CERN COURIER

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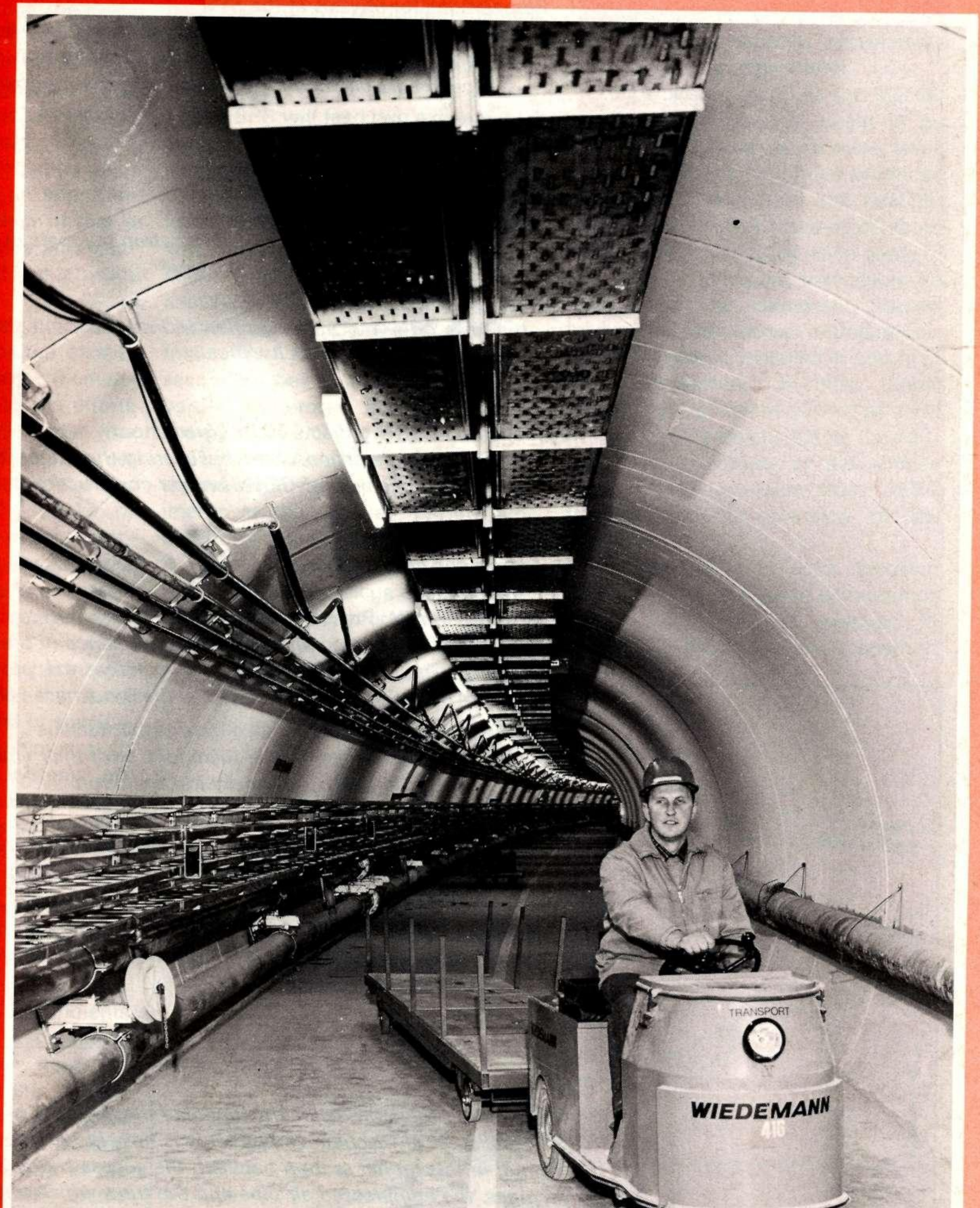

CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of sub-nuclear physics. This branch of science is concerned with the fundamental questions of the basic laws governing the structure of matter. The Organization has its seat at Meyrin near Geneva in Switzerland. There are two adjoining Laboratories known as CERN Laboratory I and CERN Laboratory II.

CERN Laboratory I has existed since 1954. Its experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). Large intersecting storage rings (ISR), are fed with protons from the PS for experiments with colliding beams. Scientists from many European Universities as well as from CERN itself take part in the experiments and it is estimated that some 1500 physicists draw research material from CERN.

The CERN Laboratory I site covers about 80 hectares almost equally divided on either side of the frontier between France and Switzerland. The staff totals about 3100 people and, in addition, there are about 1000 Fellows and Scientific Associates. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 391.1 million Swiss francs in 1974.

CERN Laboratory II came into being in 1971. It is supported by eleven countries. A 'super proton synchrotron' (SPS), capable of a peak energy of 400 GeV, is being constructed. CERN Laboratory II also spans the Franco-Swiss frontier with 412 hectares in France and 68 hectares in Switzerland. Its budget for 1974 is 227.1 million Swiss francs and the staff totals about 350 plus 10 Scientific Associates.

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Around the Laboratories

Cover photograph: Inside the tunnel of the 400 GeV proton synchrotron, SPS. Installation of machine components is now in full flood (see page 383) and, in this tunnel section between the access shafts 3 and 4, cooling water pipes, the compressed air pipe and the trays which will support the cables for powering and monitoring the accelerator, are in place. Magnets are being taken down to sit in precise array on the left of the white line. The golf cart is a much enjoyed, and very necessary, form of transport around the 7 km circumference of the machine. It can carry four passengers and pull light equipment in its trailer. (CERN 150.9.74)

Preparations for physics at the SPS

Throughout the time that the construction of a 300 GeV accelerator was under consideration in Europe, the experimental programme that could be supported by such a machine was also being discussed. This put detail into the case for building such an accelerator and was an important part of the machine design in that it pointed to energy, intensity and ejection parameters to feed the physics programme adequately.

When the project was authorized in 1971, preparations for the experimental programme gathered momentum thanks particularly to the efforts of the Working Group under the Chairmanship of P. Falk-Vairant, set up by the European Committee for Future Accelerators. The peaks of these efforts were visible at two meetings held at Tirrenia (see, for example, vol. 12 page 318) where the interests of the whole European community of users were represented.

The present stage of these preparations has moved to the more practical and detailed level of specifying beam-lines and experiments. In general, the detection systems are large, complicated and costly and the beam-lines and experimental halls that feed and house them are a large part of the total construction project. They have, therefore, to be specified well in advance so that they will be ready to receive particles just as soon as the 400 GeV SPS is able to supply them.

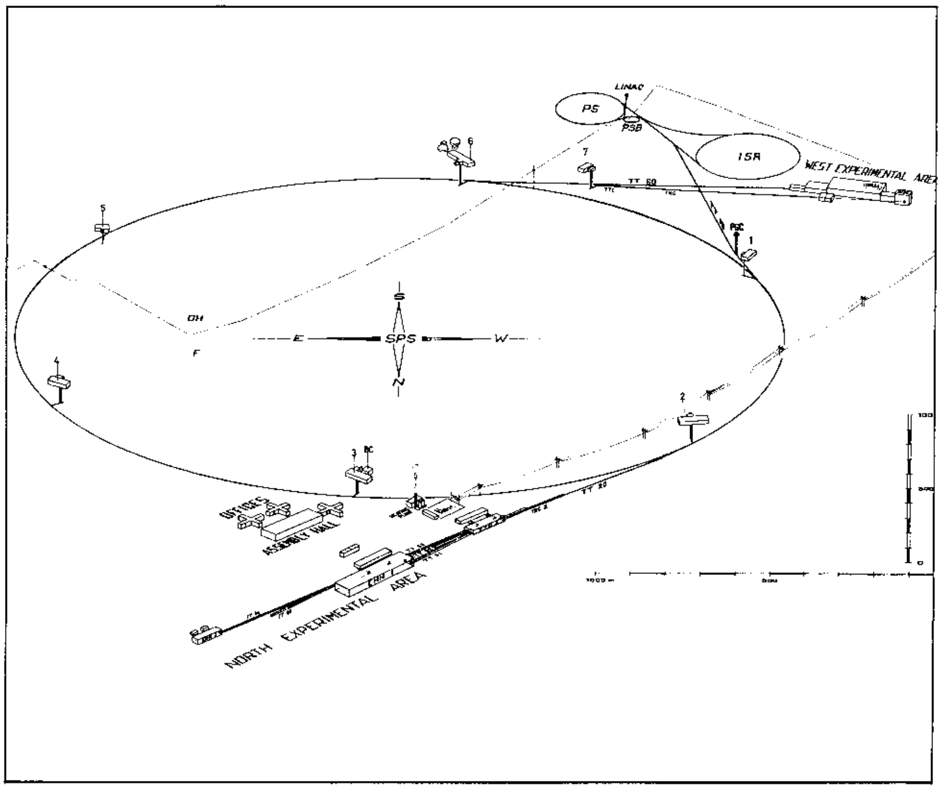
For this stage, the SPS Experiments Committee, chaired by P. Lehmann, is a major source of input from the experimenters while, within CERN itself, J.V. Allaby is co-ordinating the preparations and G. Brianti is leading the Experimental Areas Group in the project team. Details of the initial programme remain to be settled but its overall form is likely to be very close to what is sketched here. As far as possible the programme tries to avoid direct duplication of what has been done, or will be done in the next few years, at the equivalent machine at the Fermi National Accelerator Laboratory.

The SPS will feed two experimental areas — the West Area, which will receive its first beams in 1976, and the North Area, which will receive its first beams in 1978. The West Area will have secondary beams from targets bombarded by protons up to an energy of 200 GeV and neutrino beams generated from 400 GeV protons. The North Area will have secondary beams from targets bombarded by proton beams up to an energy of 400 GeV.

The West Area was built as part of the development of facilities for experiments at the 28 GeV proton synchrotron, its major detectors being the 3.7 m European bubble chamber, BEBC, and the Omega spectrometer. The experimental programme that it will support when the SPS comes into operation can be considered in two parts — neutrino experiments and electronics experiments.

To generate neutrinos, the ejected proton beam strikes a target in an underground cave at machine level. Pions and kaons which are produced are focused by a horn and reflector and allowed a drift distance of about 430 m in a tunnel rising at an angle of 2.5 degrees in which they decay to give positive or negatively charged muons and neutrinos or antineutrinos. Steel shielding is installed in 180 m of the continuation of this tunnel followed by a further 170 m of earth to filter out the muons before the neutrino beam emerges at the surface about 50 m upstream from BEBC travelling in the direction of the chamber.

The horn and reflector focusing system will give a beam of neutrinos with a wide range of energies. In addition to this 'wide band' beam, it



Schematic layout of the 400 GeV proton synchrotron, the SPS, indicating its injection system (the PS) and its two ejection lines to the West Experimental Area and the North Experimental Area. The buildings 1 to 7 seemingly erected on stilts, are service buildings in fact at ground level, the machine being below ground. Note the division of ejected beams towards the two Areas which is described in the article.

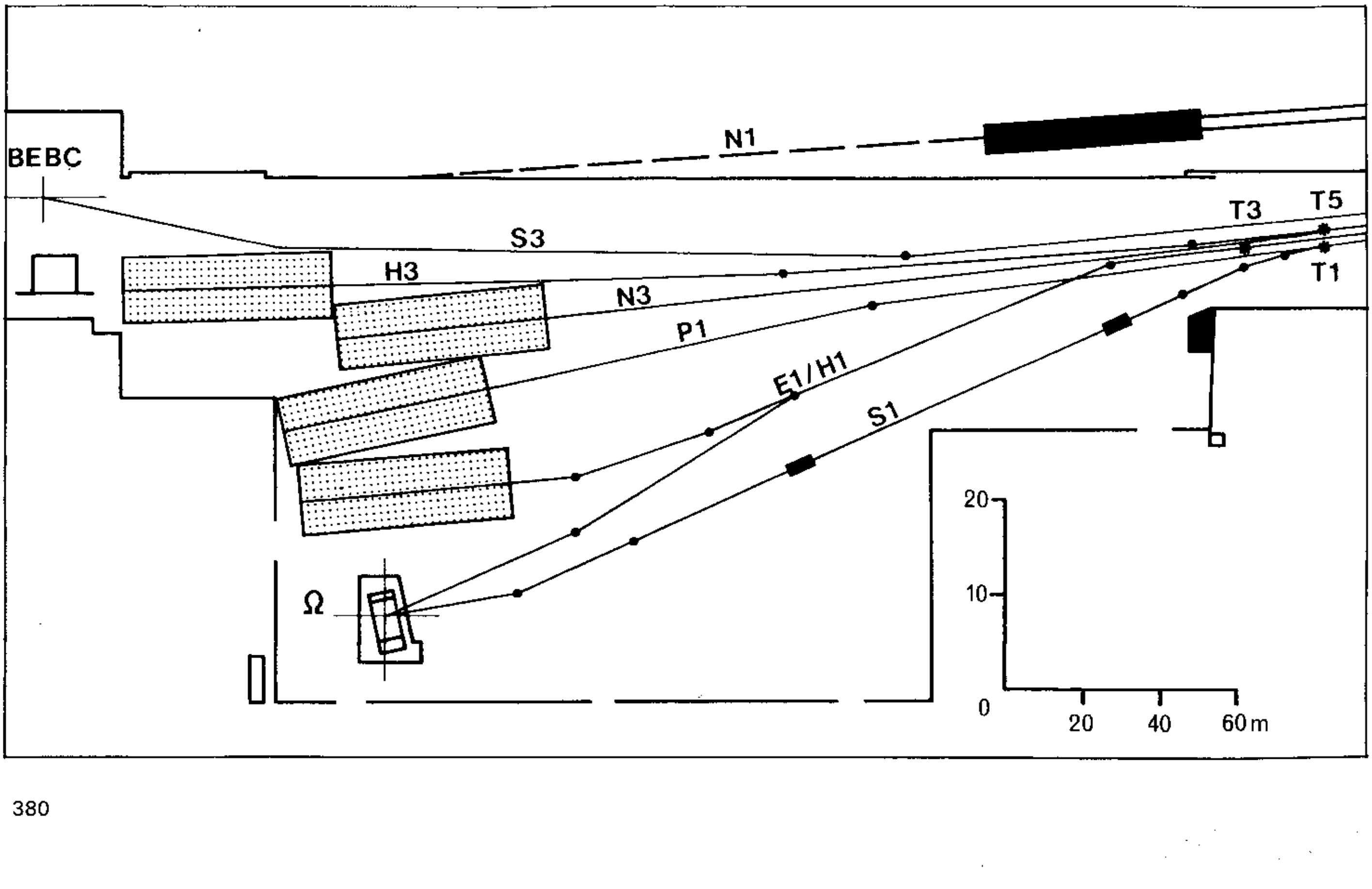
will be possible to have a 'dichromatic' beam by using bending magnets and quadrupoles to select pions and kaons around a particular momentum. The resulting neutrinos will then be clustered in two energy ranges, one from the pion decays and the other from the kaon decays. The dichromatic beam will be of higher energies than are at present available at the FermiLab, being centred on a momentum of 275 GeV/c rather than 170 GeV/c.

The 3.7 m bubble chamber BEBC, filled with hydrogen, deuterium or neon, will be the first detector at the receiving end of the neutrino beam. It will have a large array of multiwire proportional chambers (100 m^2) installed close around the downstream end of the cylindrical iron shield which contains the field of its superconducting magnet. This is known as the external muon identifier, EMI, and will improve the ability to measure the muons emerging from neutrino interactions in the chamber.

Next will come a separate detector using electronic techniques. This will be a massive assembly of 1400 tons of magnetised iron in modules, 0.9 m long and 3.75 m in diameter, interspersed with drift chambers for a total length of 20 m. It is being prepared for an experiment by a CERN/Dortmund/Heidelberg/Saclay collaboration. The first section of the detector also has plastic scintillator sections between the iron modules to measure the energy of hadrons emerging from interactions while the rest of the detector takes care of the muons. The interactions could be in the iron itself or in a volume of many cubic metres of hydrogen or deuterium placed in front of the detector. An additional 320 ton calorimeter of liquid argon interspersed with steel plate, to give precise information on the energy and direction of emerging hadrons, is also being developed by a CERN/Hamburg/Karlsruhe/Oxford/Rutherford/Westfield team.

Finally, the heavy liquid bubble chamber, Gargamelle, which was the first to detect neutral current neutrino interactions, will be moved from the 28 GeV proton synchrotron to sit in the SPS neutrino beam behind the electronic detector. The construction of the buildings to house these additional neutrino detection systems behind BEBC started at the beginning of November.

The West Area Neutrino Facility, WANF, will make possible a range of experiments with high energy neutrino beams of an intensity higher than is available, at present, at the FermiLab. Typically, BEBC filled with hydrogen is expected to catch a neutrino event once every eight pictures with the wide band beam. The experiments are likely to cover the study of elastic and inelastic cross-sections,



Inside the Hall of the West Area, three targets, (T1, T3, T5) are the source of beams to electronics experiments including those with the large Omega spectrometer. The neutrino beam (N1) can be seen at the top, heading for the 3.7 m European bubble chamber, BEBC, which is also fed with charged particles by an r.f. separated beam (S3).

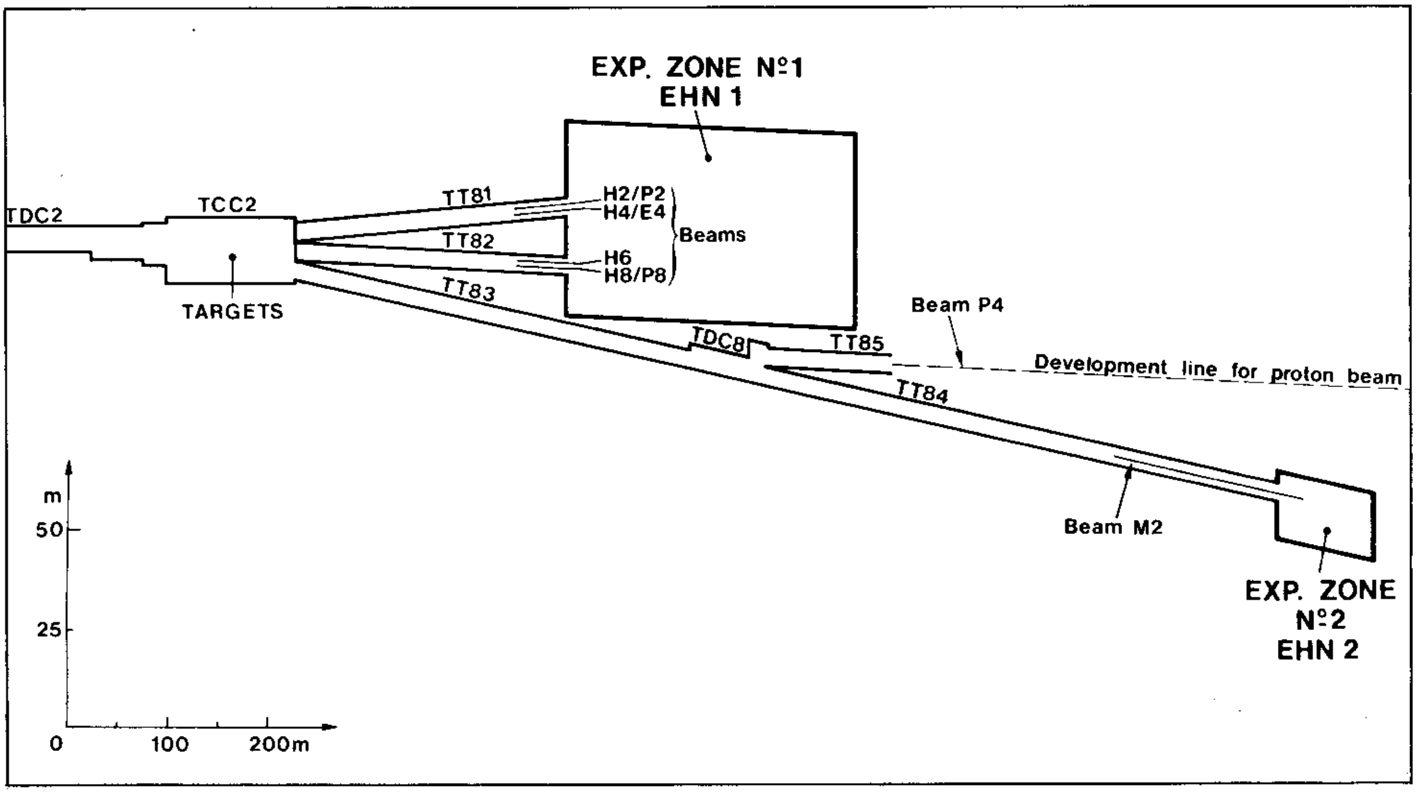
hyperon production, neutral current properties, intermediate boson search, etc.

Several beams will be set up for electronics experiments in the large hall of the West Area. They will be drawn from three targets all of which can receive protons at the same time following the use of beam splitting magnets. Five beams will emerge — H^3 with pions and kaons up to 150 GeV/c, N3 a neutral beam for neutrons or kaons, P1 for special beams beginning with a high energy hyperon beam, E1/H1 with electrons or hadrons up to 100 GeV/c which will have a branch to the Omega spectrometer and S1 which will be a separated beam, using superconducting r.f. cavities under construction at Karlsruhe, to achieve high fluxes of particles such as antiprotons also for Omega.

Some experiments are already planned in considerable detail: in beam H3, a polarized proton target will be used by a CERN/Trieste/Vienna team to measure pion-proton and proton-proton scattering parameters from 50 to 150 GeV/c using magnets and multiwire proportional chambers for measuring the particles emerging from the interactions. Another detection system (of an Indiana/Saclay team) on H3 will study backward scattering in the momentum range from 25 to 120 GeV/c. This will involve a hydrogen target surrounded by multiwire proportional chambers installed in a large aperture magnet, called Goliath, from the Saclay Laboratory. Further magnets and Cherenkov counters downstream will spot the recoil proton and avoid confusion with mesons.

In beam P1, the high incident proton energies will make high hyperon fluxes possible (for example, 5000 sigma minus hyperons per burst at 100 GeV). Rare decays of hyperons (including, eventually, those of the famous omega minus particle), which are crucial tests of weak interaction theory, can then be studied using Cherenkov counters in the identification of the hyperons and decay products and drift chambers either side of a bending magnet to measure particle momenta. A transition radiation detector may be used for the first time at CERN to sift out pions which are not produced in the rare decays which are of interest. This experiment is being prepared by a Geneva/Heidelberg/Lausanne/Orsay/Rutherford/Strasbourg collaboration.

The H1 beam will support a series of studies on strong interactions in the energy range from 30 to 80 GeV by an Amsterdam/CERN/Munich/MPI/Oxford/Rutherford team. The emphasis will be on the dynamics of boson resonance production at high energies. A large array of counters, chambers, magnets, Cherenkovs and a gamma hodoscope will be used.



The North Area will have two separate zones capable of handling particles up to the highest energies the SPS can provide. Still further downstream of the ejected beam there is scope for additional detection systems if the experimental programme should call for such a development in the future.

A second experiment in the H1 beam-line by a CERN/Genoa/Orsay/Oslo/UCL team, will look at elastic hadronic interactions with large momentum transfer. This probes the structure of the proton. Pion and proton elastic scattering will be studied. The recoil proton will be detected by multiwire proportional chambers in and around a large aperture magnet and the scattered particle will also be analysed by the same magnet and an additional magnet. Cherenkovs will be used for particle identification.

The beam-line E1 will open up a type of physics completely new to the CERN experimental programme. It will produce electrons of energy up to 80 GeV which will then give a tagged photon beam, on being passed through a radiator (the photon energies being determined by measuring the electron energies before and after the radiator), for experiments in the Omega spectrometer supported by two large Cherenkov counters. A Bonn/CERN/Daresbury/Ecole Polytechnique/Glasgow/Lancaster/Manchester/Orsay collaboration will use the photon beam (which can also be polarized by using a suitable crystal as the radiator) for a series of studies including vector meson photoproduction, Compton scattering, energy dependence of pseudoscalar meson production, photoproduction on nuclei, etc.

The Omega spectrometer will continue to serve as a general purpose detector and will have a programme of experiments fed with hadrons via the S1 beam-line. BEBC, in addition to its neutrino experiments, will also be fed with hadrons using the S3 beam-line which will climb from underground allowing long drift distances to ensure particle separation with conventional (warm) r.f. separators operating at 6000 MHz.

Since beams will reach the North Area two years after they reach the West Area, there is a little more breathing space in planning the experimental programme. No experiments have yet been 'approved', though proposals are being considered and the type of experiment and the corresponding beam requirements have dictated the overall layout of the Area.

Beams will be generated in a target area 10 m below ground. This helps in absorbing the flood of muons which emerge from the targets but which are then lost in the earth downstream while the required particles are brought to the surface via bending magnets. Three targets (T2, T4, T6) can receive beam simultaneously by splitting the ejected proton beam. Two of them will provide four hadron beams (two up to an energy of 270 GeV, two up to an energy of 400 GeV) for Zone I — a hall 50 m wide and 290 m long.

Experiments in Zone I, which have already been proposed, include studies of polarization in high energy interactions, studies of 'fragmentation' (such as have been carried out for the proton-proton interaction at the ISR) and studies of large momentum transfer phenomena for a variety of particles (also as have been carried out for proton-proton interactions at the ISR). These last mentioned experiments are likely to include experiments on lepton production which is currently a burning topic at the FermiLab and the ISR.

Zone II, further downstream, will receive a beam from the third target. The beam-line will begin by taking a high flux of pions and kaons and allowing a decay length for them to yield a muon beam, M2. The muon beam will be of much higher intensity than that now available at the FermiLab where muons are pulled off as an adjunct to the neutrino beam-line. For Zone II of the North Area, quadrupoles will be used to concentrate the muons in the decay region and magnets will bend them around in the vertical plane towards their detection systems. Magnetic collimators will be used in an effort to reduce further the muon 'halo' which inevitably surrounds the desired beam. Muons are such penetrating particles that any going slightly adrift from the desired beam still tend to sail on through magnets, etc., in the direction of the detectors. It is anticipated that the M2 beam-line will yield 10^8 muons in a beam of 5 cm radius while the halo, out to about 2 m, will have only about 2 % of the beam flux.

Experiments with the muon beam are likely to begin with deep inelastic scattering studies. All the experiments so far considered for the North Area would use electronic detector systems (with the possible addition of a small rapid cycling bubble chamber as a vertex detector).

There is room beyond Zone II for further developments if the physics programme eventually calls for it and a proton beam-line, now pointing out into the void, will be available. However, for the initial programme, the SPS probably has quite enough on its plate.

CERN News

First SPS magnets go down the tunnel

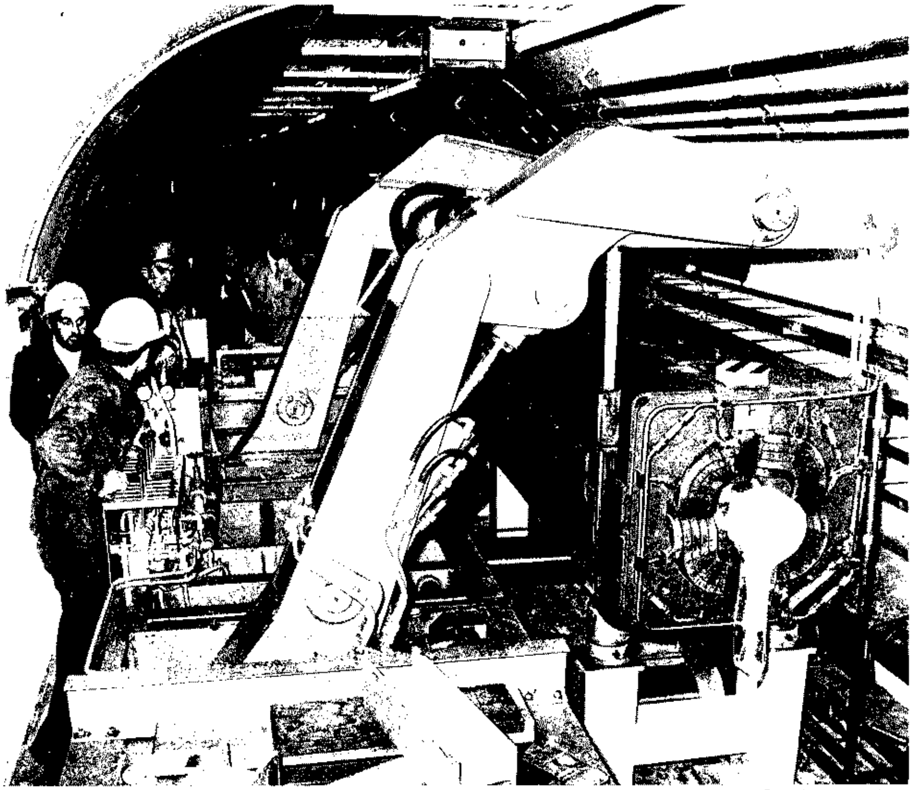
On 18 October, fifteen days ahead of the scheduled date, the first magnet was lowered via access shaft no. 3 to the tunnel of the 400 GeV proton synchrotron.

The first to descend was a quadrupole taken from the growing stack of tested magnets in the large assembly hall. Via various vehicular manoeuvres it was put in the lift at the access shaft, PA3, lowered 60 m to tunnel level and again manoeuvred and wheeled to its scheduled position near PP4. In this sextant of the ring all the electrical, water and compressed air services are now almost completely installed.

Before the magnets are put in position a series of preparatory operations take place with several teams of workmen keeping a healthy distance in advance of the magnet installation point — holes accurately bored to take the magnet supports, high frequency welding, tests on bus-bars for water leaks and electrical properties, alignment and cementing in place of magnet supports.

On 21 October the magnet was lifted onto its support stand using a special two-armed hydraulic machine. At the time of writing, over thirty magnets (bending magnets and quadrupoles) are in place and installation is proceeding at the rate of five per day. Strategically positioning a camera gives the impression of a complete machine since there are enough magnets to fill an arc disappearing around the curve of the ring. Alas it is an illusion for 1000 magnets are needed around the 7 km of the ring circumference. Still, a good start has been made.

Next month we shall return to the SPS with an article covering the progress of the project in more detail.



A quadrupole magnet of the 400 GeV proton synchrotron being lowered into place in the machine tunnel on 21 October. It was the first of the thousand magnets of the SPS to be installed. The hydraulically operated device on the left lowers the magnet onto its support stands. Watching the operation, third from the left, is J.B. Adams, Director General of CERN Laboratory II.

CERN 287.10.74

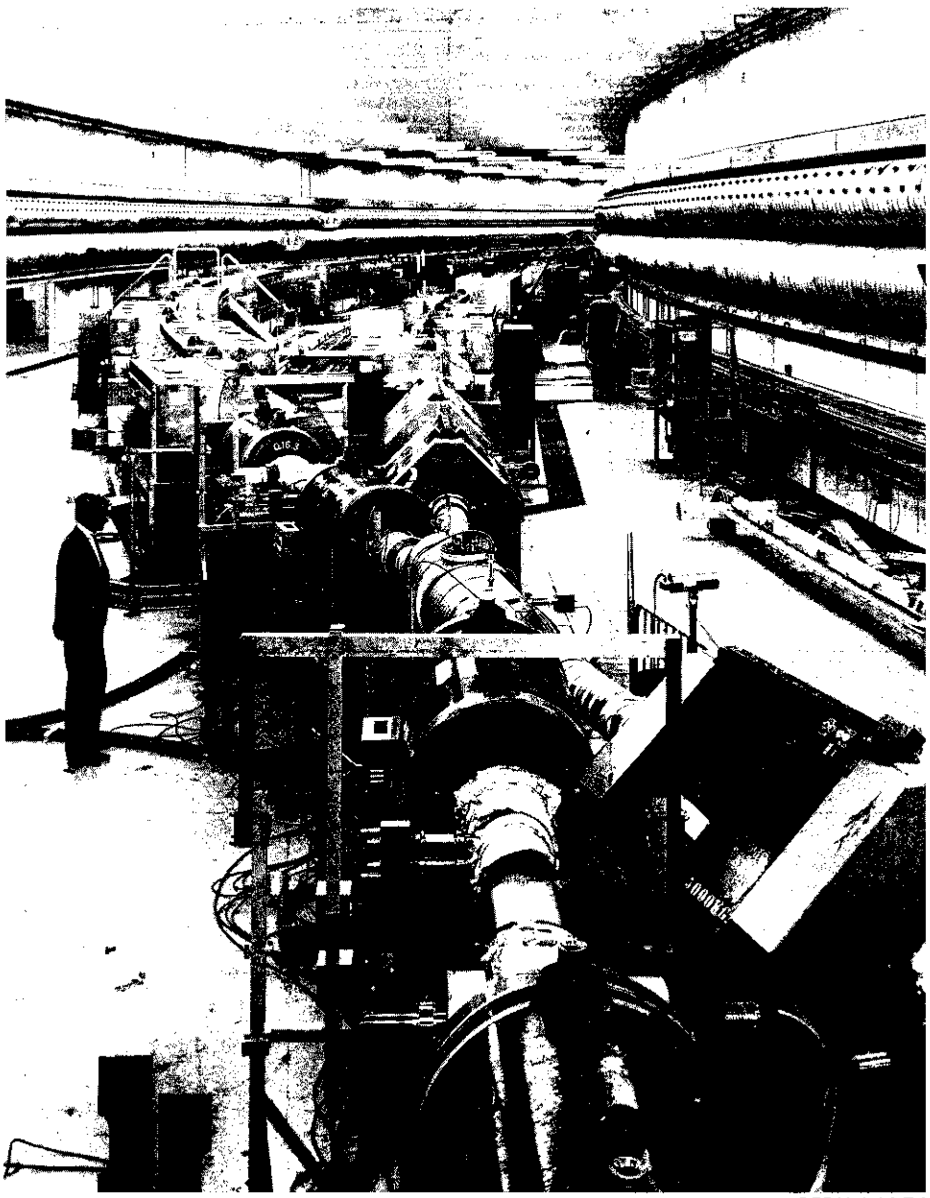
Getting yet more from the ISR

The Intersecting Storage Rings have already comfortably passed their design parameters but it is possible to squeeze still more out of the machine — literally, by squeezing the beams.

The parameter which is important for the physicists is the 'luminosity' since it gives the number of interactions per second that they can see in their experiments. The number of interactions, when the two colliding beams pass through one another, is generally smaller than in a conventional accelerator experiment where a beam is fired at a fixed target and this is why storage rings lean hard on pushing the luminosity higher.

Up to now this has been achieved at the ISR by building up the intensity of the stored beams. With beams of 24 A in each ring, a luminosity of 1.4 × 10^{31} per cm^2 per s has been reached. It is hard to go much further in this direction, however, and the recent efforts have taken another tack — using a low beta insertion in one of the machine intersection regions.

Since the luminosity depends also on the dimensions of the beams where they cross, the idea of the low beta insertion is to squeeze the beams where they pass through the intersection. This is done by introducing focusing magnets to reduce the beam height (the luminosity is inversely proportional to the beam height). Five quadrupoles have been installed on each beam, four in intersection I-7 (recently vacated by the streamer chamber), to give vertical focusing. They are modified magnets which have been garnered from Daresbury, DESY, the PS and the ISR. A special vacuum chamber was built and it contains 'scrapers' which can be



CERN 1.11.74

General view of the low beta section of the ISR. This installation, at intersection I-7, uses five quadrupoles per ring, four of which are sited in the intersection region itself. The central bicone contains a 'scraper' device for beam height measurement.

CERN 285.10.74

R.W.K. Blagborough and W.D.H. Gregson (left and second from left), who were Secretary and Chairman of the British Measurements, Control and Automation Conference, visiting stands during the week's exhibition of equipment from the U.K. held at CERN from 21-25 October.

moved in to measure the beam height with an accuracy of 0.01 mm. These changes affect only I-7 and one of the difficulties has been to ensure that the manoeuvres in this region do not disturb the beam behaviour in the rest of the ring.

The first tests were carried out at the end of October and went exactly as anticipated. The measurements indicated that the beam height had been reduced by a factor of 2.3 in I-7 and thus the luminosity increased by the same factor. The measurements were carried out with a beam intensity of 12 A in Ring I and 14 A in Ring II. The luminosity reached 1.02 × 10^{31} per cm^2 per s. This does not pass the record that has been achieved with more intense beams but, when higher currents are stored with the low beta section in action, it is expected that the record will be doubled. The most comforting aspect of the tests is that they have confirmed that it is possible to reduce the beam height in one part of the machine without perturbing beam behaviour elsewhere.

Tests with higher intensity beams are anticipated before the end of the year and, if the expected performance is achieved, it is intended to transfer the focusing magnets to intersection region I-1 in the course of 1975 to take advantage of the higher luminosity in an experiment.

Late news : During the night of 13-14 November another test of the low beta insertion was carried out. Feedback on the beams was operating and it was possible to stack higher current. With 20 A and 24 A circulating a new record luminosity was achieved – 2.2. × 10^{31} per cm^2 per s. In the same week, the ISR stored 30 A in each ring and passed 10 000 h of operation.

Managing CERN projects

C.J. Zilverschoon

At the Meeting on Technology Arising from High Energy Physics held at CERN in April, C.J. Zilverschoon (Director of the Proton Synchrotron Department with special responsibilities in the field of financial planning) gave a talk entitled 'Some Aspects of the Realization of High Energy Projects at CERN'. This talk covered several themes which many people regard as having played a crucial role in the successful management of the CERN Laboratories. Since these themes can be of wide interest, we present here a condensed version of the talk.

Projects in high energy physics can be big — big in size (they may be of the order of 100 metres up to kilometres), big in money (costing hundreds of millions, up to a milliard francs) and technologically advanced.

In 1959, the Proton Synchrotron was the first of its type working in the world and the same was true for the Intersecting Storage Rings in 1971. The big machine (the SPS) will be the largest of its type in the world and will be full of technical novelties. From the point of view of technical advancement, these projects can be considered at the same level as large rockets, or supersonic airplanes, or new types of reactors. Yet, when we bring them into operation, they generally work immediately up to the promised performance specifications and we have done rather well in keeping to the timescale and to the cost estimates.

The largest project so far completed is the Intersecting Storage Rings. We informed the CERN Council that we could build it for 332 MSF (at 1965 prices) and that it would be in operation by the middle of 1971. In reality, the machine worked four months earlier and approximately 5 million Swiss Francs of the project money was left over. This is quite a different affair with some other advanced projects or even some of the more conventional projects such as underground railways, airports, Olympic games, or even motorways, where sometimes large over-expenditures and delays have occurred. We do not always underspend; we have sometimes had an over-expenditure of 5 % or even 10 % but never a factor of 2 to 5 over-expenditure that sometimes is found in other fields.

This discipline of sticking to promised figures is not limited to CERN but is typical of high energy physics. To give one other example: in 1960, the Alternating Gradient Synchrotron in Brookhaven, USA (a parallel machine to the CERN Proton Synchrotron), was finished and the project leader was able to hand back a sum of money to the USAEC.

Project control and set-up

I should like to discuss a few points which we believe are of importance in making the projects not only a technical success but also a success from the management point of view. Let me start with a topic, 'project control', which is so fashionable that it is the subject of big conferences. It is, of course, important to control the project. During construction of the ISR we had PERT, a critical path system, and it worked very nicely. But when building the PS these systems did not exist. All that one had at that time was commonsense and yet the PS was ready six weeks before schedule. It would be stupid not to use these management tools when they are available but I do not believe that they are so essential that a project would be doomed without them.

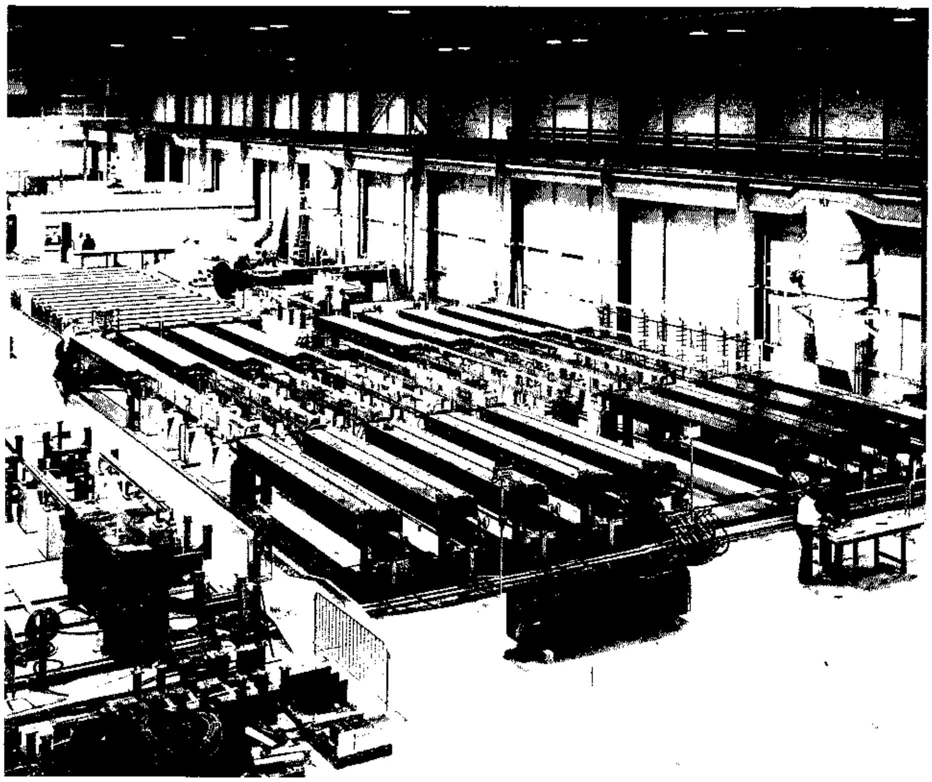
There are more essential things. We have always followed a clear line at CERN in the project set-up. A project leader has always been given great liberty in devising his own set-up

Aerial view of the Intersecting Storage Rings, the largest project so far completed at CERN. This 330 million Swiss franc project was completed ahead of schedule and for less than the cost estimate

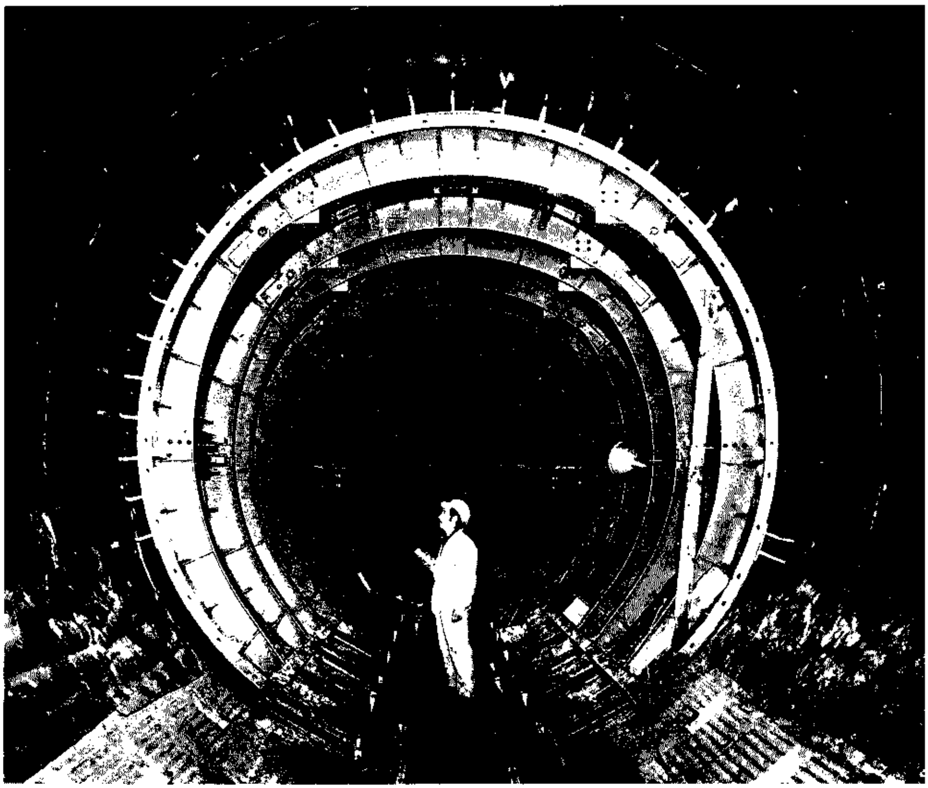
CERN 57.2.71

Two aspects of the huge project to construct the SPS, an accelerator to give energies of several hundred GeV:

1. *A tunnel about 7 km in circumference had to be built 40 m below ground;*
2. *A magnet assembly and testing factory had to be set up to produce close to 1000 magnets of high precision.*



1. *CERN 16.1.74*



2. *CERN 42.2.74*

and, for projects the size of the large accelerators, we have created a special project division which, from the technical point of view, was almost self-supporting.

It had its own magnet group, its own electronics workshop, its own mechanical workshop, its own drawing office, even sometimes its own buildings group. For technical matters the project leader never had to rely on general services from the Laboratory; he used general services from the administrative point of view but technical matters were always in his own hands and, if something went wrong, he could only blame himself or his own people. We believe that this is an essential point: to give great independence to the project and, therefore, the full responsibility to the project leader.

Staffing a project

The quality of the staff has to be good and we have been lucky in being allowed to hire staff from wherever we wanted within Europe. The CERN Convention allows us to hire people without considering their nationalities. We do not have to distribute posts in accordance with the contributions of the Member States.

What may be even more important is the motivation of the staff and here we come to a point that I should like to call the 'continuity of the staff' throughout the project. Starting a new project, the first step is to set up a design study group, which may have about ten senior engineers and physicists. They work together for a year or so to produce the Design Study Report. This contains the reasons for the project and how to go about it. It gives the first layout and technical drawings; it mentions where difficulties can be expected and contains the cost estimate and the time-table.

Various types of vacuum chamber section as used in the proton synchrotron. For each type the manufacturing procedure was selected according to the complexity involved, the capabilities of industry and the cost. A section of the initial chamber is seen on the extreme right — it was produced, to CERN's complete satisfaction, by a firm that normally made washing machines.

CERN 246.1.72

It is with this book that we go to our Council for approval of the project.

It is very important that the senior staff, when making the design study, know that they will stay on later to actually do the work, forming the nucleus of the project division. Then a man who, in the design study, estimates a magnet to cost a certain amount of money knows that, if the project is approved, he will have to build it for that money. This motivates him to make a proper cost estimate. It is extremely important at an early stage to motivate people by letting them know that they will stay with the project.

There is another facet of staff continuity that is interesting. Once the big accelerators or detectors start to function, we know from experience that we need more people to operate, maintain and develop them than to construct them. The equipment has a long and busy life, running 24 hours a day, 7 days a week and for each operator we need five or six posts, which means a large operating staff. Also, advanced precision equipment needs a lot of maintenance and hence maintenance staff. Finally, we want the equipment to last a long time, say 25 years. During its lifetime the technology can change completely and the physics interest may require a continuous development of the equipment. We need a large operating staff, maintenance staff and a development staff.

A fairly large percentage of the staff that works throughout the construction stage stays on with the project. This gives the same sort of motivation to do a good job. Because of the need for a large number of staff when the equipment is in operation, we can have a sizable staff during the construction period without worrying about the problem of laying-off large numbers of people.

Collaboration with industry

In order to make the total cost of a project as close as possible to the cost estimate, we try to obtain the equipment for as low a price as we can. To do this we have two rules: we give industry specifications that are as precise as possible, (in the hope that they can make price calculations with a minimum of unknowns and therefore a minimum of risk for them) and we ensure that there is sufficient competition for each tender.

The placing of a limited number of extremely large and complicated orders with only one or two big firms, such as is sometimes done in space work, is not in accordance with these rules. We do the opposite: we tend to break down the whole project into a relatively large number of contracts, each of which is relatively simple in itself and therefore often suitable for medium-size or small firms. In this way we increase the number of firms that we can interest and increase the competition.

The equipment can be of various types: It can be standard equipment such as a power transformer. There are plenty of factories that make transformers, so we know that, when we need a transformer, there are experts in these firms who can design the equipment. Then we never think of setting up our own design group but we simply prepare performance specifications, possibly giving some dimensions or specifying how much cooling is available and so on, and do not make a detailed design. In this same class there are many other items such as computers, vacuum pumps, cranes, switchgear...

A second type of equipment is a sort of extension of what already exists. For example, there may be on the market a high frequency tube producing 2 MW of power and we want something similar but for 5 MW. Here again we do not try to set up a special development group but try to interest firms in making us an offer to develop something that suits us from their existing model. Of course we ask them to develop it at a fixed price. Much of our work is in this category. We often establish a good relationship with the firms, for instance, helping them to do tests or even to advance the work.

A third type consists of equipment not normally made in factories; for example, synchrotron vacuum chambers, synchrotron magnets, etc. Here we insist on having our own experts and set up small design sections who work out the specifications with detailed drawings that are sent out to firms who we believe can do the job. Firms are contacted even if the job is not their normal speciality and in this way we often get lower prices than if we go to the specialist firms only. To give an example: the vacuum

Around the Laboratories

chamber of the PS was made by a factory manufacturing washing machines, which nevertheless had the right type of production facilities and was cheaper than the specialized vacuum firms. They built the vacuum chamber very well but we would not have let them do the design work.

This philosophy also fits well with our financial rules. Contrary to what generally prevails in international organizations, we do not have a system of 'fair return'. In other words, if a country contributes 20 % of the budget it does not insist on getting back 20 % of the expenditure. There is no geographical distribution of contracts; we have to accept the lowest offer that meets the technical requirements and delivery time. This freedom to spread our contracts through the Member States, without being under the constraints of 'fair return', is of great importance and certainly helps in getting low prices.

These rules are not advantageous to CERN alone. We have noticed that sometimes a firm is temporarily not fully occupied and can make a lower offer. If this firm gets the order, it is obvious that more than one party will be satisfied. The firm is happy because it needs the work. CERN is happy because it gets a lower price and the Member States know they get good value for their (taxpayers') money.

'Fall out'

We have slowly come to realize that industry may gain something else from our efforts beyond the immediate orders they get from us. In the course of doing a job, a firm may introduce a new product or gain experience in new techniques or use CERN as a test-bed. We are now investigating what has happened to firms that have had big contracts with us and are finding that this 'fall out' exists to a greater extent than we thought.

BROOKHAVEN
Present and future programmes

The Brookhaven National Laboratory for many years enjoyed a pre-eminent reputation among high energy physics research centres. In its heyday many of the major discoveries fell to the 33 GeV Alternating Gradient Synchrotron, AGS, which was then the highest energy machine in the world. The inevitable leap-frogging process has since taken place and facilities at Serpukhov, CERN and the FermiLab have extended the fields of research beyond the reach of the BNL machine. There is therefore the keenest interest in the major project for the future at BNL — the construction of the very high energy colliding beam machine, known as ISABELLE, which will bring the research back into the front-line at the highest energies.

The present programme has endured 'constant dollars' in recent years. In an inflationary situation, this has meant that progressively less physics could be supported at the AGS. For example, unless pennies from heaven are forthcoming, operation of the accelerator will be limited to about 26 weeks of the present fiscal year. Even in this situation, however, it is recognized on all sides that research and development in relation to the accelerator facilities should continue to be funded (the level usually being at about 10 %, i.e. $ 2 million in this fiscal year). This money is split about evenly between the improvement programme on the existing machine, where the full potential is taking a long time to reach because of lack of funds and people, and the ISABELLE project.

While the accelerator/high energy physics components of Brookhaven have not yet seen an upturn in budgets, the Laboratory as a whole has more money this year, much of the increase being related to a variety of energy projects. J.P. Blewett, the highly respected practitioner of accelerator physics, has had special responsibility in the co-ordination of the energy programmes and the Accelerator Department, led by M.Q. Barton, is participating in this work.

For example, a 30 MeV linac to accelerate deuterons has been designed by a Steering Committee headed by D. Gurinsky and D. Parkin with the linac group of K. Batchelor. The beams would be used to yield 14 MeV neutron beams for studying the neutron environment around thermonuclear fusion reactors. Other Labs, such as Los Alamos and Livermore, have also looked at neutron beam devices for the same purpose. The Brookhaven design is for a high intensity (1 A) deuteron beam giving a neutron flux of 10^{14} per cm^2 per s. It involves no new technology and is ready to go almost as soon as the financial button is pressed.

Another project, stimulated by J.G. Cottingham and G.K. Green, is for a solar powered steam plant. Their proposed scheme involves concave reflectors focusing the energy from the sun onto the entrance of a high pressure steam boiler. The orientation of the reflectors would be controlled by a simple computer system to sustain the optimum settings as the sun moves across the sky. A unit system of 29 reflectors and a boiler is predicted to give 850 kW of peak power. These two potential energy sources, fusion and solar, are perhaps the only two that hold out the promise of virtually limitless energy and they do not bring serious environmental problems in their wake.

A power transmission project, involving the use of superconducting cable, has scientists from many of the BNL Departments participating in the studies led by E. Forsyth. The

Several months ago the foam fire protection system for the 7 foot bubble chamber came on automatically because of an electrical design fault in the manufacturer's circuit. The incident provided a vivid demonstration of the system's ability to flood the entire building with extinguishing foam very quickly. Clean-up was completed in about a day and left the bubble chamber whiter than white.

challenge is the long range plan of the Long Island Lighting Company for a 70 km link between a nuclear reactor site and a large substation which will require 345 kV cables capable of 4800 MVA. Thorough cost comparisons with conventional systems came out favourably for a superconducting version. One advantage is that the superconducting cable is well matched to the load and would therefore be suitable for transmission over many hundreds of kilometers (the critical length for the BNL type being 680 km).

The optimum design of the cable and its cryogenic envelope is being chased hard. In contrast to most other work on this problem, BNL have gone for niobium-tin as the superconductor in flexible cables with gaseous helium cooling. They have several techniques for achieving good Nb_3Sn layers on a substrate, including one similar to that recently tried in the Rutherford/Harwell work on magnets (see September issue page 349). A cable for 345 kV to carry a current of 500 A per centimetre of circumference has been developed. It is 14 cm in diameter shrouded by insulation, etc., to give a total diameter of 46 cm, with helium cooling sustaining a temperature between 6 and 9 K. Just how tricky the materials problem is for such cables, can be realised from the fact that 1 km of normal pipe shrinks several metres in cooling to such temperatures.

Most of the remaining questions centre on the cooling system. The BNL people are confident of the properties of the superconducting cable itself; what is not optimised is the method of cooling it to superconducting temperatures and holding it there reliably. To check the techniques developed so far, a 1 km length is to be installed at the Laboratory.

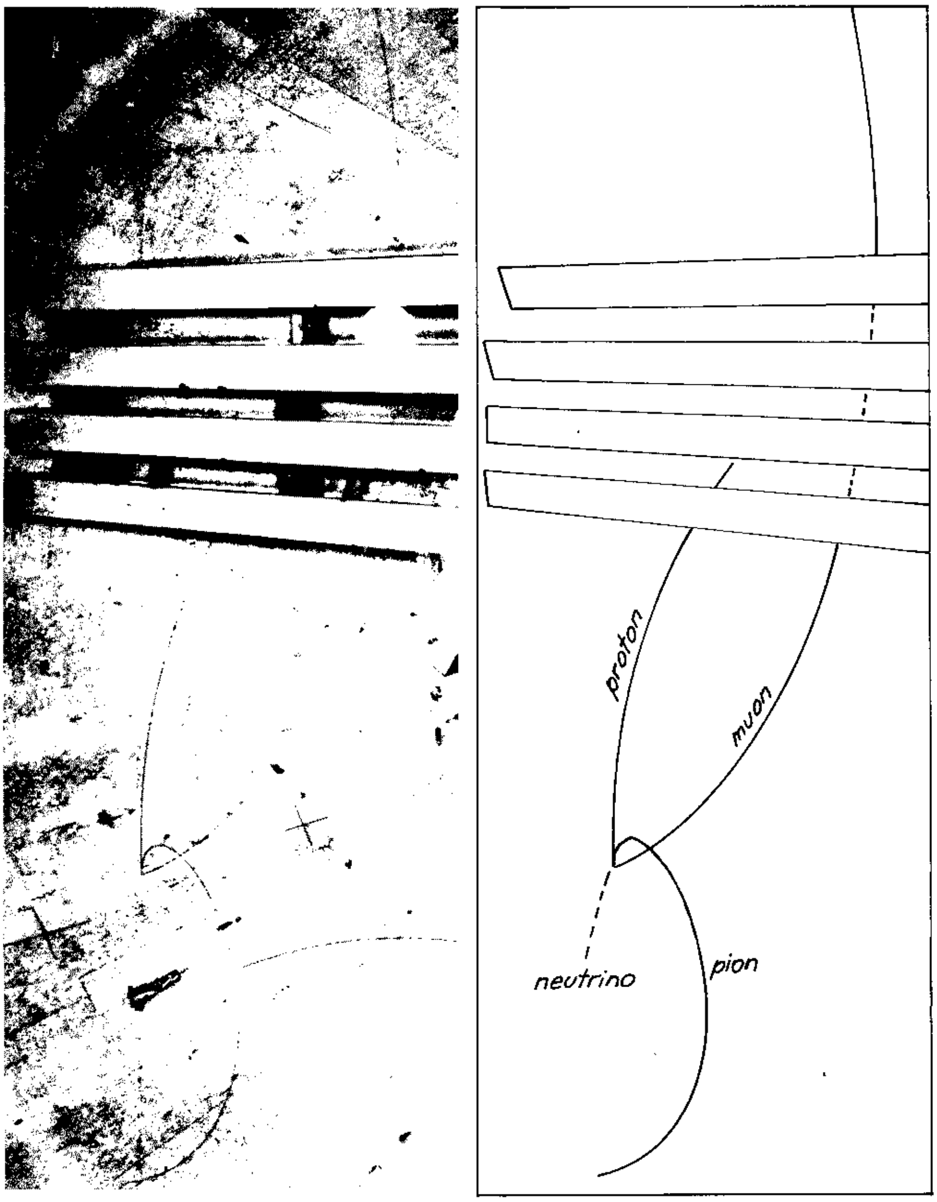
But, of course, the major activities remain centred on the high energy physics programme and the operation and development of the AGS. The 33 GeV Alternating Gradient Synchrotron now operates at intensities around 7×10^{12} protons per pulse. The peak accelerated intensity (to transition) has been 9.7×10^{12} and the necessary manoeuvres to top 10^{13} are expected to have been completed by early 1975. Beyond this level, further advances might be possible by injecting negative hydrogen ions from the linac into the synchrotron ring for conversion into protons, as has been pursued at Argonne. T. Sluyters and K. Prelec have achieved encouraging performances from negative ion sources of the type developed at Dubna and Novosibirsk. Currents of over 100 mA for 1 ms are already possible. Such sources also have relevance to fusion work since negative beams are an efficient route to the neutral beams which can be used to top up fusion reactors. A 1 A source is being developed for this purpose while at the AGS a second pre-injector is being built for negative ion injection into the linac.

The 200 MeV linac now has a debuncher operating in the self-excited mode, reducing momentum spread by a factor of three, and full instrumentation and computerization is being brought into action. It normally feeds 50 mA beams for multi-turn injection into the ring during 120 μs injecting from 1.2 to 2×10^{13} protons. At the lower intensities, capture efficiency is about 70 % falling to 50 % when the full ring aperture is filled.

At the output of the linac, there are parasitic branches for other uses since the linac pulse repetition rate is much higher than is needed simply to feed the AGS ring. Branches for nuclear chemistry and for isotope production for medical applications are in regular use. The shield wall has also been breached to take an additional low intensity proton beam for cancer diagnostics and therapy but such a use has not yet been financially supported. One entertaining application of protons from the linac was the irradiation of a pattern on the nose cone of a space rocket. The aim was to see how the cone wore away during entry into the earth's atmosphere.

In the accelerator ring, there are troublesome losses with high intensity beams and closed orbit control and feedback systems to cure coherent instabilities are receiving more attention. The gamma jump technique (see vol. 4, page 10) is to be applied to improve the ability to take the beam through transition. Ejection systems are also receiving attention since it is important to have them in a tidy state for high intensity beams so as to avoid irradiation problems. Slow ejection efficiencies have been around 75 % for some time and it is hoped to nudge this up above 95 %.

The experimental programme has



A 'standard' three prong neutrino event where the neutrino interacts with a proton, converting to a muon and producing a proton and a pion. The weakly interacting muon goes through four stainless steel plates installed in the chamber. A strongly interacting pion or proton almost always interacts in the plates (as the proton does here) making it possible to distinguish between a muon and pion. This will be the primary means of separating neutral current events, such as $\nu + p \rightarrow \pi^- + p + \nu + \pi^+$ *from charged current events, such as* $\nu + p \rightarrow \mu^- + p + \pi^+$.

been fed by beams from an internal target, by two fast ejected beams to the 80 inch and 7 foot bubble chambers, and by a slow ejected beam to a variety of counter experiments. Financial restrictions forced the close down of the 80 inch chamber at the end of September. The chamber was built by a team led by R. Shutt and came into action in 1963. In the eleven years of its life, it did noble service, collecting some 12 million photographs for seventy experiments. Its particular moment of glory came with the identification of the omega minus in the Brookhaven experiment led by N.P. Samios. It has run with hydrogen and deuterium fillings and received a variety of particle beams ranging from pions of momenta up to 25 GeV/c to deuterons of momenta up to 29 GeV/c.

The bubble chamber burden is now taken up by the 7 foot chamber. This chamber sits in a region of the North Experimental area where it is fed by a neutrino beam. It came into operation at its new location in November 1973 and since then has taken pictures with hydrogen and deuterium. An example of a neutrino event is shown in the photograph. Some problems still exist on the superconducting magnet and with leaks but control of the chamber operating conditions is very refined and the refrigeration system is working excellently.

Three neutrino experiments are under way. In the chamber itself, the usual information is being collected with an event rate of about 1 in 40 pictures. There is emphasis on neutral current events using stainless steel plates, 5 cm thick, in the chamber volume to help distinguish between pions and muons, thus pinpointing the neutral current events when muons are not produced in the interaction. It is hoped to build a 'narrow band' neutrino beam where the momentum of all the neutrinos will be close to 8 GeV/c. This will make it possible to study the dynamics of neutral current interactions using a hydrogen-neon mixture in the chamber.

A spark chamber experiment by a Columbia team led by W. Lee is downstream of the chamber and they reported their first tentative neutral current candidates at the London Conference in July. Further downstream, is a large liquid scintillator detector of a Harvard/Pennsylvania/Wisconsin team. They hope to observe neutrino-proton elastic scattering and to measure the angular distribution of the recoil protons. This experiment is easier at AGS energies than at higher energies when other interactions come more into play.

In the East Experimental Area the internal target (in straight section G10) provides a neutral kaon beam, a separated 3 GeV/c negative kaon beam and test beams. The slow ejected beam, via two splitting stations and a bending station, can give protons onto four targets (three at the same time). Targets A and D can be fed alternately by powering a bending magnet. An experiment fed by target A is by a MIT/Brookhaven team led by S.C.C. Ting to continue the study of the electromagnetic properties of the nucleon by measuring electron pairs emerging from proton-proton collisions. Target B is the most prolific, providing a high energy (up to 30 GeV) charged beam at zero degrees and a neutral kaon beam (from B'). It is also the source of particles for experiments with the MultiParticle Spectrometer (MPS) a large, general purpose detection system which is now coming into action. It has a big magnet whose aperture is filled with magnetostrictive wire chambers plus a surrounding array of large chambers ending with a downstream Cherenkov counter. Several experiments are lined up to use the MPS. It will later be fed with a high energy unseparated

✱ Fascinating news from this experiment at the beginning of November: They believe they have seen a new particle (baptised the J particle) of mass 3.1 GeV which decays into an electron-positron pair. The electron-positron ring SPEAR at Stanford has seen it also. Another tantalising contribution to the melting pot of the hadron/lepton relationship. More next month.

beam from target A incorporating four new superconducting magnets mentioned below. Finally, target C has a two-branch low energy separated beam and is the source of a muon beam and a hyperon beam.

The bright light on the horizon is the ISABELLE project for the construction of 200 GeV proton-proton storage rings. ISABELLE draws its name from 'Intersecting Storage Accelerator' since the ISABELLE ring will receive protons from the AGS and accelerate them to higher energies to store them for colliding beam physics. The outline design was given in vol. 11, page 227. It has evolved to have fourfold symmetry with two rings 2690 m in circumference intersecting at four 200 m straight sections for colliding beam experiments. With 10 A circulating in each beam it is hoped to achieve luminosities of 10^{33} per cm^2 per s. A detailed description of the project can be found in BNL 18891 edited by H. Hahn and M. Plotkin.

The work that is now under way, or foreseen in the near future, for ISABELLE is concerned with tidying up some aspects which have not yet been studied in detail or aspects where uncertainties still exist. This is particularly true of the uncertainties raised in the course of the HEPAP Subpanel discussions on the project (see July issue, page 260). They included the remaining questions on the ability to produce superconducting magnets of adequate quality and there are several moves at Brookhaven to take superconducting magnet technology further.

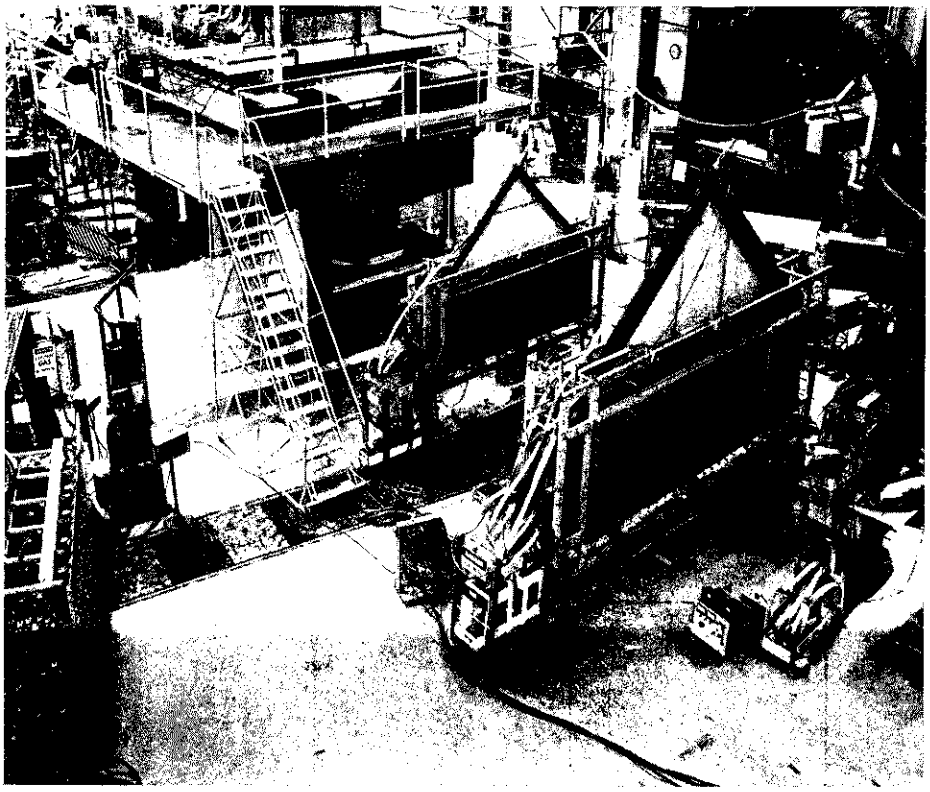
The group of W. Sampson, who have already produced magnet models ISA-1 and ISA-2, will construct full size ISABELLE magnets — 4.25 m long, 12 cm aperture diameter, 8 cm warm bore, 4 T field — hopefully for tests by mid-1975. It is not, however, clear that length has any influence on properties that can be checked on shorter models. Further 1 m models will be built to continue studying such things as end effects, quadrupole error, etc., and four large dipole magnets (close to what would be required in an ISABELLE intersection region) will be built for an AGS high energy unseparated beam.

The group of G. Danby, who built the superconducting magnets which have operated in the 8° bend of the beam to the 7 foot chamber, are using a different (two layer) construction method to build a 6 T magnet.

Higher fields are being sought also by continuing work on magnets using niobium-tin as the superconductor. Three methods of producing filamentary niobium-tin conductor are being tried and a magnet will be built using each method. The interest in higher fields has been strengthened by the HEPAP Subpanel's recommendation that colliding beam energies of higher than 200 GeV are desirable.

Development work on the vacuum, which CERN ISR experience has shown to be crucial to good performance of storage rings, is continuing with measurements on outgassing, desorption, etc. It is intended to use an aluminium chamber at room temperature rather than at cryogenic temperatures in the magnet dewars. This requires increased magnet aperture to leave room for insulation of the chamber but avoids the many penetrations into the vacuum going from warm to cold and simplifies outgassing the chamber and general maintenance. Other materials, such as stainless steel will be measured also.

Theoretical and design studies will consider the extension to higher energies and problems such as beam ejection and dumping (there will be many megajoules of energy in the circulating beams), shielding require-

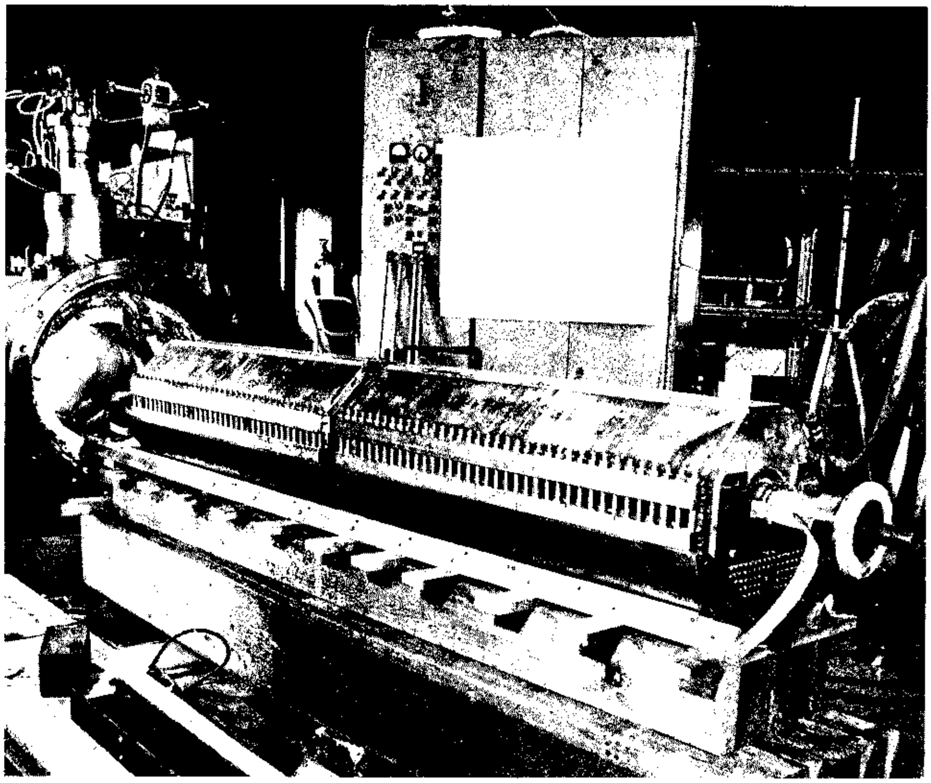


The Brookhaven MultiParticle Spectrometer, MPS, viewed from downstream: A medium energy separated beam enters the area from the upper left of the picture. A 700 ton magnet (at the centre) has spark chamber modules in its large aperture, 1.2 m high with a 1 T field extending over an area roughly 1.8 m wide by 4.5 m long. The magnetostrictive readout portion of the modules can be seen on top of the magnet. Two spark chamber modules in the foreground detect high momentum particles, which escape the magnet gap, to improve the momentum measurements. Two small spark chambers modules are seen furthest downstream before insertion into the magnet gap as target region detectors.

The Brookhaven superconducting magnets ISA I and II just before they were rolled into the horizontal cryostat for a long term test. These magnets pulsed away happily for well beyond the number of pulses such magnets could be expected to give in the lifetime of the ISABELLE storage rings and showed no deterioration in performance. The ability to leave ISA I and II pulsing unattended without problems for very long periods has been an important factor in boosting confidence in the advent of superconducting machines.

(Photos Brookhaven)

The Orsay mass spectrometer swings into the air outside the Laboratory of Nuclear Reactions at Dubna. The spectrometer was used to gather data on a series of fission and fusion reactions using beams from the heavy ion cyclotron.



ments (where an acceptable reduction on the figures used so far would bring welcome cost savings), review of the accelerating system design, etc. . . More money has been requested to tackle some practical problems such as optimizing the dewar design. This is important because the dewar costs come out higher than those for the magnets at present.

There is obviously much afoot to keep the ISABELLE flame alight.

DUBNA/ORSAY Collaborative look at the nucleus

Dubna's Laboratory of Nuclear Reactions under G.N. Flerov got together this year with the Orsay mass spectroscopy group under R. Klapisch to bring their combined talents to bear on the study of the nucleus.

The Laboratory has one of the world's finest heavy ion machines — a 3 m cyclotron capable of accelerating ions to energies of 8 MeV per nucleon with intensities up to 200 μA. A recent development, reported in the October issue page 353, has extended the range of accelerated ions to chromium, vanadium and titanium. A 4 m cyclotron is now under construction to carry the abilities of the Laboratory still further.

The Orsay group has a high reputation in nuclear and mass spectroscopy. Under the initial stimulus of the late R. Bernas, they have evolved techniques of studying rare isotopes in very clean experimental conditions. The team has done notable work at the CERN proton synchrotron (see, for example, vol. 13 page 185) particularly on a long series of sodium and lithium isotopes. Their spectrometer is a mobile instrument and could therefore be readily transported to the heavy ion cyclotron, at the invitation of Dubna, to carry out some collaborative experiments.

An agreement was reached between Dubna and the Institut National de Physique Nucléaire et de Physique des Particules for 500 hours of beam time at the cyclotron. The experiments began in June and were completed at the end of August. Beams of boron, phospherous, neon, argon and oxygen ions were used on uranium, tungsten, cobalt, copper, titanium, silver, nickel, germanium, rhodium and gadolinium targets. Very pure target specimens were prepared at the Orsay isotope separator.

It is the first time that a refined mass spectrometer technique has been used on the complex reactions produced by accelerated heavy ions. Both fission and fusion reactions were studied. In the fusion reactions, the spectrometer was able to pick out, for example, rubidium 81 from the fusion of a boron 11 ion with a germanium 70 nucleus or from the fusion of an oxygen 18 ion with a copper 63 nucleus.

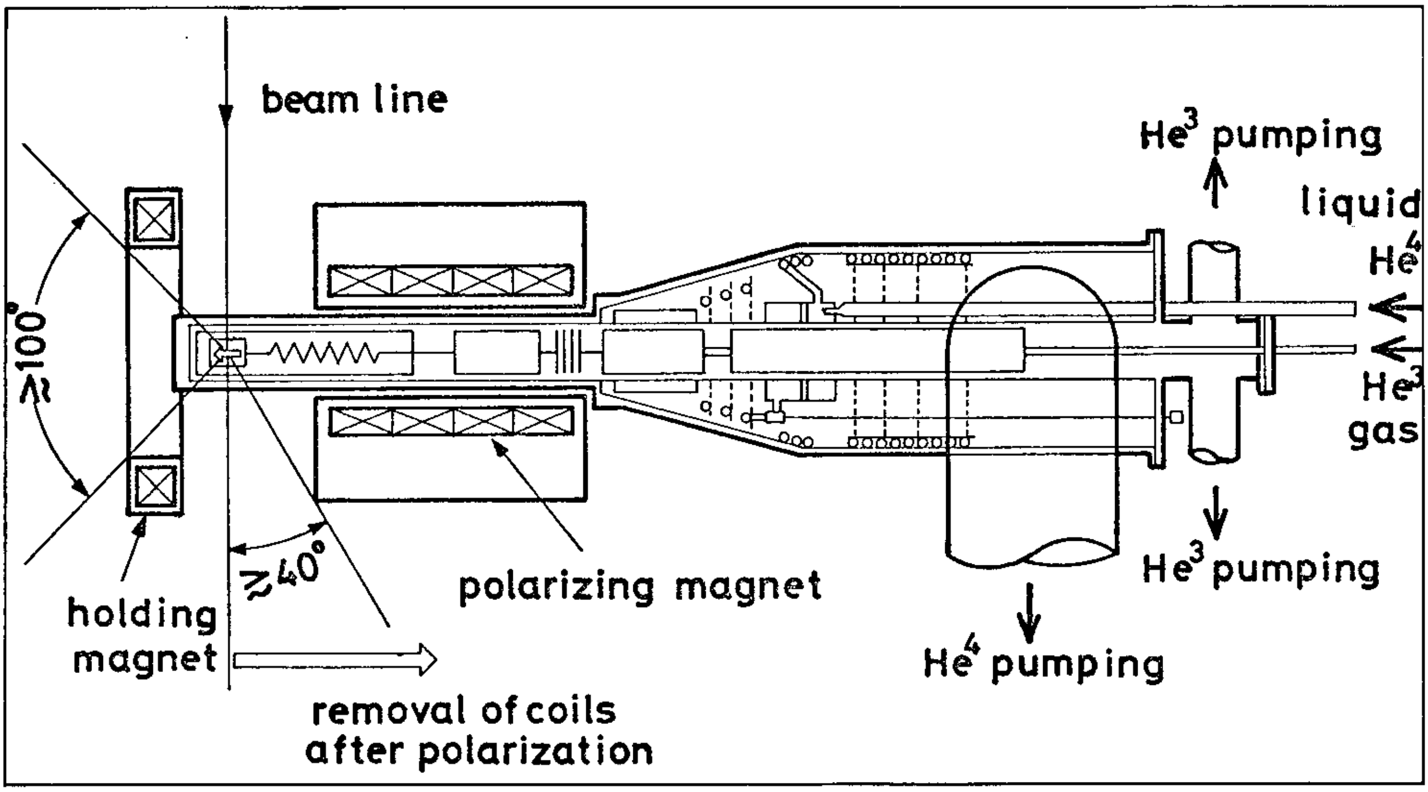
The mass spectrometer can be set, for example, to count rubidium isotopes through a range of ion momenta. This records a series of peaks corresponding to the cross-section for production of an isotope with evaporation of two, three, four, etc. neutrons. Very clean data on these reactions has been obtained.

The fission reactions were of particular interest to the Dubna team since they can use the information in interpreting the data they record when manufacturing new heavy elements. An example is the fission of uranium 222 produced from an argon 40 ion and a tungsten 182 nucleus. The uranium isotope can fission into rubidium and cesium. Knowing the nuclear composition of the rubidium and cesium isotopes tells us how many neutrons 'evaporate' when the fission takes place. It is inferences on neutron evaporation which are used in the very heavy element search.

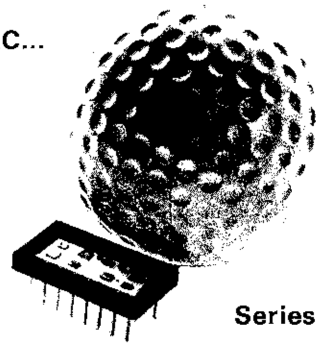
The collaboration has been fruitful for both parties and it is likely that they will get together again, perhaps when the 4 m cyclotron comes into action and opens the door to a new range of nuclear studies.

KEK
Frozen spin target

Hot (or cold) on the heels of the news of the successful operation of the frozen spin target at CERN, we have information from the National Laboratory for High Energy Physics (KEK) in Japan, where a frozen spin target is nearing completion. It is to be used for the direct measurement of scattering amplitudes of elastic and inelastic



Schematic diagram of the KEK frozen spin target in its horizontal configuration. (It can also be used vertically.) The coils are removed about 25 cm after polarizing the target, which is then accessible to the beam.



scattering up to large momentum transfers (the measurement of spin rotational parameters as well as polarization parameters) on the 10 GeV synchrotron now under construction. The target work is led by A. Masaike who invented the helium 3 cryostat for polarized targets.

In the KEK frozen spin target, protons and deuterons in organic materials are polarized in a magnetic field of 2.5 or 5 T with good homogeneity at about 0.3 K and are then used in a beam while at a lower temperature of 0.1 K and in a lower magnetic field. The spins of the proton and the deuteron can be kept polarized at such a low temperature for a long time. For example, the relaxation time of protons in propanediol is about two weeks at 0.1 K in 1.5 T and therefore, a field of 1.5 T with a homogeneity of 2×10^{-2} is adequate for holding the polarization. It is then comparatively easy to make such a magnetic field with a large access angle. Moreover, the lower magnetic field makes it easier to bring in the beam and to detect the scattered particles.

The frozen spin target at KEK is designed to be used in horizontal or vertical configurations. The target material is polarized in a solenoid coil giving a field of 2.5 T for the proton and 5 T for the deuteron in a horizontal dilution refrigerator. The polarizing coil, which is 35 cm long, is moved horizontally about 25 cm to free the target for the beam. The holding field is the fringe field of the polarizing coil plus a small auxiliary coil adjusted to give a homogeneous field at the target. This gives good access for studying scattering and the auxiliary holding coil can be changed to meet the requirements of different experiments.

A high power horizontal dilution refrigerator of He^3-He^4 and a horizontal superconducting solenoid coil were successfully operated in August. The precooler and the still of the refrigerator are larger versions of the cryostat built by T. Niinikoski for CERN (see vol. 11, p. 353). There is enough cooling power near 0.1 K for holding, and 0.3 K for polarizing, by means of special heat exchangers. The flow rate of He^3 is about 3×10^{-4} mol/s or higher at about 0.1 K and the cooling time from 1 K to 0.1 K is about 15 min. Detail of the cryostat design is to be published by K. Amako, S. Ishimoto, A. Masaike and K. Morimoto.

Have you heard of ERDA?

The US Atomic Energy Commission is becoming part of the Energy Research and Development Administration following legislation signed by the President in October. The high energy physics Laboratories will therefore now be administered by ERDA rather than the AEC.

ERDA has a broad charter to develop and improve energy sources and methods of using them. It has management of a five year budget of over $ 10 000 million for research and development on energy problems. ERDA is headed by Robert Seamans former Deputy Administrator of the National Aeronautical and Space Administration.

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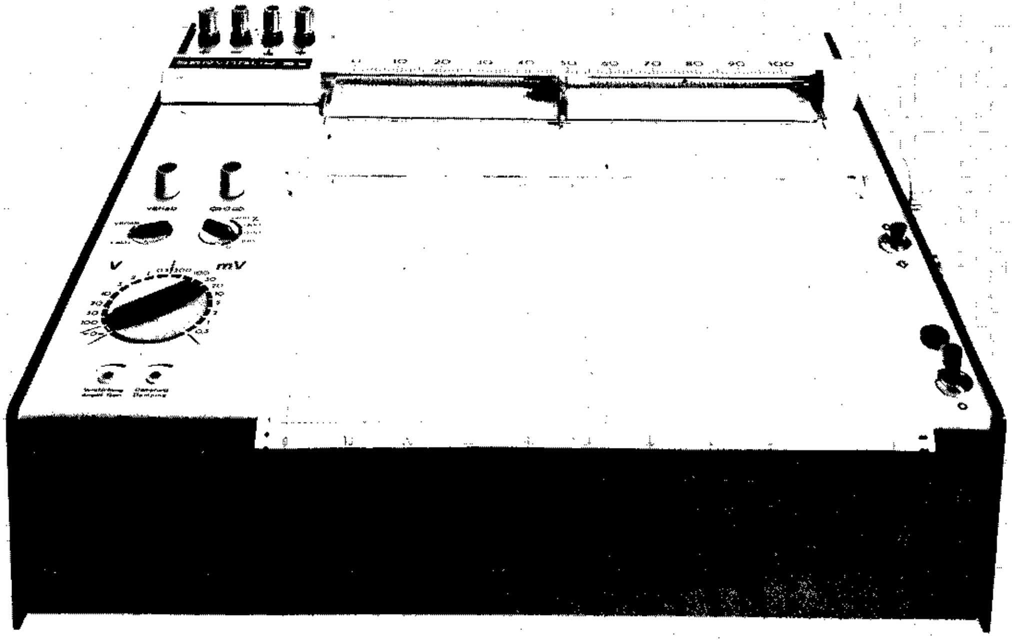

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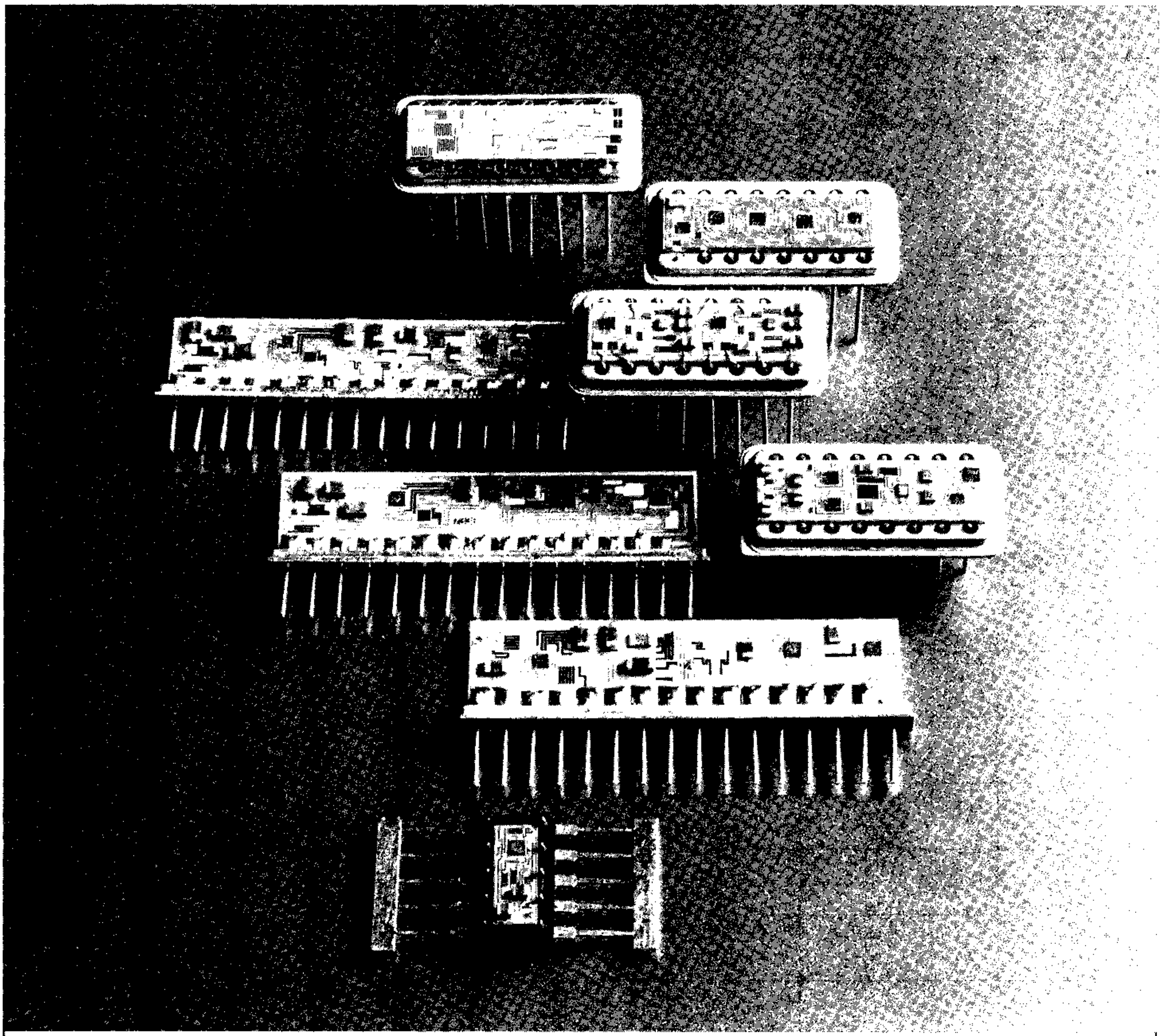

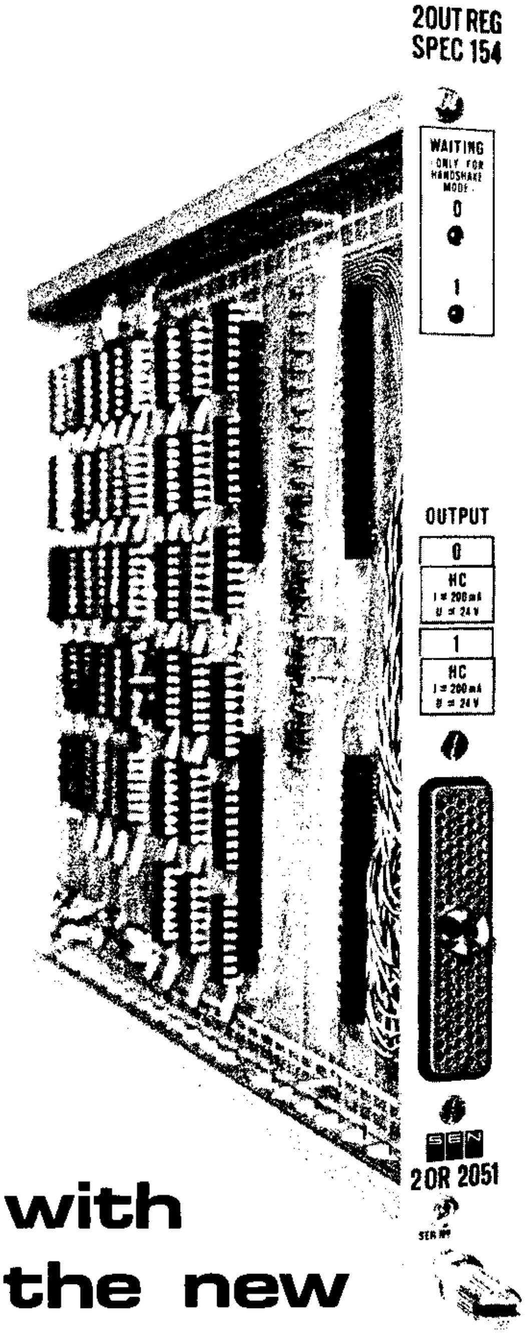
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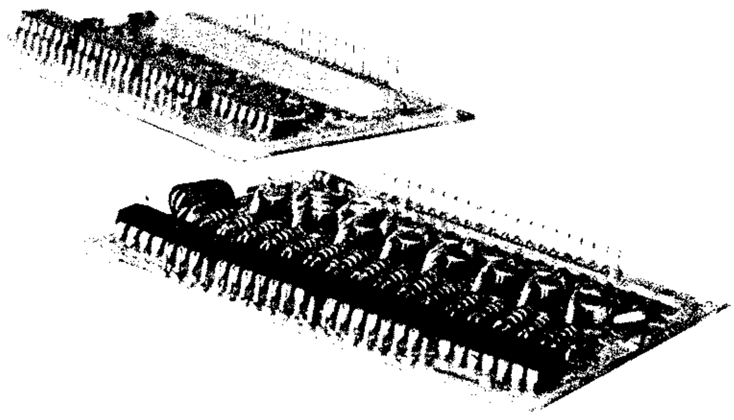


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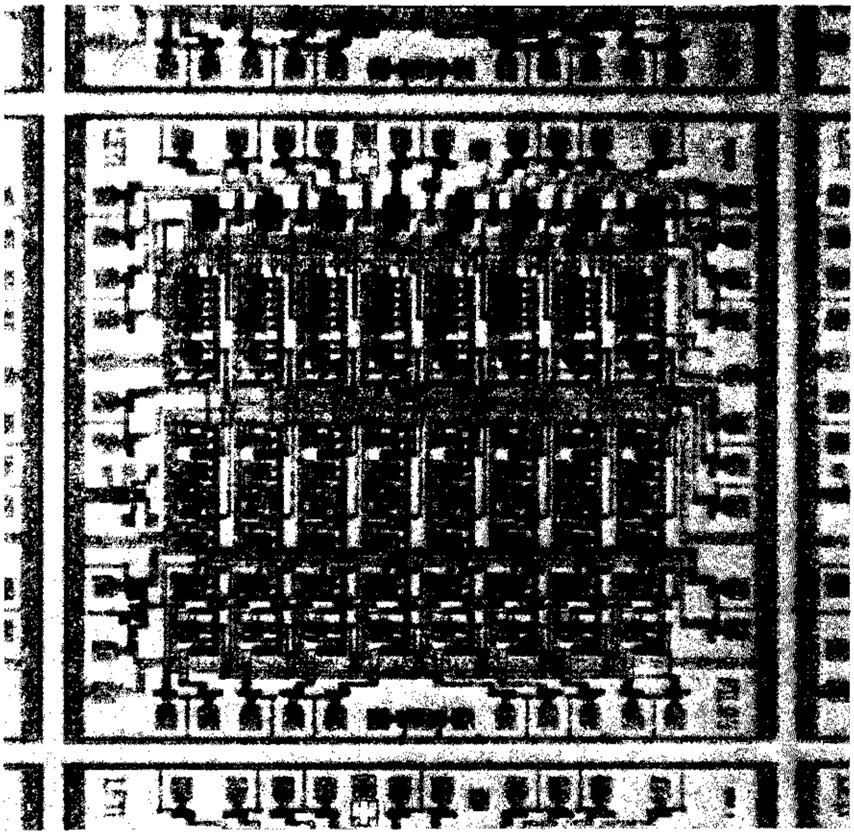

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- ☐ Samples available from stock – few months delay in 1000 quantity.

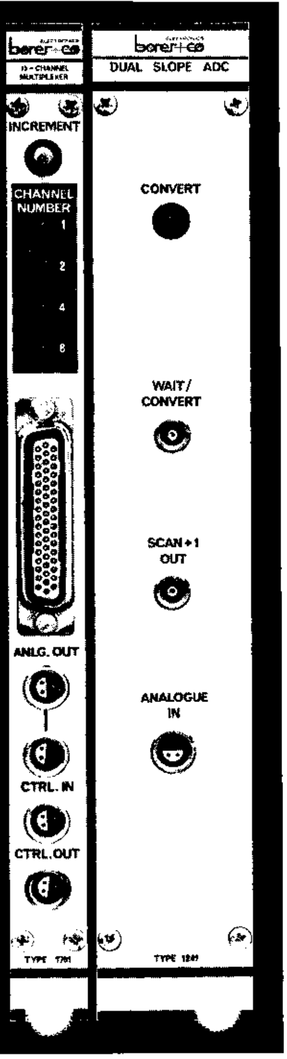
REFERENCES

CEN / SACLAY: Used on large MWPC' selectronic equipment.

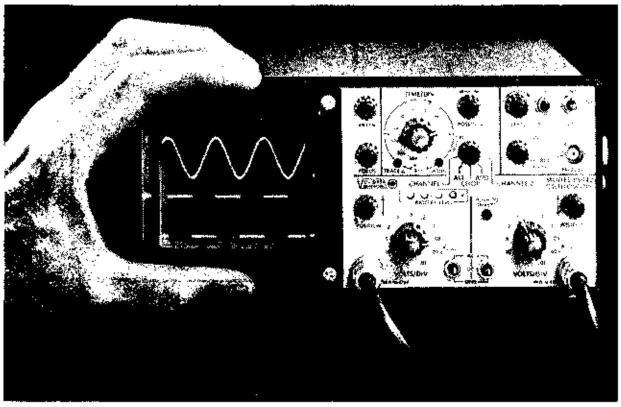
CERN (Geneva): On test.

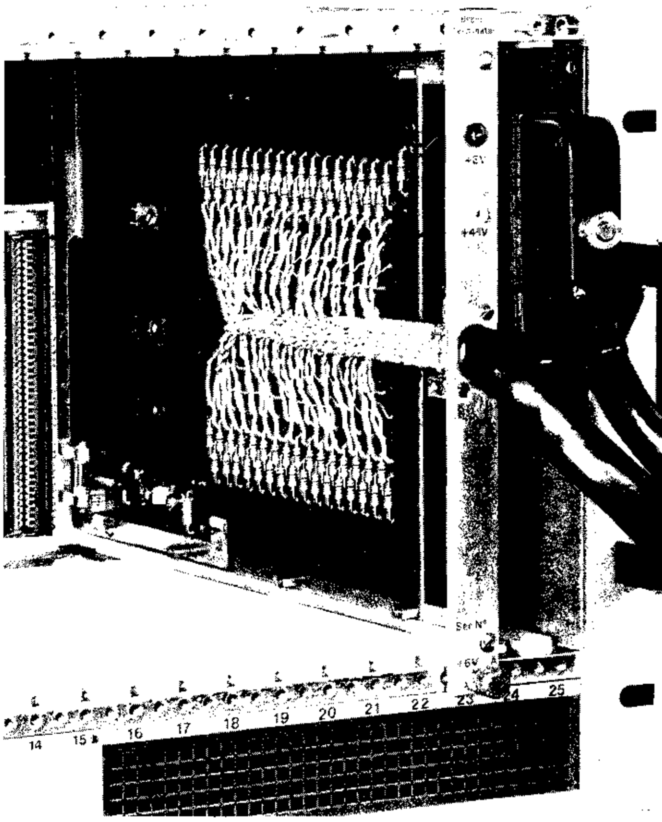
For data sheets, application reports, delay, prices or any information you may need for your particular application, write or call:

E.F.C.I.S. BP. 85, Centre de Tri 38041 GRENOBLE CEDEX (FRANCE)
Tel.: (76) 97 41 11 — Telex: ENERGAT GRENO 32 323



borer+co
15-CHANNEL MULTIPLEXER
INCREMENT
CHANNEL NUMBER
1
2
4
8
ANLG. OUT
CTRL. IN
CTRL. OUT
TYPE 1701
borer+co
DUAL SLOPE ADC
CONVERT
WAIT/ CONVERT
SCAN+1 OUT
ANALOGUE IN
TYPE 1241





+6V
+6V
Ser N°
14
15
16
17
18
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20
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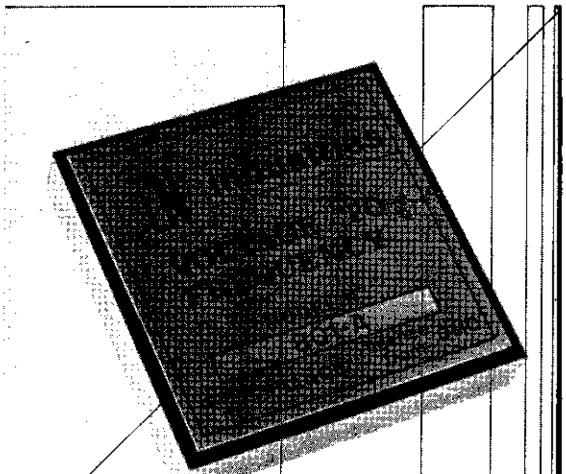
23
24
25



information Dewald Electronic

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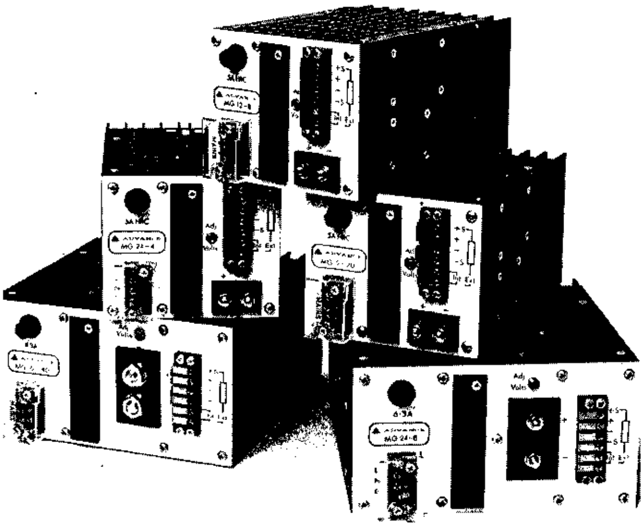
Reliable
Light weight
Small size
Many units working at CERN



5 V,	20/40/60 A
12 V.	8 A
15 V,	7/14 A
24 V,	4/ 8 A

Ripple 10 mV rms
Overload- and Overvoltage Protection
Efficiency > 70%
Series and Parallel Operation
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5V units from stock Zürich

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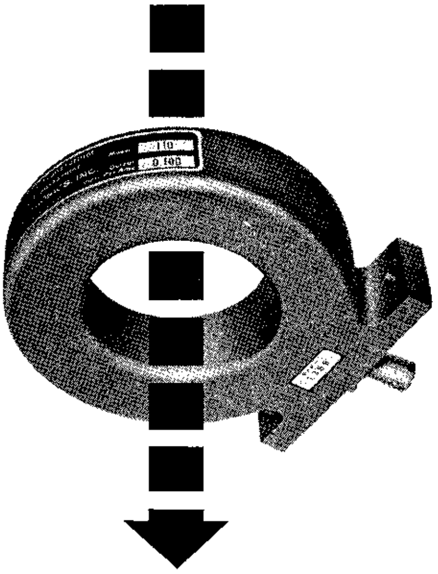
8038 Zürich Telex 52012



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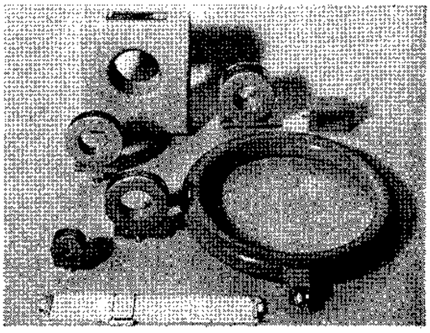

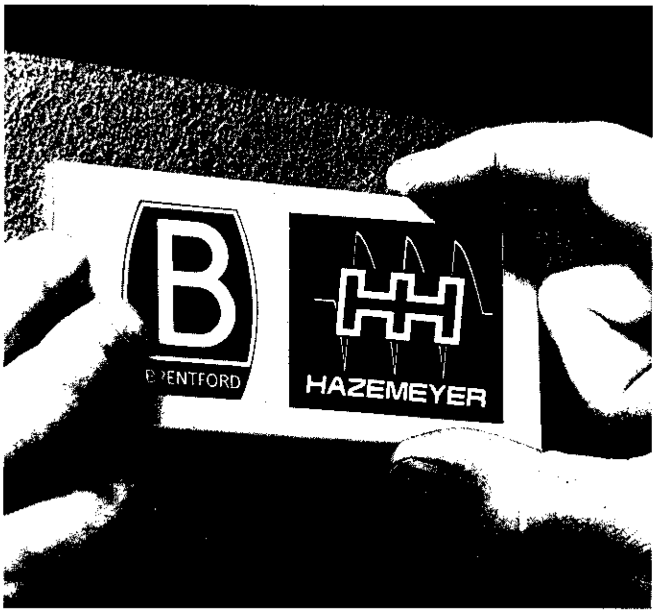

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England,
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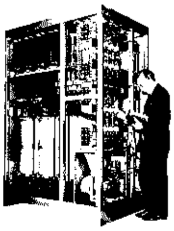
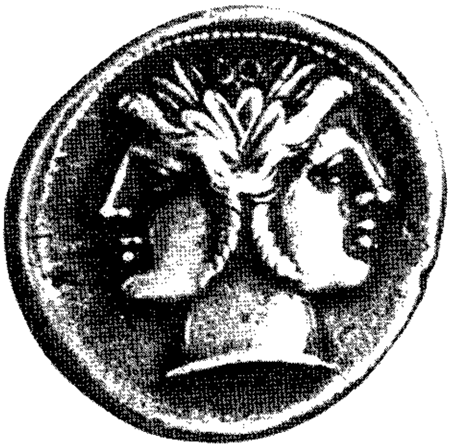
Telex 87252

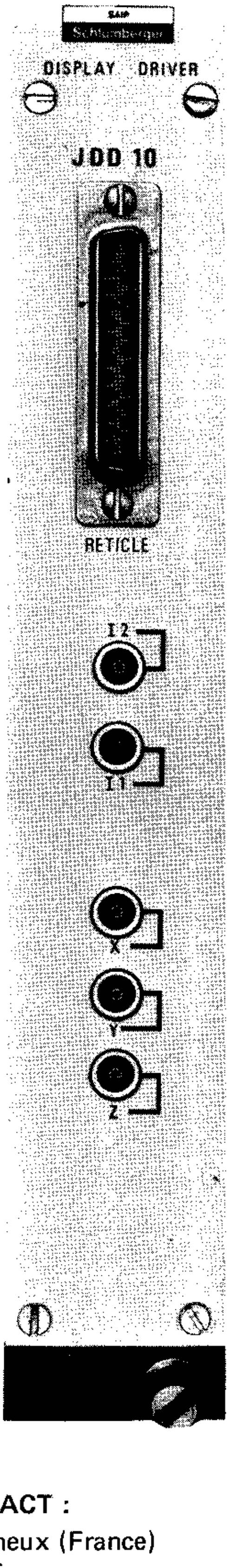


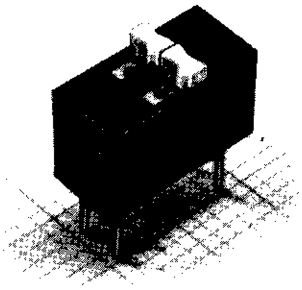
Hazemeyer

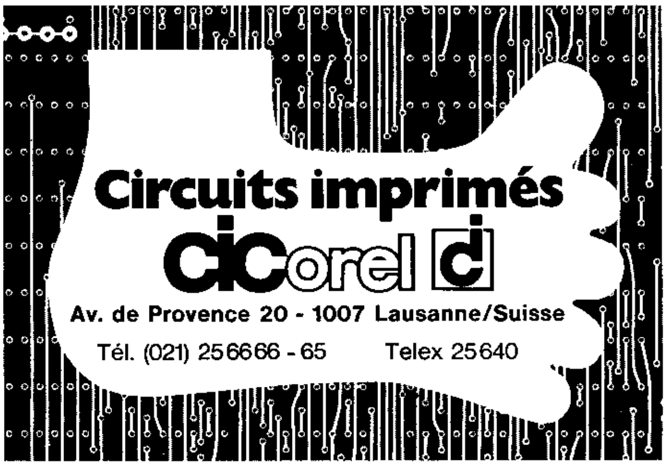
Hazemeyer B.V. RT - department
P.O. Box 23, Hengelo,
Holland,
Teleph. 05400 - 62723
Telex 44892

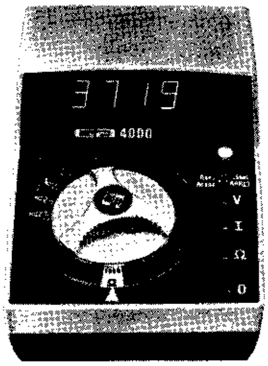
The power section of a 185 volt 1100 ampere Brentford/Hazemeyer highly stabilized DC power supply.




SAIP
Schlumberger
DISPLAY DRIVER
JDD 10
RETICLE
I 2
I 1
X
Y
Z

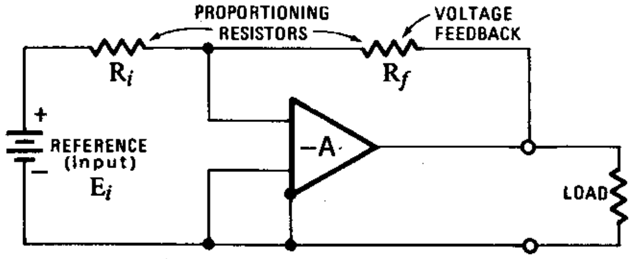





3719
4000
V
I
Ω
0

KEPCO INFORMATION

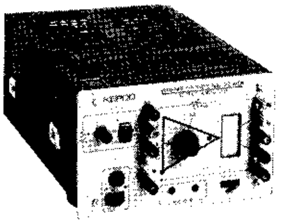
When is a Power Supply Not a Power Supply?



Power Operational Amplifier/Power Supply

- Bring feedback from current sensor and it will regulate current
- Bring voltage feedback and it will regulate voltage
- Bring feedback from your load and the power supply is a servo amp.

Bipolar Operational Power Supply



+ 15 V to – 15 V@20 amps
+ 36 V to – 36 V@1.5 amps
+ 36 V to – 36 V@5.0 amps
+ 72 V to – 72 V@1.5 amps
+ 72 V to – 72 V@5.0 amps

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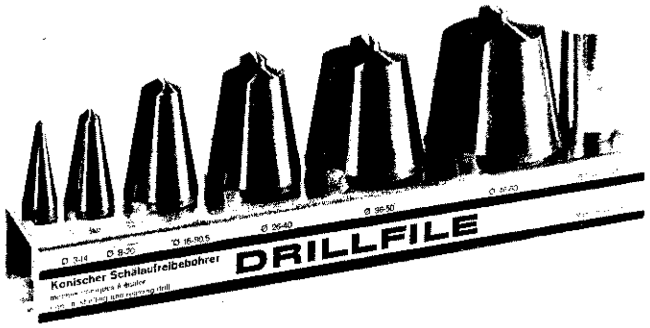
special drill



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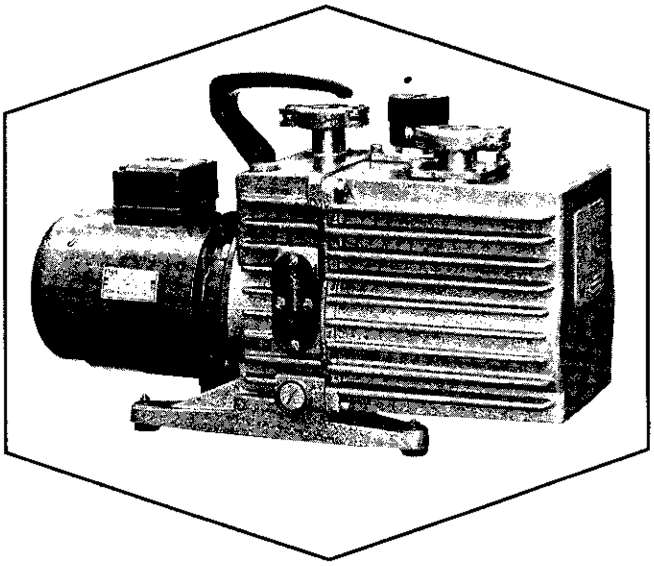

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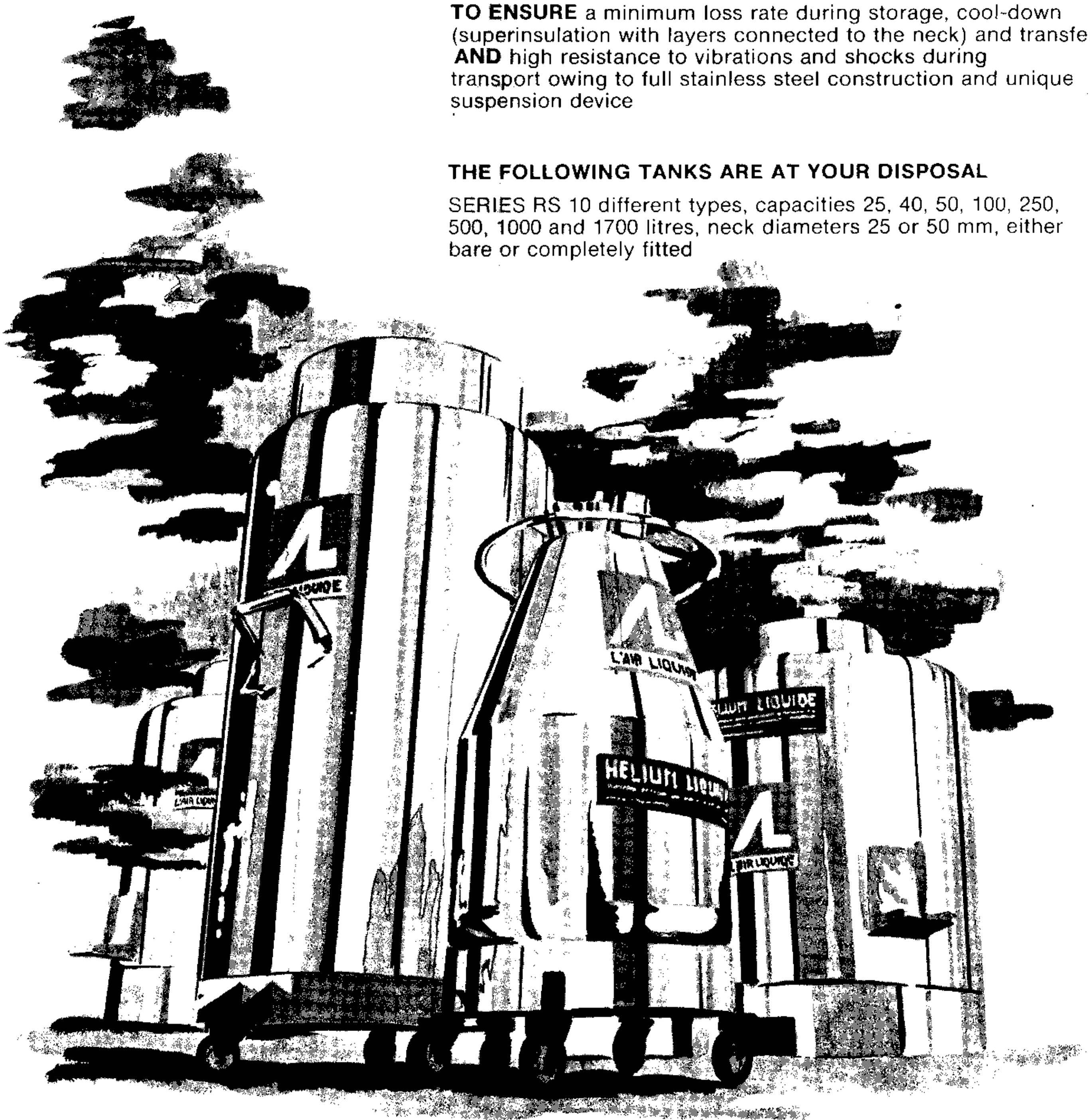

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NbTi High Field Superconductor

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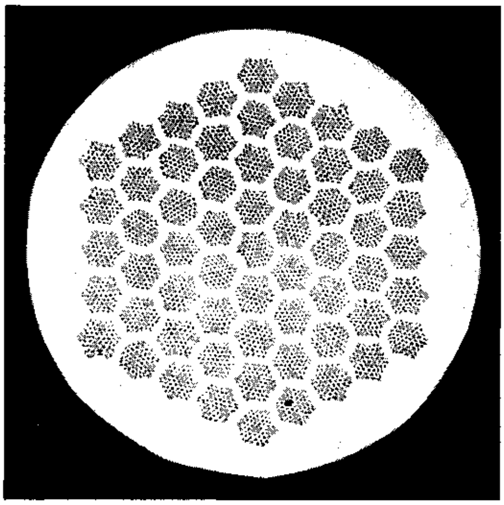

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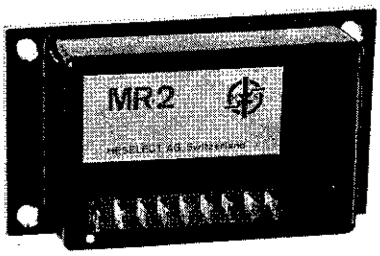

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MR 1 MR 2	2 to 7 V dc 7 to 33 V dc	Voltage adjustable by built-in cermet pot
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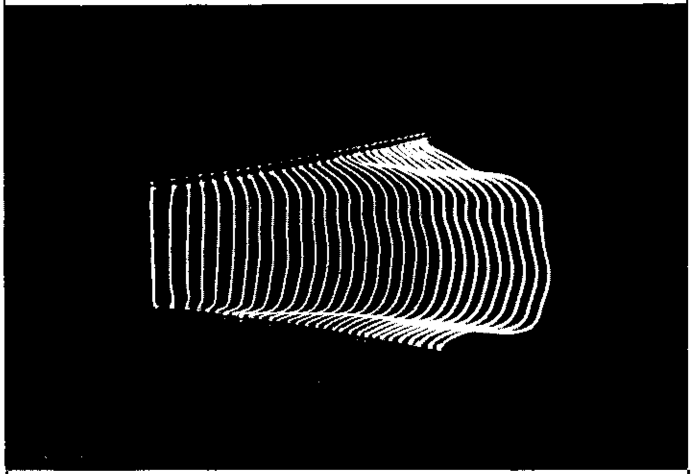

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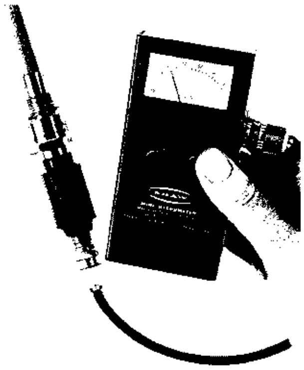

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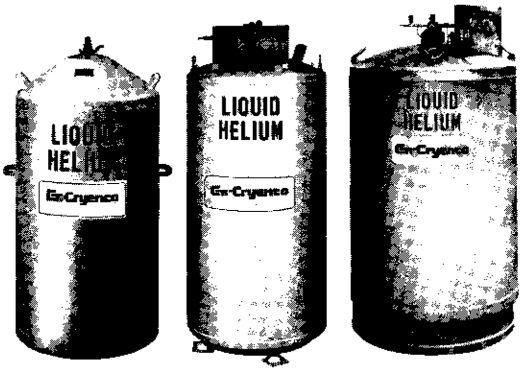
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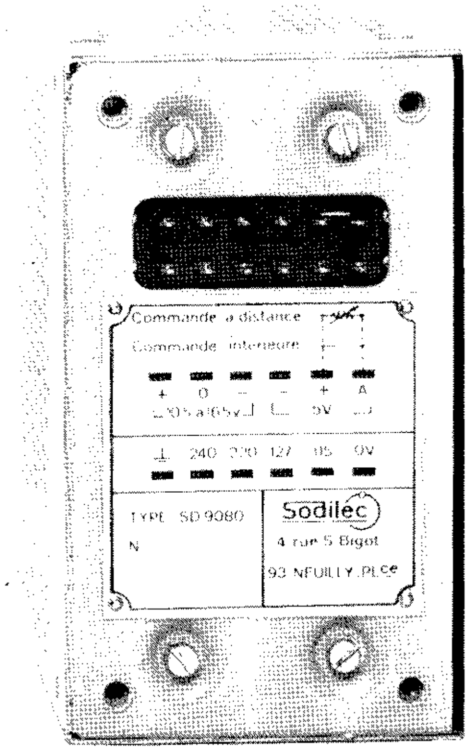
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+ 0 − − + A
10% à 16,5 V 5V
⊥ 240 220 127 115 0V
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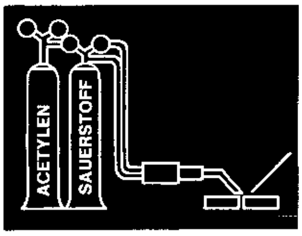
5 Procédés de soudage avec les gaz Carba



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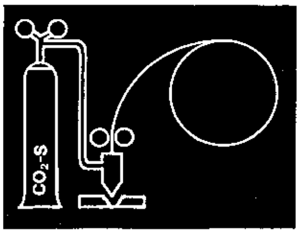
brasage, oxycoupage, chauffage, redressement, trempe, projection et décapage à la flamme.



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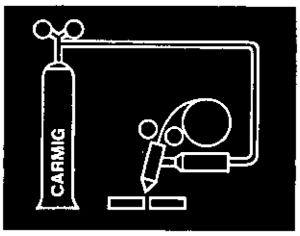
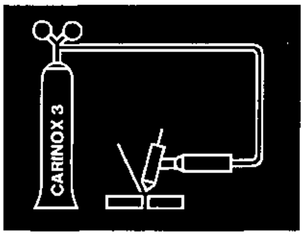
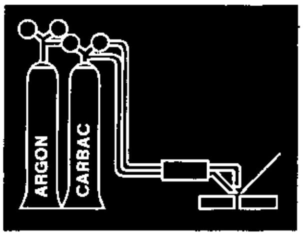


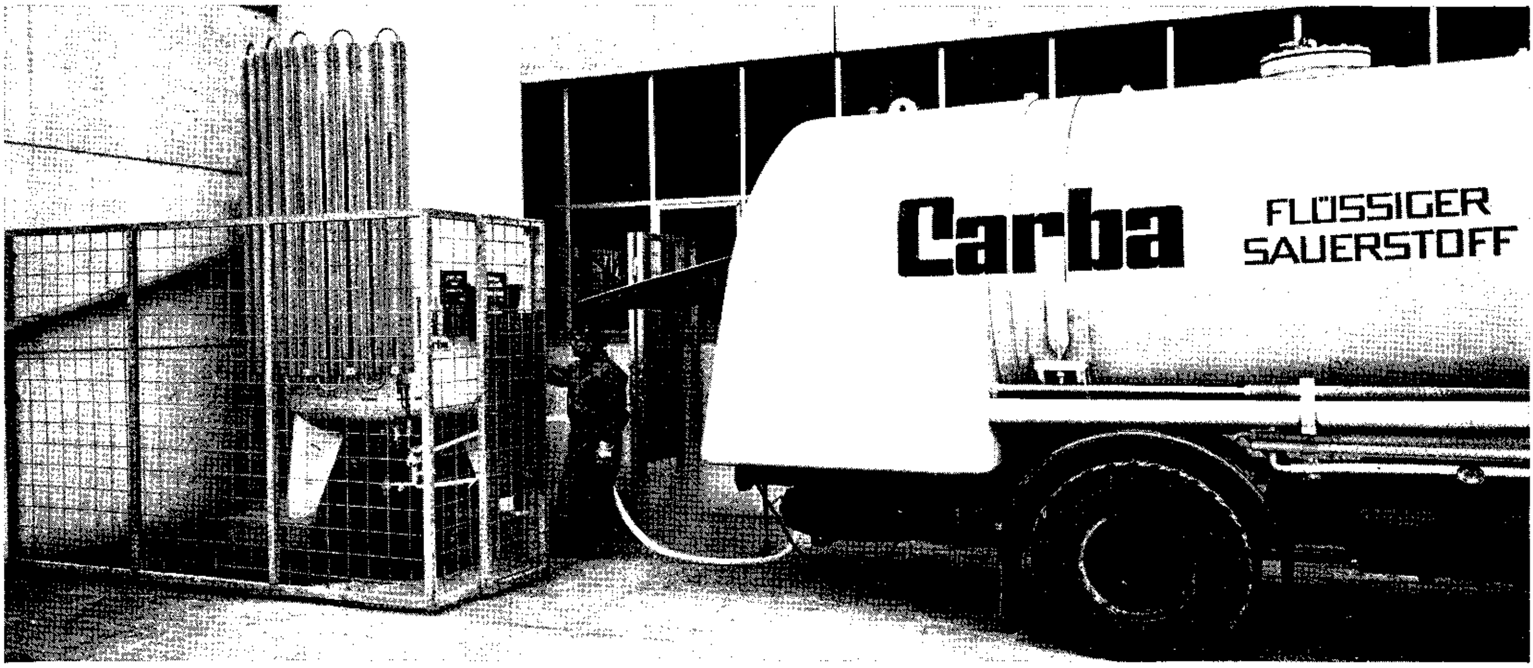
Soudage MIG
avec les mélanges Carba (Carmig, Carmox, Carinox 4, Carbac 30) l'argon et l'hélium pour: les aciers faiblement et fortement alliés, l'aluminium, le cuivre et leurs alliages.



Soudage TIG
avec l'argon, l'hélium, Carinox 3 et Carbac pour: l'aluminium et ses alliages, les aciers inoxydables de toutes compositions, les métaux cuivreux et à base de nickel, le titane et d'autres métaux spéciaux.



Techniques Plasma
Soudage, coupage, rechargement par projection
avec Carbac, l'argon et d'autres mélanges pour tous les métaux



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