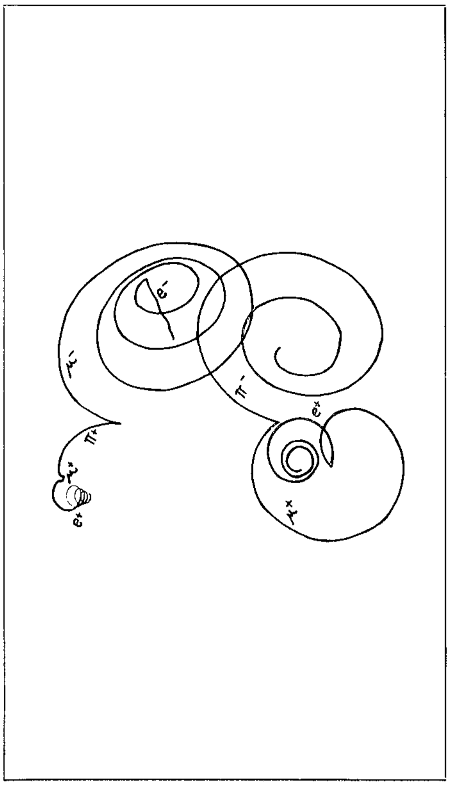
Because of the large chamber volume, there is a good chance that the kaon decay products will spiral within the photographable volume under the influence of the magnetic field. This makes it comparatively easy to spot the decay modes which are of greatest interest (decays into pion / muon / neutrino, into pion / electron / neutrino and into three pions) and relatively few ambiguities are encountered. It is hoped to build up 300 000 pictures for this experiment giving a very large number of kaon decays with unusually few experimental biases. The data will contribute to the study of several interesting aspects of kaon decay including form factors and the $\Delta I = 1/2$ rule.

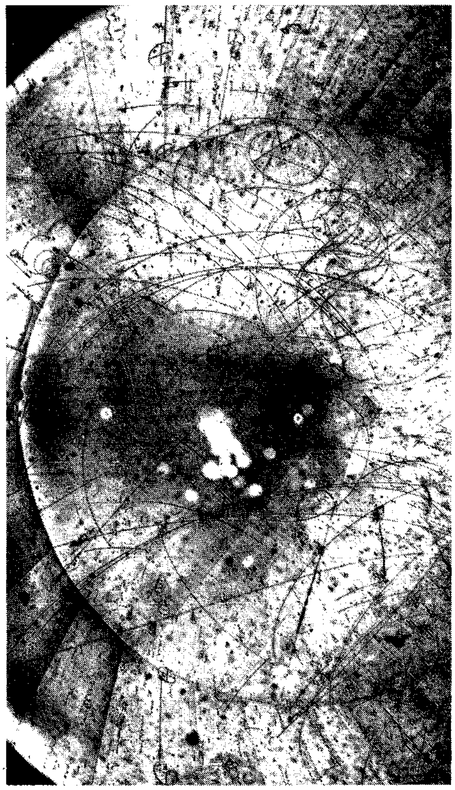
The twelve foot chamber had its first exercise at double and triple pulsing on 25, 26 March. The expansions were carried out with time intervals between them ranging from 150 to 400 ms with an overall pulse period of 4 s. Track sensitivity was achieved during all expansions and, when the accelerator comes back into operation, it is probable that double pulsing will be the routine method of operation. All the chamber systems are being checked and overhauled during the shutdown.

The accelerator is scheduled to be in action again on 1 September but during the shutdown it will be possible to operate the linac so as to continue commissioning of the booster. During a development period earlier this year a peak circulating current of 150 mA (5.2×10^{11} protons) was achieved in the booster. In the summer months it is hoped to advance a good way towards the design goals of booster beams at 200 MeV with eight pulses of 10^{12} protons per pulse to inject into the ZGS during 1 s.





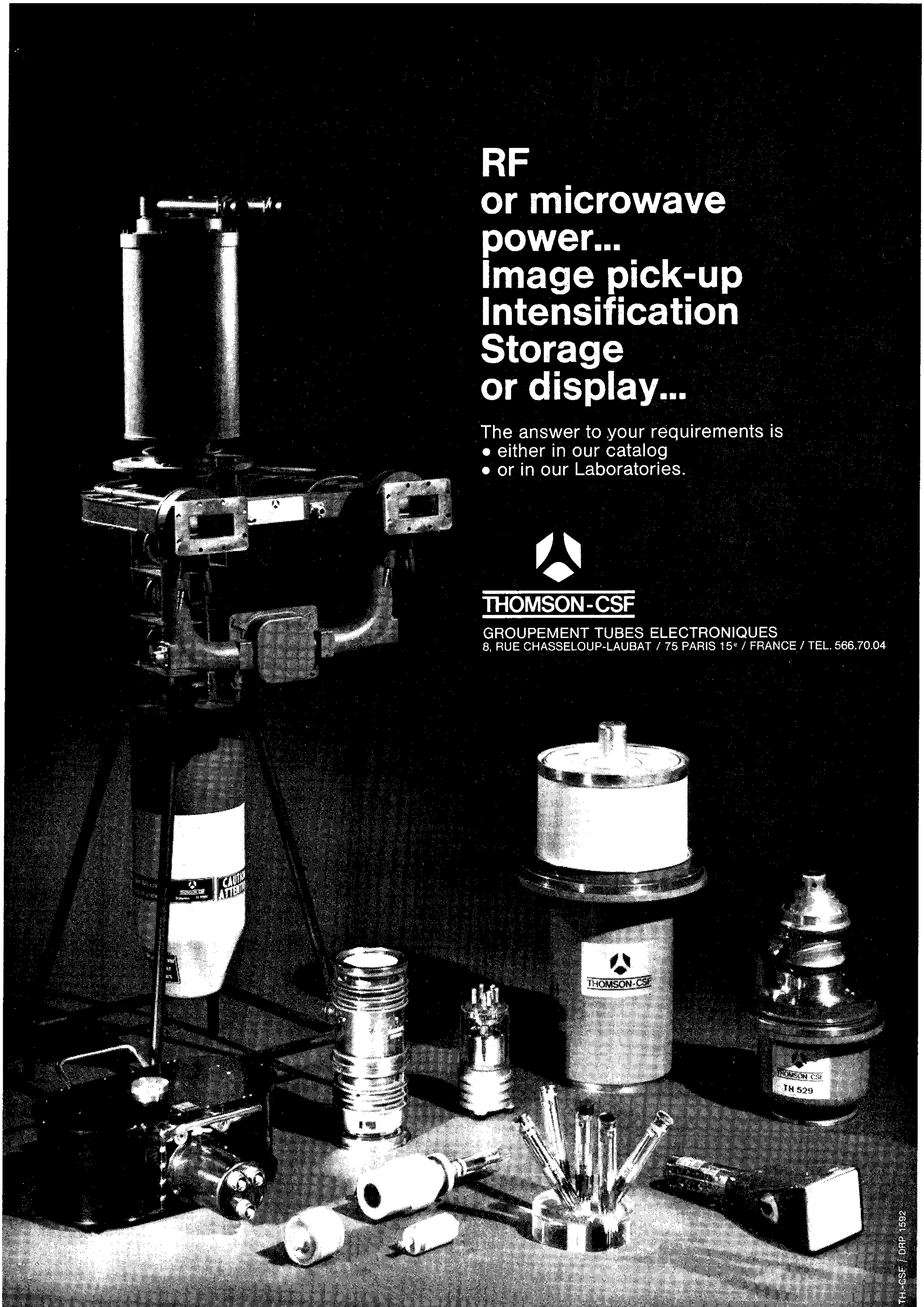




Photographs from the 12 foot chamber at Argonne.

The top picture shows the first neutrino event ever recorded in deuterium. The neutrino interacting with a deuterium nucleus gives a muon, a proton and a 'spectator' proton (Ps).

Below, is a picture from the neutral kaon decay experiment. Two decays are recorded and the ability of the 1.8 T magnetic field to 'trap' the low momentum decay products within the large chamber volume is clear. This feature makes unambiguous identification of the events much easier.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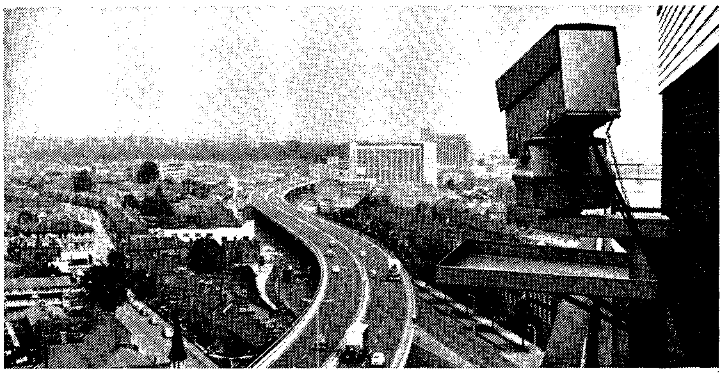

Some people still have the idea that TV cameras need good lighting conditions before they can work effectively. There is, of course, a wide range of vidicons for tungsten or daylight conditions, but until you know about our low light level tubes you haven't really seen anything.

You can, for example, see a black cat in a dark room, clearly, sharply, continuously – with light levels as low as 10^{-5} foot candles. To do this a high-sensitivity 3-inch image isocon is used fibre-optically coupled to a compact image intensifier which amplifies light 150 times.
Sensitive though this unit is, it can't be put out of action by bright lights. Applications include night observation, astronomy, microscopy and nuclear physics.

CRC 28

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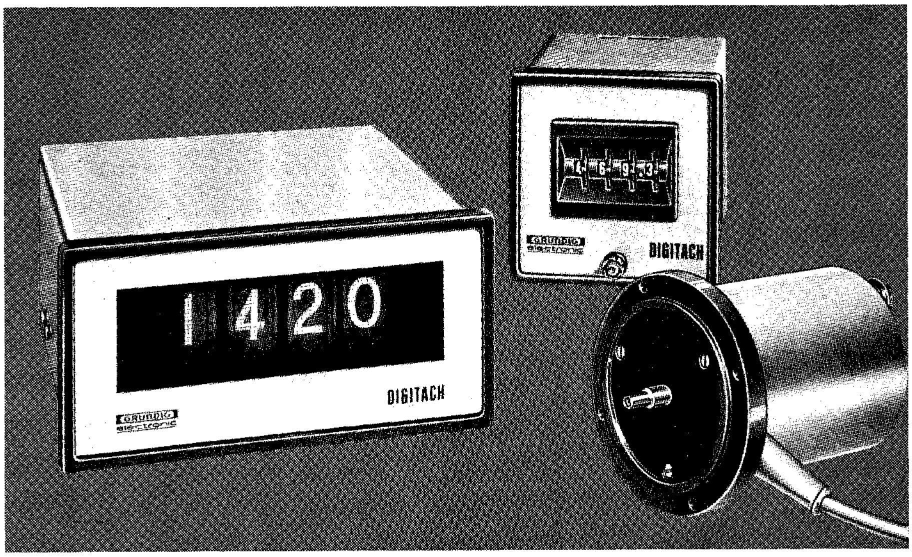

Frequency-counter F 20, Time base: mains frequency, error: 0.1 % approx.
Frequency-counter Q 20, Time base: crystal controlled, error: $\pm 5 \times 10^{-5}$ approx.
Pulse-counter J 20, Maximum counter frequency: 1 MHz
Period-duration counter P 20, Measurement over 1, 10, 60, 100-periods
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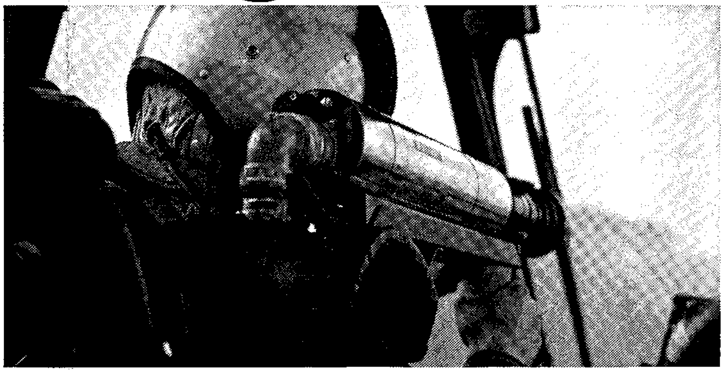
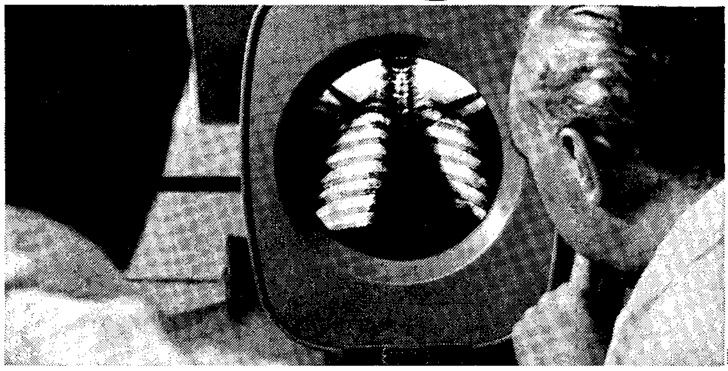
things in a different light.





Certain scientific work, or surveillance applications, might demand tubes that are sensitive to infra-red or ultra-violet light. EEV vidicons are available with special photosurfaces to satisfy these requirements. They're also available as short-lag types for high light levels or long-lag types for integrating light over $\frac{1}{8}$ to $\frac{1}{2}$ second, e latter for viewing repetitive light of low levels, such as radar screens emit.

In the EEV image isocon range there's a tube that can give radiologists a bright, moving X-ray picture in daylight – without exposing a patient to high X-ray dosage. In fact dose rates as low as 5 micro-Rontgens per second can be used, so enabling prolonged diagnostic study.
Ask for details of these or any other EEV camera tubes for industrial and specialist applications.

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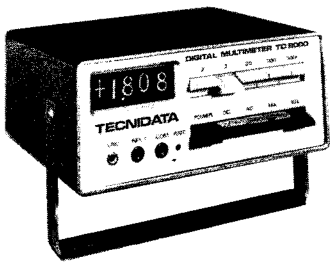

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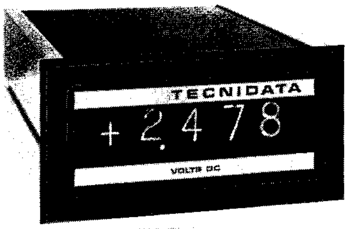

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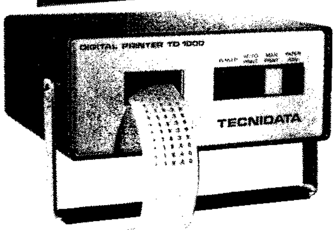

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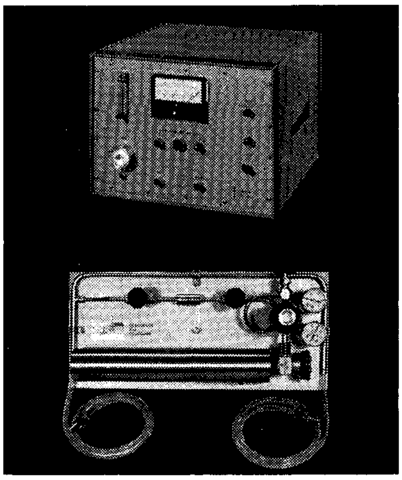

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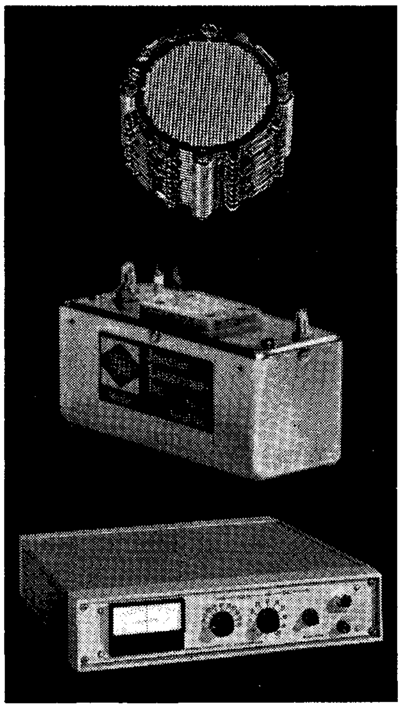

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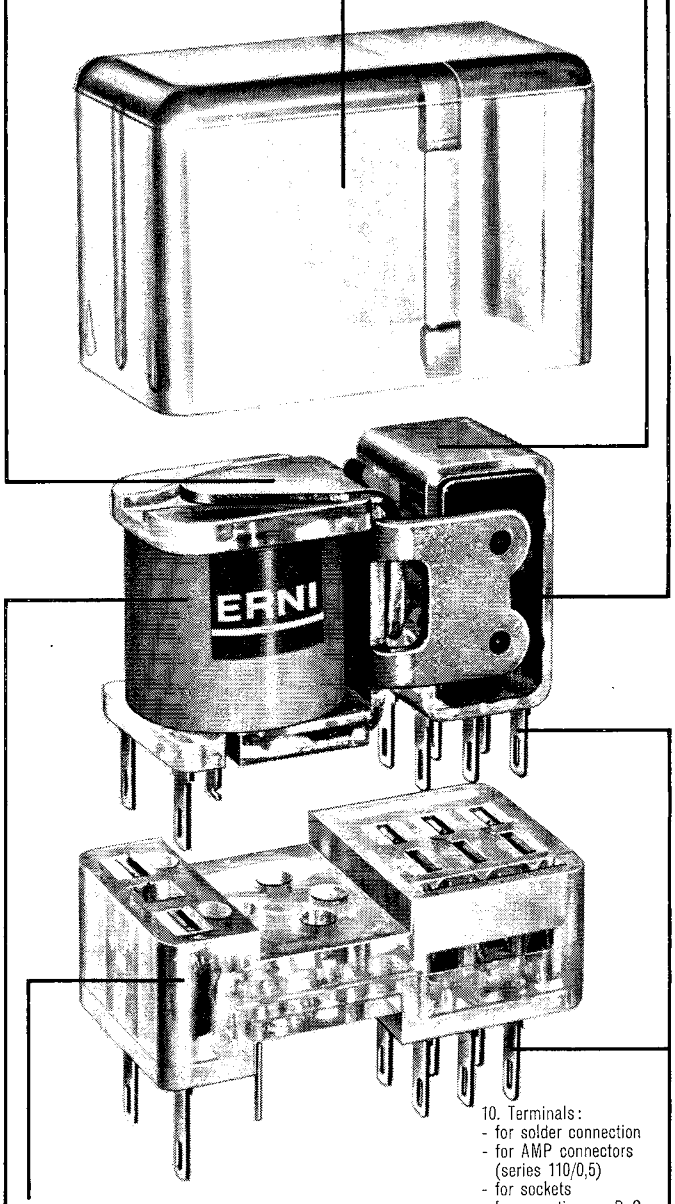

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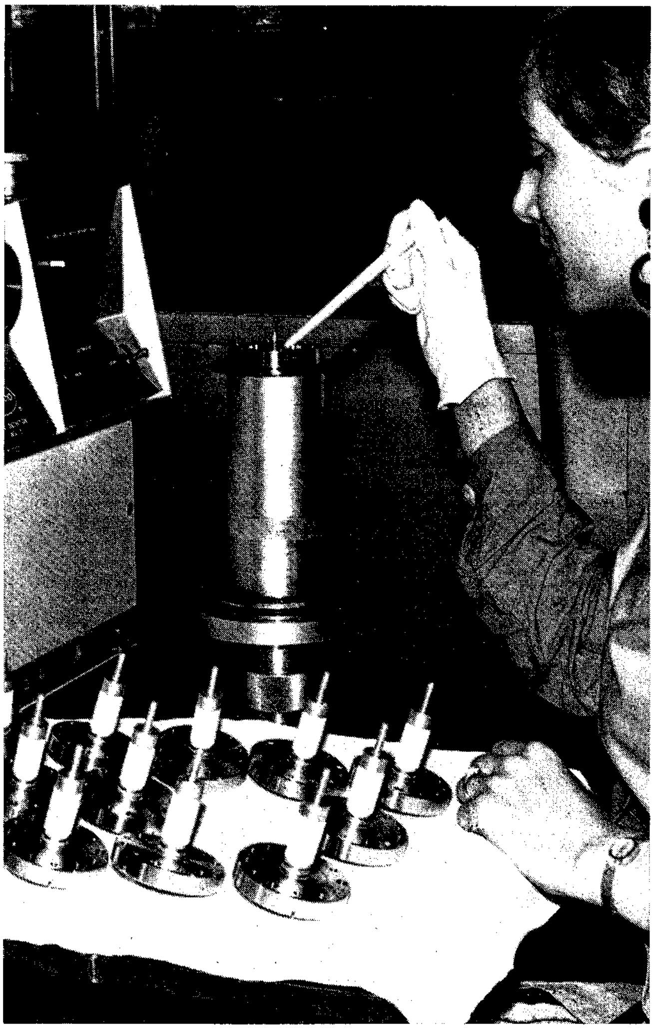

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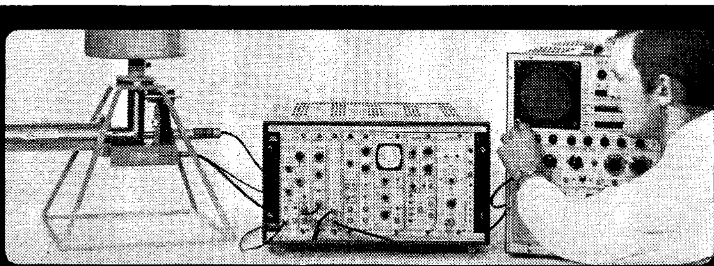

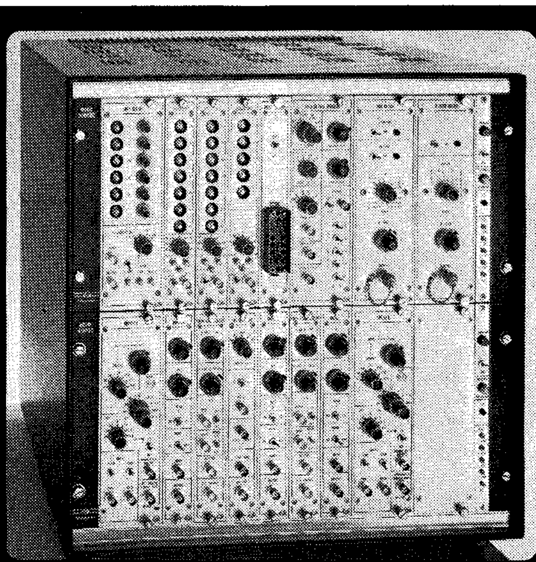

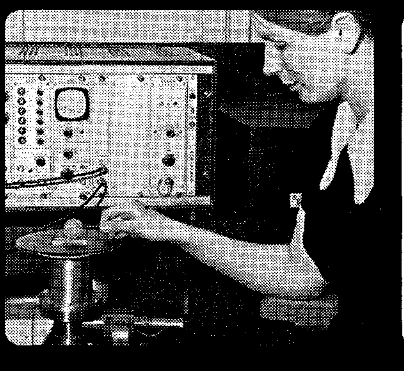

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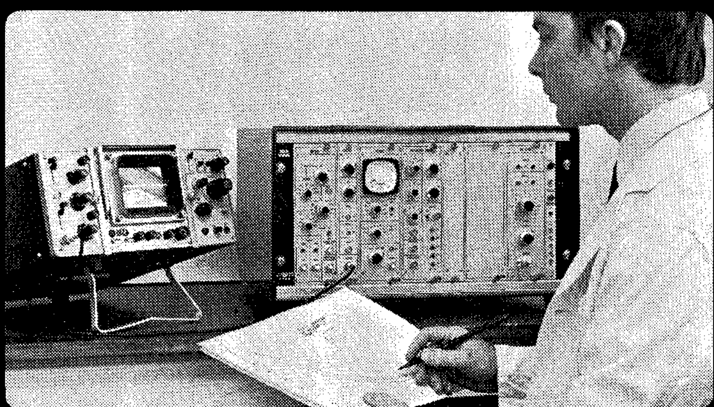

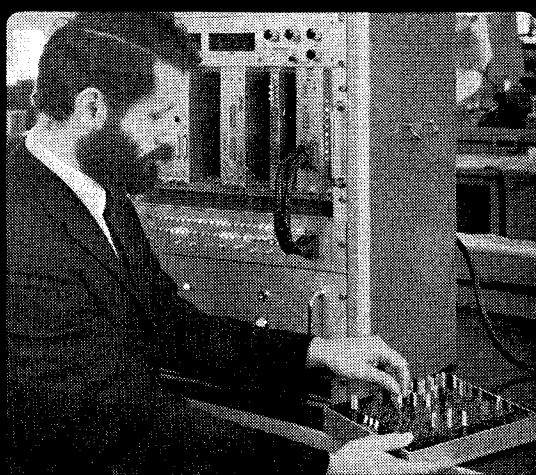

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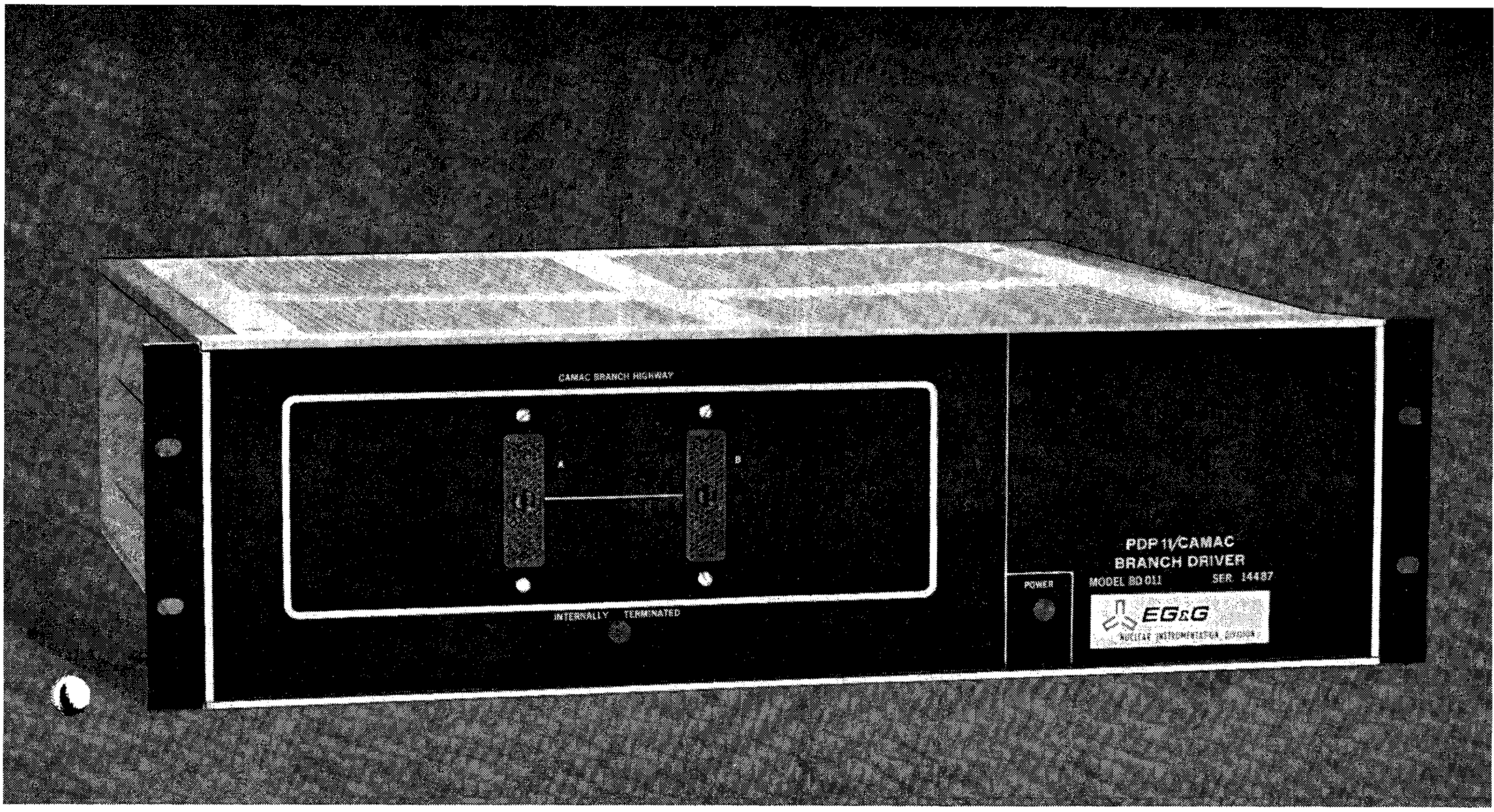

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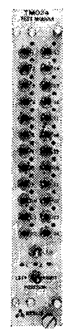

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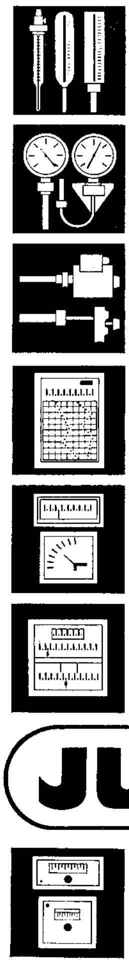

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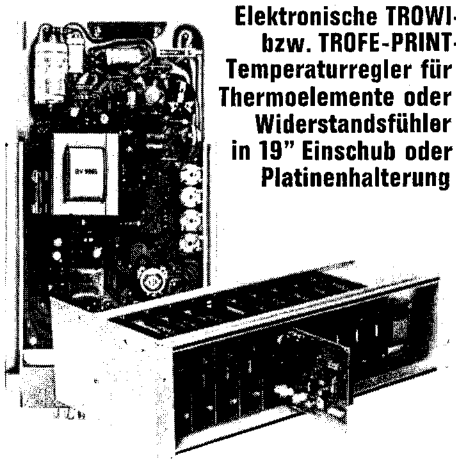

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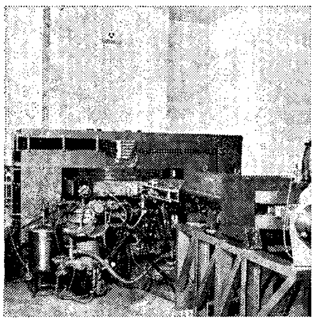

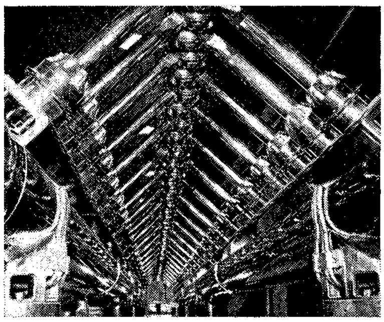

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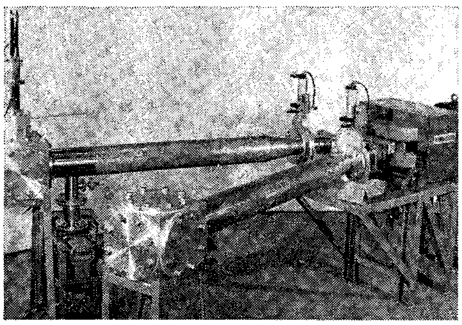

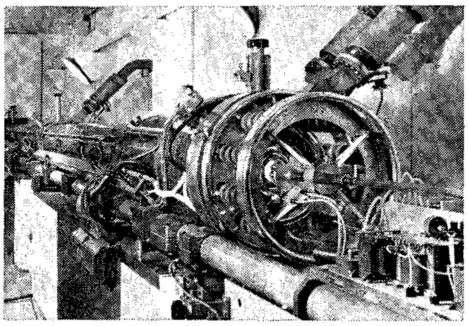

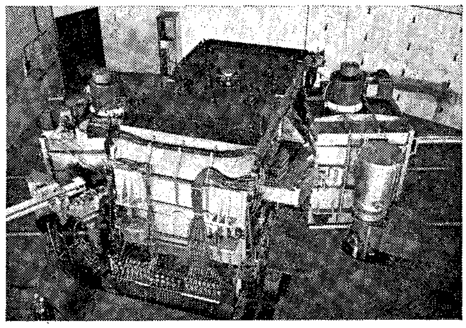

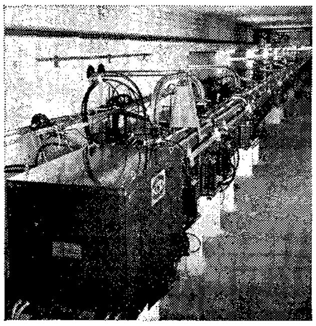

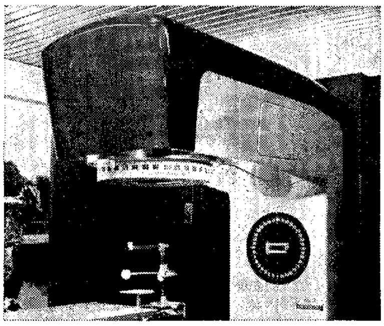

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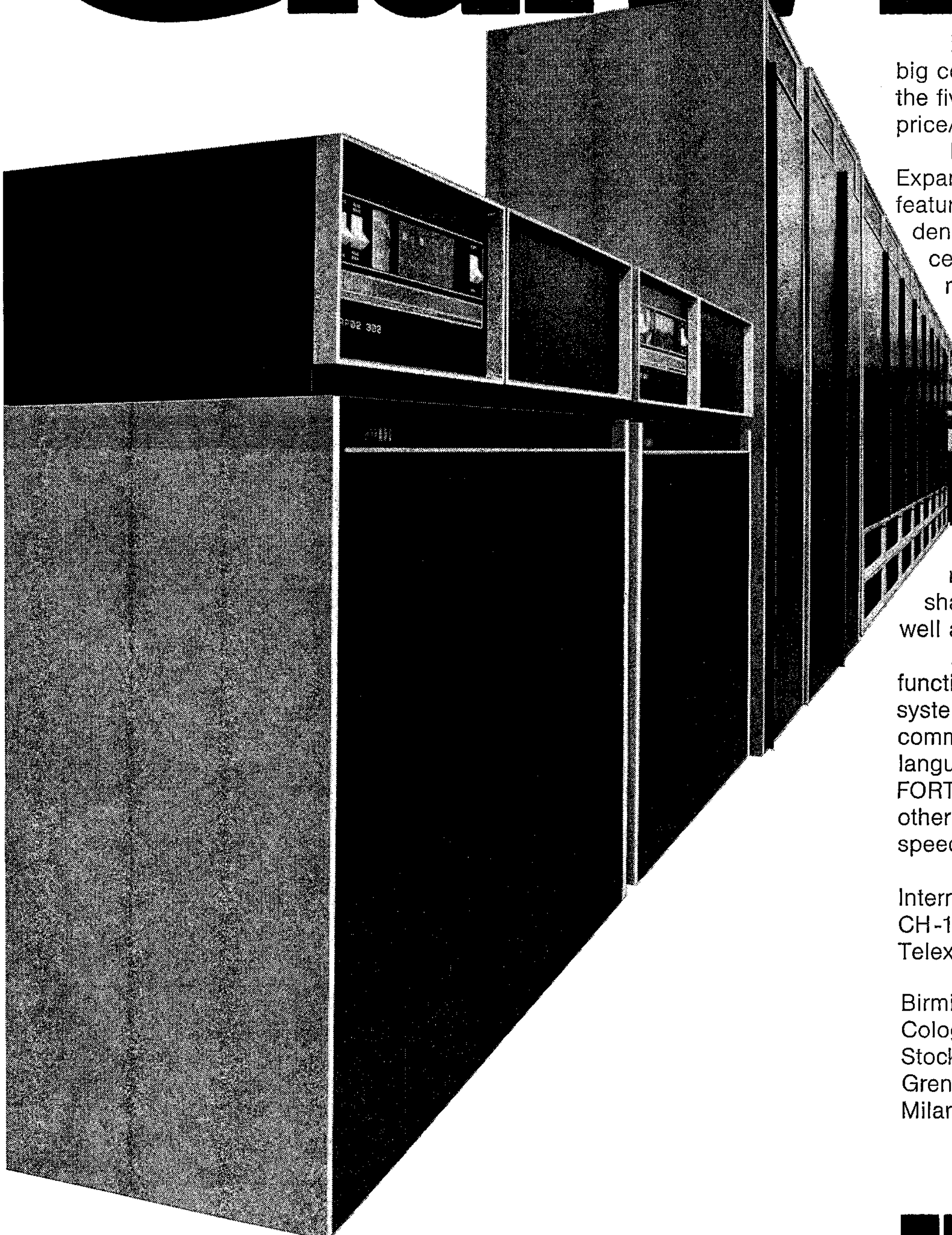

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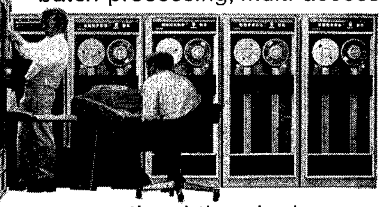

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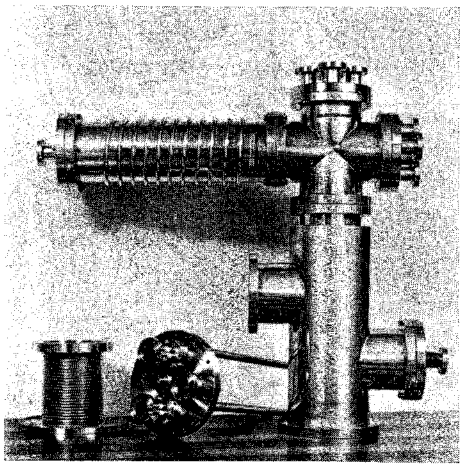

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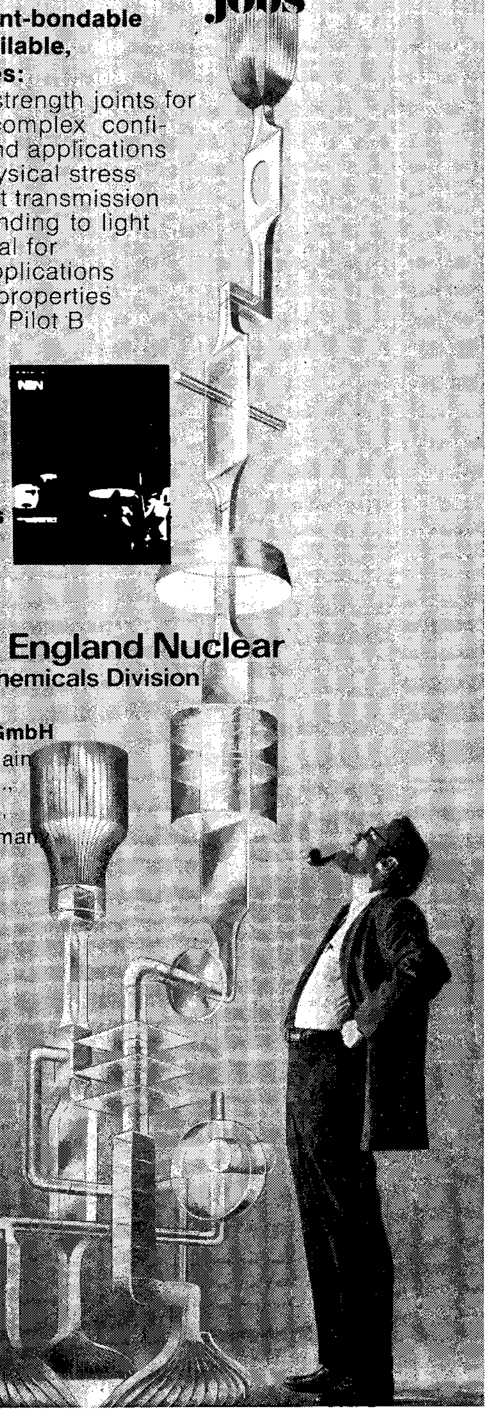

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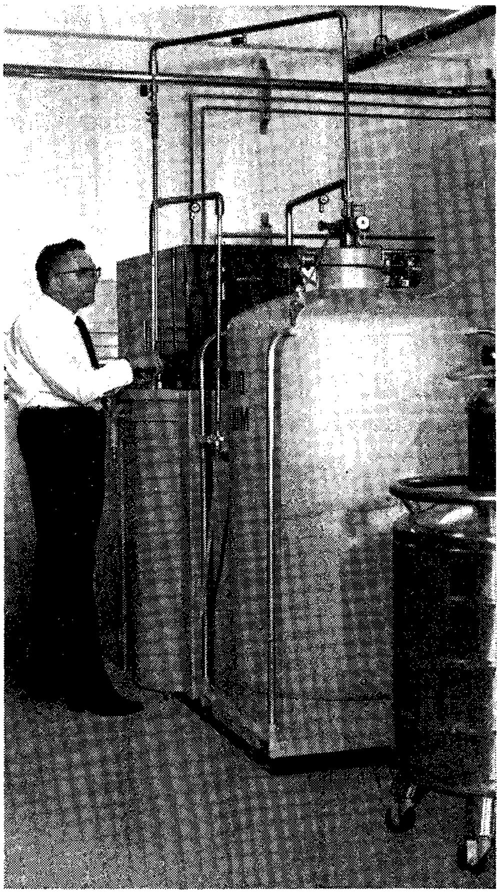

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	2N6261 V_{CER}(sus) = 85 V h_{FE} = 25-100 @ 1.5 A f_T = 0.8 MHz min. P_T = 50 W 527		2N6254 V_{CER}(sus) = 85 V h_{FE} = 20-70 @ 5 A f_T = 0.8 MHz min. P_T = 150 W 524	TA8243 V_{CER}(sus) = 120 V h_{FE} = 30-150 @ 6 A f_T = 2 MHz typ.	2N6258 V_{CER}(sus) = 85 V h_{FE} = 20-60 @ 15 A f_T = 0.6 MHz min. P_T = 250 W I_c = 30 A 525

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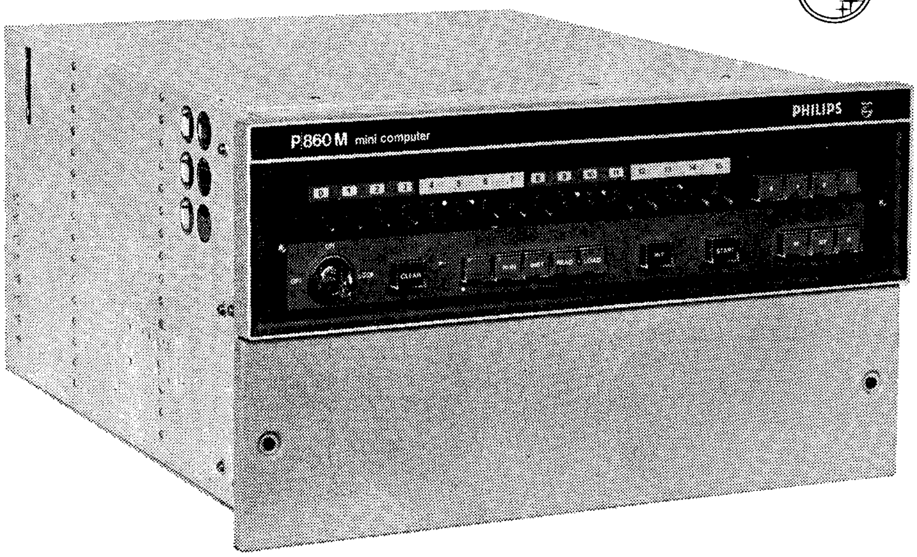

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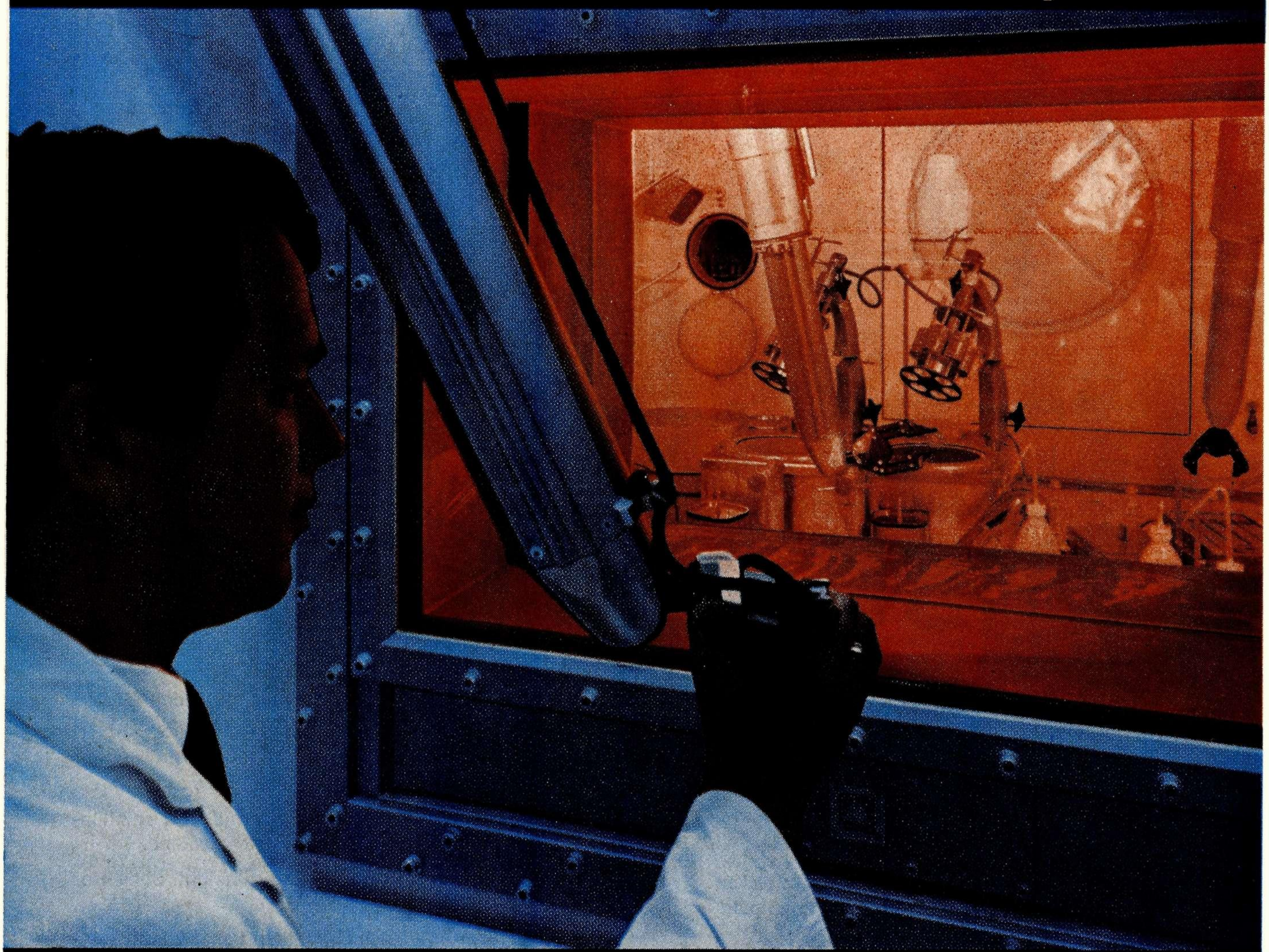

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