CERN COURIER

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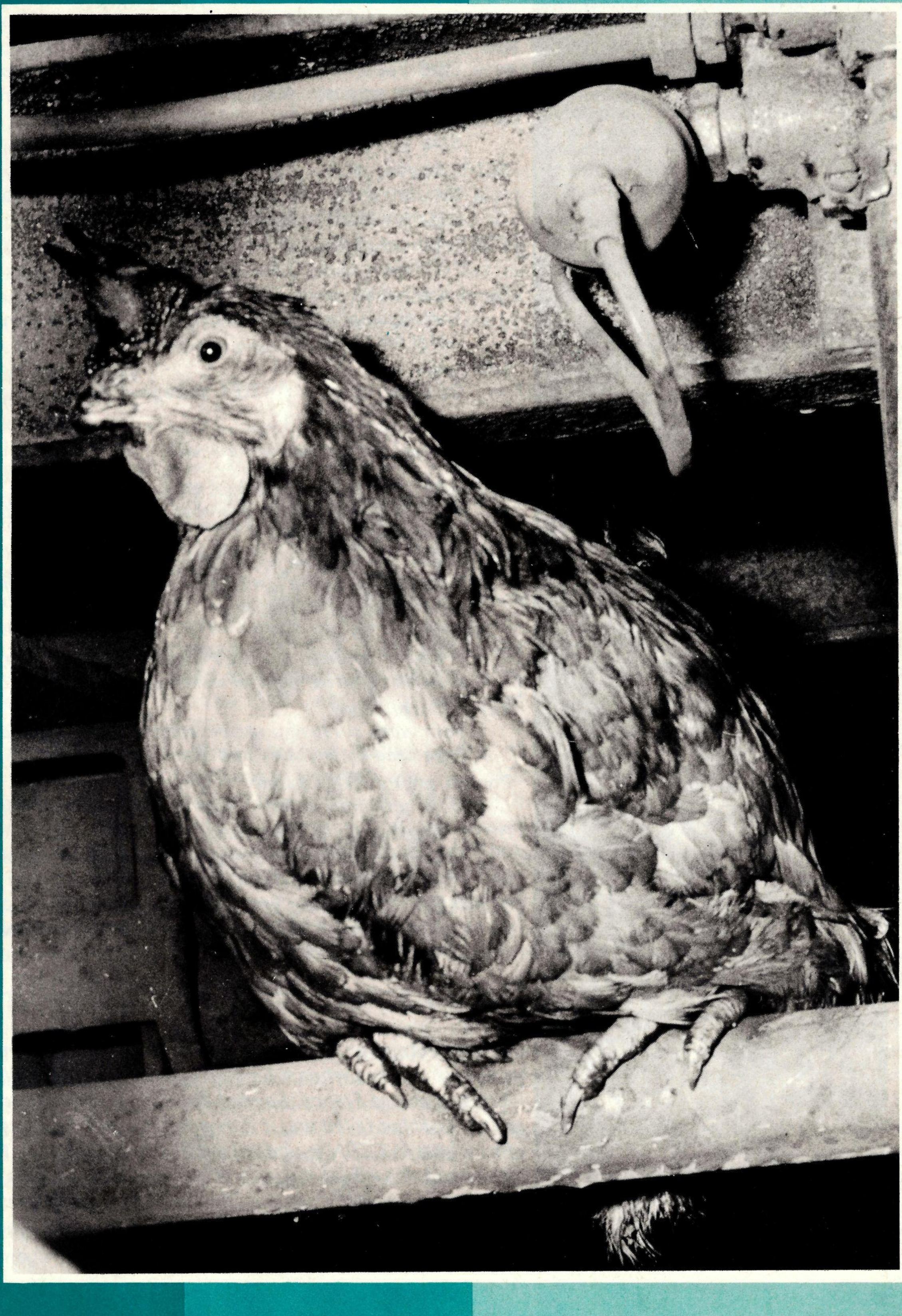

CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, 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 1100 Fellows and Scientific Associates. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 382.9 million Swiss francs in 1973.

CERN Laboratory II came into being in 1971. It is supported by eleven countries. A 'super proton synchrotron' (SPS), capable of a peak energy of 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 1973 is 188 million Swiss francs and the staff will total about 370 people by the end of the year.

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Editor: Brian Southworth
Assistant Editors: Henri-L. Felder
Michel Darbin
Advertisements: Micheline Falciola
Photographs: PIO photographic section

Public Information Office
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 41 98 11 Telex 2 36 98

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Cover photograph: This contented looking hen became attached to the SPS magnets at Arras when it jumped on to the lorry bringing half-cores from England across France. Several attempts by the driver to return the hen to its natural habitat failed and it duly arrived in the Laboratory II assembly hall. Its interest in CERN is understandable for, judging by the location that it jumped aboard (at the start of the autoroute to Paris), it is almost certainly a European hen raised in the Benelux for consumption in France. It left CERN later, on the same lorry, to take a look around Switzerland. (CERN 182.10.73)

Progress in construction of the SPS

Part I: Injection-Ejection, Magnets and Power Supplies

The SPS project, formally known as the 300 GeV Programme, is now deep into its third year. Practically all the big decisions, which determine its final form from among the many options left open in the initial presentation, have now been taken. The civil engineering work is well advanced and machine components are beginning to pour onto the site.

Individual happenings in the course of the project have been reported in CERN COURIER when they were topical but it now seems worthwhile to pull together a fairly full review of the construction progress. Since there is so much information to report at this stage, we will divide the review into two parts, like King Henry IV. This month we cover beam transfer, injection and ejection systems, magnet construction and the magnet power supplies. Next month we will turn to the radio-frequency system, the civil engineering work, the control system and the experimental areas.

First, a rapid outline of the project to inform new readers, and remind old readers, of the main features of the accelerators. The synchrotron is being built in a tunnel 2.2 km in diameter some tens of meters underground (predominantly in France) on the opposite side of the Geneva-St. Genis road from CERN Laboratory I. It will be fed at an energy of 10 GeV by the existing proton synchrotron in Laboratory I and will accelerate the protons further with a radio-frequency accelerating system operating at 200 MHz. About 750 bending magnets with a maximum field of 1.8 T will be installed in the ring and will be able to hold the protons up to a peak energy of 400 GeV. Ejection systems will eject protons from two of six long straight sections in the machine. One system will direct protons towards the existing West Hall in Laboratory I where the 3.7 m European bubble chamber and the Omega spectrometer provide a basis for two major detection systems. The second system will direct protons to a completely new experimental area, the North Area, where there is room to make full use of the peak energies available from the machine.

The project was approved in February 1971 and is to run for eight years. Following the construction and commissioning programme known as 'Schedule C', beams will be fed to experiments in the West Hall by the end of 1976 and to the North Area by early 1978.

The ins and outs

The 28 GeV proton synchrotron, PS, universal provender of high energy protons at CERN, is the injector for the SPS. Problem number one is to doctor the beam orbiting the PS which has a diameter of 0.2 km so as to produce a ribbon of beam which will wrap once around the circumference of the SPS with its diameter of 2.2 km.

The chosen technique is that of 'continuous transfer' (see vol. 12, page 203) whereby the PS beam is gradually peeled off during eleven turns to give the right length of ribbon for the SPS. This technique has been tested with very good results and components of the final system (bumpers, electrostatic septum, etc.) have been specified.

From the PS the ejected beam follows the beam transfer channel towards the ISR. About 200 m beyond the point where the protons can be deviated to one or other of the storage rings, a transfer tunnel known as TT10 dips underground towards the SPS. The design of this beam-line is complete. It uses six bending magnets originally foreseen for the ISR-West Hall link, which has not been built, and thirty quadrupoles being built by Smit (Netherlands).

The injection system is the inverse of an ejection system in a synchrotron. It does not have to handle very high energy beams since injection will be in the range from 10 to 14 GeV — an energy chosen to make maximum use of the repetition cycle capabilities of the PS while still being sufficiently high to clear the worst remanent field effects etc. in the SPS magnet ring. The injection kicker magnets are unusual in that they have to be powered for longer than normal so as to take the long ribbon of protons coming from the PS. A pulse length of 23 μs is needed rather than the 2 μs which is sufficient at the PS. A short prototype kicker and a full-scale pulse forming network have been successfully tested. Ferrite (for all the injection, ejection and beam dumping kickers) is on order from Philips (Netherlands) and thyratrons from English Electric Valve Co. (UK).

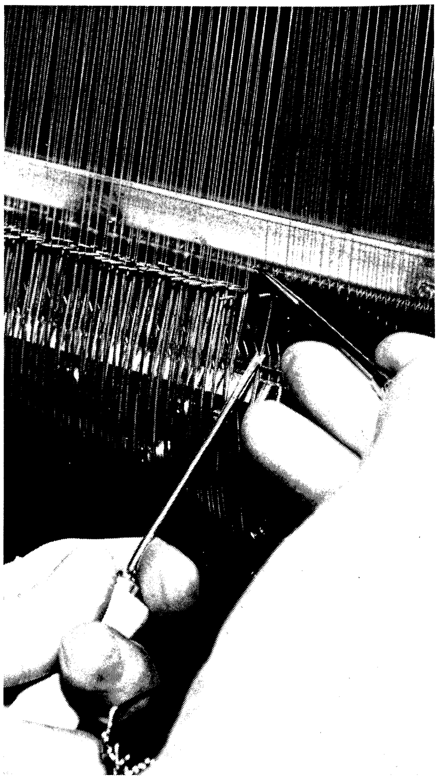
Once protons are in and accelerated to energies of hundreds of GeV, comes the most difficult of the accelerator technology problems — how to get the protons out of the ring to the experimental areas. Two ejection channels are to be built, one to serve the West Hall and one to serve the North Area. For the West Hall the experimental physicists have asked for fast bursts of particles a few microseconds long to supply the radio-frequency separated beam to BEBC, for bursts a few milliseconds long (called 'fast slow' ejection) which is the maximum BEBC can cope with while being just acceptable for counter experiments set up in association with BEBC, and for slow bursts of a second or more for counter experiments. For the North Area only the fast slow and the slow ejections are foreseen at present.

Equipment to implement integer, half integer and third integer resonance

An electrostatic septum with the septum consisting of thin molybdenum wires (0.1 mm thick, 1 mm pitch). Four of these, each 3 m long, are being built for the SPS.

On the right, wires for the electrostatic septum are being individually attached to springs so that if a wire breaks it will be pulled clear of the aperture where the proton beam is circulating.

CERN 399.10.73



CERN 392.10.73

ejection is being provided. Bumpers, quadrupoles, sextupoles and octupoles have all been ordered from Brown Boveri Co. (Switzerland). The electrostatic septum, whose performance is crucial for efficient ejection, and septum magnets are being developed and built at CERN.

The need is to bend the high energy beam out of the ring with as few protons as possible intercepted by matter. Electrostatic septa using thin molybdenum wires, about 0.1 mm thick and with a 1 mm pitch, provide the first slight deviation. Special construction techniques have been developed incorporating springs to stretch each wire individually and to pull it clear of the aperture should it break. There are four of these septa each 3 m long and they deflect the beam into the aperture of septum magnets with septa 4 mm thick. Prototypes have been tested satisfactorily up to current densities of 110 A/mm^2. Eight of these sit in pairs in four vacuum tanks and they deflect the beam into the apertures of further septum magnets with septa 16 mm thick. There are ten of these, again in pairs, in five vacuum tanks.

These ejection components will be among the 'hottest' regions of the machine from the point of view of radioactivity. For this reason a lot of attention has been given to methods of rapid replacement in case of failure. Quick release connections for the power and water cooling lines are being developed in association with the Mechanical Design Group and variants will be used also at the hot points in the experimental areas. Reference points on the vacuum tanks to line up with fixed points in the ring will speed installation and alignment.

The particle beams required for the West Hall involve the ejected beam being divided into four channels — one rises to the surface from the underground machine and is subdivided with splitter magnets in the West Hall onto three targets; a second is directed by means of pulsed switching magnets onto a target underground to provide the r.f. separated beam for BEBC; the third and fourth are derived from the second with further pulsed switching magnets and provide the wide-band and narrow-band neutrino beams. Adding the beams to the North Area gives a total of about a hundred quadrupoles and 80 bending magnets (of the type used in the ring) which will be installed in the beam transfer lines.

The sections of beam-line up to the switch magnets will use pulsed magnets. In this way they can easily handle beams of different energies on alternate cycles (for example, a 200 GeV beam to the West Hall for counter experiments followed by a 400 GeV beam for neutrino experiments with BEBC). It is also more economic in power costs to pulse the beam transfer magnets but not much more can be done to take advantage of this because of the limits on power swing during accelerator operation which is acceptable to the electricity company (EDF).

Another concern of the Beam Transfer Group, which it is studying in conjunction with the Experimental Areas Group, the Radiation Group and the Mechanical Design Group, is that of targets and beam dumps. This needs watching because an intense beam of very high energy and of small cross-section can locally heat a piece of metal to about a thousand degrees so that its yield stress is exceeded. However accurate calculations are difficult and some learning by experience will be needed as the beam intensity is gradually increased to its design value of 10^{13} protons per pulse. The energy stored in the circulating beam will then be 640 000 joules!

Of cores and coils

The design and construction techniques for the magnets of the SPS have obviously been greatly influenced by the scale of the project. Over a thousand magnets will populate the accelerator ring — 744 bending magnets, 216 quadrupole magnets and a variety of correction magnets (dipole, *Prototype septum magnets for ejection of the high energy beams from the SPS. There are a total of eighteen of these magnets (eight with 4 mm septa and ten with 16 mm septa) which will be installed in pairs in vacuum tanks. Note that to simplify access to the prototype its vacuum tank opens across the diagonal.*

sextupole, octupole). This requires simplicity in the design wherever possible so as to keep costs down and to ease the task of mass production in their assembly and testing.

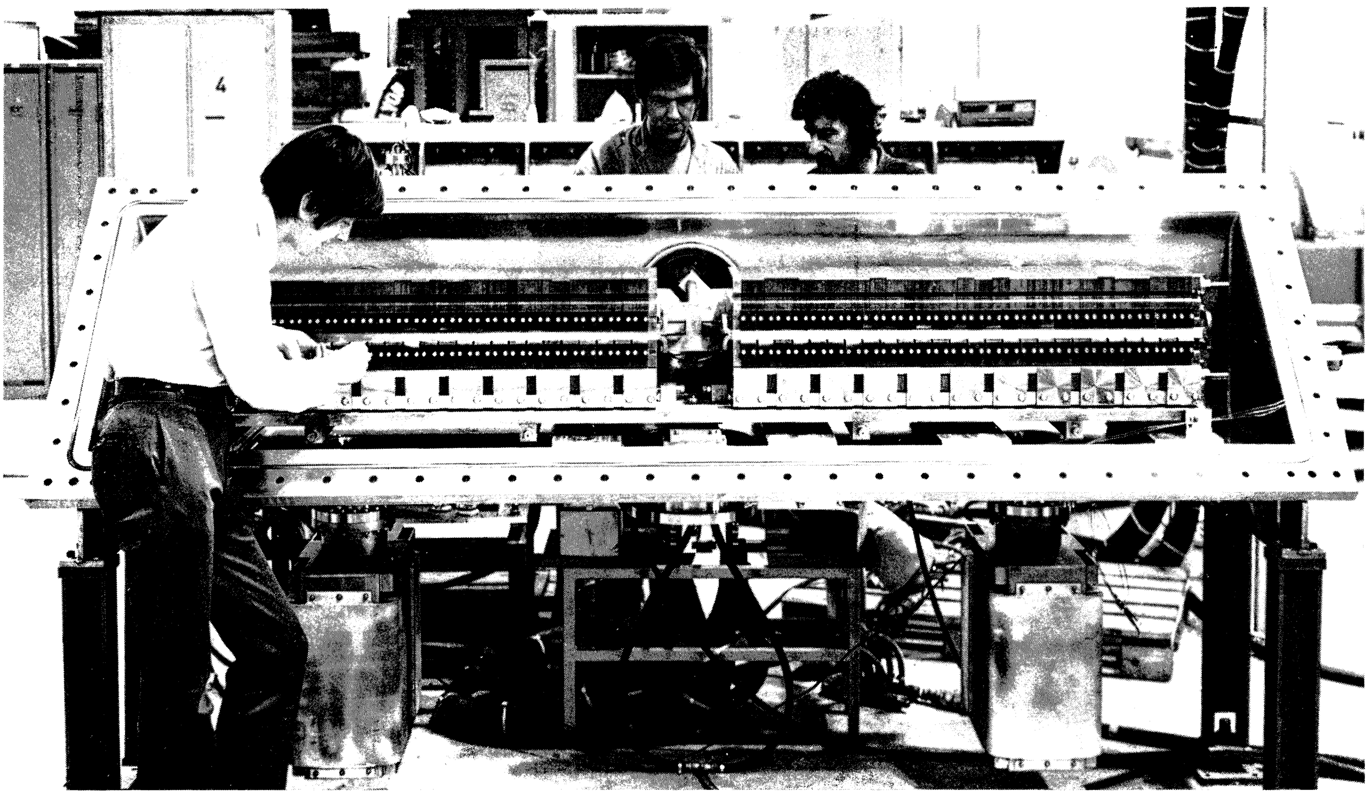
The bending magnets are of two types each 6.25 m long but varying in aperture — 39×129 mm^2 (MBA type) and 52×94 mm^2 (MBB type). Both types are being assembled and tested at CERN in a magnet factory which takes almost half of the huge assembly hall of Laboratory II.

The process begins with the supply of steel from Cockerill (Belgium). Collaboration between CERN and the steel manufacturer has been exceptionally good and the quality of the steel produced so far (with low coercivity and a small spread of properties between different batches) has been well within specification. 5000 tons have so far found their way to Morfax Ltd. (UK) for production of the bending magnet half-cores and another 2000 tons to the quadrupole manufacturer.

Half-cores are already arriving at CERN in quantity. The precision of the deliveries are matching the precision of the half-core stampings and both are giving full satisfaction. At the beginning of November 134 half-cores of the MBA type and 60 half-cores of the MBB type had been delivered. Coils for the MBA type are being manufactured at Alsthom S.A. (France) and for the MBB type at Lintott Engineering Ltd. (UK). These are the trickiest components of the magnets and both firms have had teething troubles which, hopefully, are now over with deliveries building up to four of each type of coil per week. At the beginning of November, 17 MBA and 21 MBB coils had been delivered.

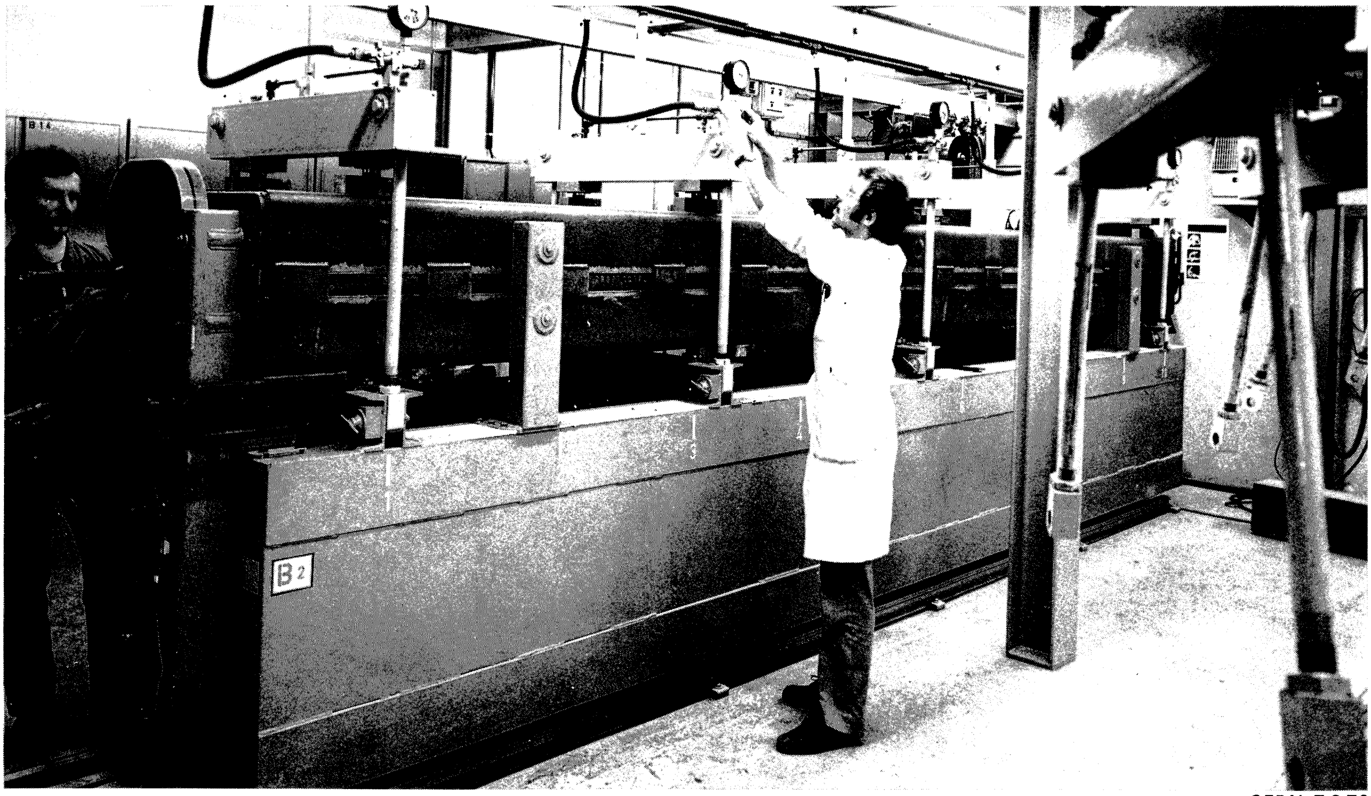
The first step in assembly is to check the mechanical dimensions of the components (the coils have already passed high voltage, pressure and water tests at the manufacturers). The coil is examined on a precision measuring bench which computes the shim thicknesses required along the coil so as to locate it accurately in the magnet core. The coil and vacuum vessel are put in place on the lower half-core, thin mylar insulation is introduced and the upper half-core then sits on top.

High current leads are passed through the aperture and when they are powered, they set up a magnetic field which pulls the half-cores together while tie plates are welded along the sides. Hydraulic clamps are attached to hold the magnet down onto the table. This gives the welded magnet a slight arc, being just over 3 mm higher in the centre. When the 6 m long magnet is later supported on feet at each end, the centre sags 3 mm by courtesy of the force of gravity and a straight magnet is thus



CERN 106.7.73

Assembly of a bending magnet. High current leads pass through the aperture and are powered to pull the two half-cores together while tie plates are welded in place. Hydraulic clamps hold the magnet firmly down onto the table. Two tables have been equipped for each type of magnet.



CERN 7.8.73

achieved. Two of these special welding tables have been built for each type of magnet.

The assembled magnet is then checked mechanically and the feet are welded on. Each foot block is machined so as to tidy up any misalignment in height or twist so that the magnet should be able to sit on presurveyed conical receiving points down in the tunnel with a minimum of further adjustment. The various alignment problems have been solved in collaboration with the Survey Group.

The important magnetic measurements are then carried out in a special test bay. For both MBA and MBB types, two banks of four stations can receive magnets for measurement. With this capacity it will be possible to be measuring some magnets while bringing in or taking out others, or modifying magnets after measurement. In between the two banks are the long, carefully wound, measuring coils which can slide into the magnet apertures on either side. The power supply can feed any bank of four magnets plus a reference magnet. The measurements are implemented and recorded via a PDP 11/20 computer using control systems evolved in collaboration with the Controls Group.

The measurements are intended to establish that the magnets will behave well throughout the current cycle to which they are submitted in the course of accelerator operation. This means that they must provide the required field accurate to better than 2×10^{-4} when powered from 118 A to 4900 A.

The integral of the field along the length of the magnet is the most important parameter. It is measured at injection field level by rolling the measuring coil through the full length of the aperture and recording the signals and at other field levels by pulsing the magnet with the coil stationary. End shims are used to bring all the magnets to the same value as the reference magnet at medium field values within 1×10^{-4}. The high field values are important since the closed orbit deviations at peak energies, when extraction has to be implemented, should be kept to a minimum. Variations are found at low fields, when injection takes place, due to remanent fields but the correction elements incorporated in the accelerator can take care of this. Eddy current effects are checked by varying the rate of current rise in the magnets while the measuring coils are in place. Resistors are incorporated in the circuit and these are modified to even out the variations which can come from differences in the thickness of the vacuum chamber from one magnet to another.

The quadrupoles do not require as much attention at CERN itself since they arrive completely assembled from the manufacturers — Plessey Precision Co. Ltd. (UK). They therefore need only mechanical and magnetic checking. Two completed quadrupoles had arrived at the beginning of November. A bank of four measuring stations is being set up and will use the same power supply and computer system as the bending magnets during the quadrupole tests.

The correction magnets are also being manufactured. Orbit correction dipoles are being made at Sindetec (France). Sextupoles are to be built at GEC (UK) and enlarged quadrupoles at BBC-Oerlikon (Switzerland). The order for octupoles is about to be placed.

A bending magnet is scheduled to be wheeled into the machine tunnel for the first time mid-1974. By then it is hoped to have a heap of 400 magnets (including the quadrupoles) assembled, tested and sorted according to measured properties, so that they can be distributed around the ring circumference to even out the small variations.

When everything is in full swing, eight bending magnets and about three quadrupoles per week will go through the system.

The power supplies

Almost all contracts for components of the magnet power supplies have now been placed. There are three main ones:

Work concerning the reactive power compensator has recently begun at General Electric Co. (UK). This equipment replaces the large motor-generator sets of the previous generation of accelerators in that it prevents large voltage surges, due to pulsing of the accelerator, appearing on the electricity network supplying the Laboratory. The pulses of current to the magnets can then be handled without perturbing other electricity users. The idea is comparatively new, but the electrical engineering involved is straightforward and, although the SPS compensator system is bigger than existing systems, no problems are foreseen.

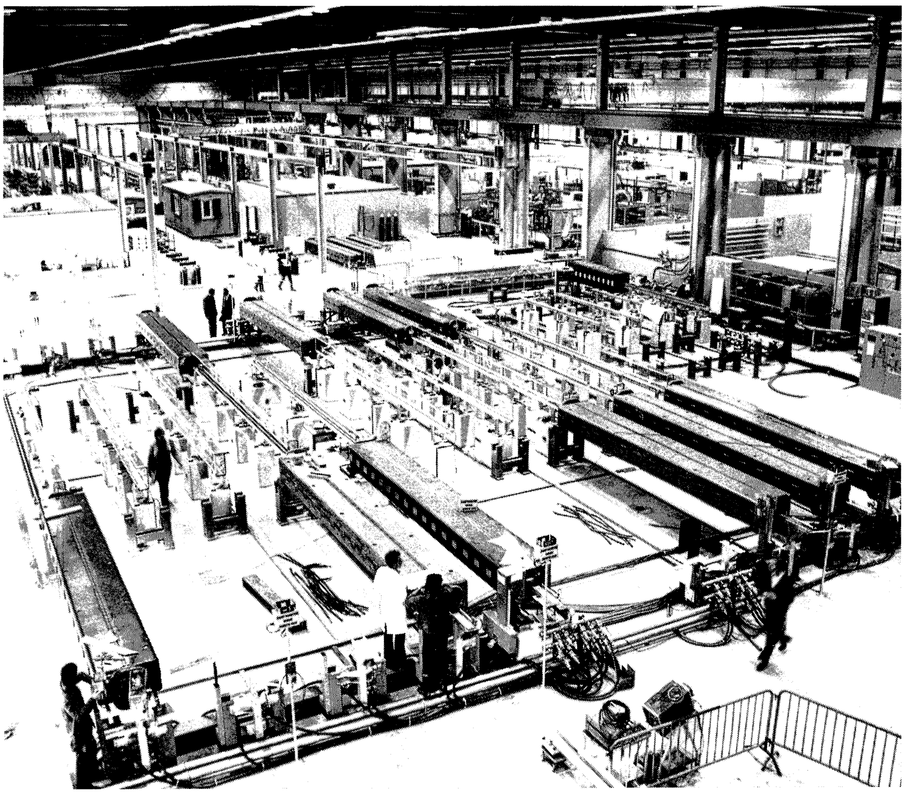
The second is that for the transformers, rectifiers and filters for the main magnet power supplies which are being built by Siemens (Federal Republic of Germany). Four of the fifty transformers arrived at CERN in November and production of the other equipment is expected to be on schedule.

The difficult requirement for the power supplies is to achieve voltage pulses of up to 2 kV with only a few hundred millivolt ripple. The low level electronics and the control circuitry to ensure such precision are being developed and built at CERN. Prototypes are already operating.

The controls will be concentrated in one of the computers of the SPS control network. This computer will be linked to twelve stations in series (each handling an acceptable voltage below 2 kV from the total of 24 kV which is required). Magnetic field measurements taken every 60 ms during a pulse will be fed to this computer so that the power supply programmes can be adjusted if necessary in readiness for the next pulse.

The third contract is for 172 auxiliary rectifiers (of 40 different types with powers varying from 13 kW to 1.9 MW) which are used as the power supplies to magnets in the main ring and the injection and ejection beamlines. They are being built by Brentford Electric/Smit (UK/Netherlands) who have just received the order.

Much more on the control system and other features of the machine next month.



The magnet measuring bay. The measuring coils are located in the central positions and can slide into magnet apertures on either side. Two banks of four stations, plus a reference magnet are being installed for each type of magnet. This capacity will cope with the maximum rate of magnet assembly which will be reached in the months to come.

CERN 390.9.73

CERN News

Schematic diagram showing the location of the new 50 MeV linac which will provide better quality, more intense beams for injection into the PS. It will be constructed in a separate building alongside the existing injector and its construction will not interfere with the normal operation of the synchrotron.

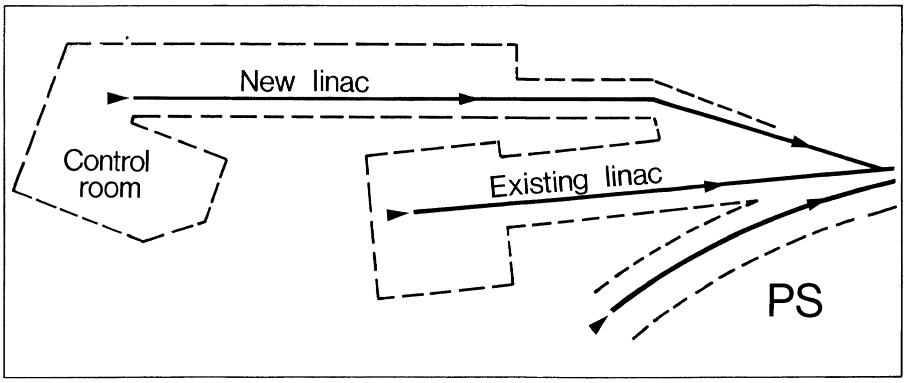
New linac for the PS

The days of the 50 MeV linac, which has been supplying protons to the 28 GeV proton synchrotron for the past thirteen years, are numbered. It has been decided to build a new linear accelerator to replace it.

The present linac was commissioned in 1958/59 and was then supplying pulses at an intensity of 10 mA for 10 μs (6×10^{11} ppp). Over the years, its performance has been continually improved making it possible for the beam intensity of the PS to be increased by two orders of magnitude. For injection into the PS (over one turn) the improvements related solely to increasing the linac intensity but when the 800 MeV booster was added (requiring injection over fifteen turns) the linac pulse duration also had to be increased. It now provides 50 mA pulses for 100 μs.

A considerable number of changes had to be made to obtain this performance, taking some components to their limits, and in these conditions, it has proved hard to maintain the stability and reproducibility of the linac beam at the high level required by the booster. Moreover, the reliability of the linac in general is becoming suspect — a problem of prime importance since the linear accelerator is the vital first stage of the whole complex formed by the booster, the PS, the ISR and (soon) the SPS.

In order to meet the demands of the years to come, it has become essential to build a new machine. It will be built close to the existing one and their axes are almost parallel. It is not feasible to replace the existing machine in the same building because that would require stopping the PS and, with it, the experimental programme of Laboratory I for at least nine months. Furthermore, the savings would not have been more than about 10 % of the cost of the machine.



The building programme is scheduled to span four years and the new linac will be commissioned in 1977. The output energy is unchanged at 50 MeV, since the booster was specially designed to accelerate beams of this energy, but it is to be built as a 'proton factory' providing pulses of up to 10^{14} particles with a view to reaching a high level of stability and reproducibility in regular operation at slightly lower intensities. In addition, it will be possible to adapt it, if the interest should arise, to the acceleration of negative hydrogen ions.

An essential feature of the new machine will be the wide freedom of choice in operating conditions and flexibility will be built in so as to be able to alter these conditions rapidly. Monitoring will mainly be carried out with the aid of a PDP 11/45 computer in the control room, located in a corner of the South Hall, which will allow the operating parameters to be checked and modified.

Though the energy of the linac beam is not changed, the energy of the pre-accelerator will be increased from 520 to 750 keV, taking the voltage supported by the accelerating columns of the existing Faraday cage to 750 kV (an increase of 50 %). The beam leaving the pre-accelerator is prepared for the linac proper by means of two bunchers and a third buncher near the linac will correct for any space charge effects. The beam quality will be monitored before it enters the linac by intensity and emittance measuring instruments.

The linac consists of three cylindrical resonant cavities made of copper-coated steel fed with power at 200 MHz. The first cavity takes protons to an energy of between 5 and 10 MeV (the final value has not yet been decided) and the two successive ones to 30 and 50 MeV.

The drift tubes along the axes of the cavities must be aligned to a high degree of accuracy and a laser beam will be used for this purpose. To ensure that the alignment is maintained during operation, the tubes, each containing a focusing quadrupole, will be maintained at a temperature of $21 \pm 0.5°$ by means of a closed circuit water cooling system.

It is possible, thanks to modern surface-treatment methods, to increase the maximum fields which the cavities can take above the traditional value of 15 MV m^{-1}. Nevertheless, in order to ensure that the machine is reliable, these fields will not exceed 14 MV m^{-1}. The average acceleration rate will be 1 MeV m^{-1} between 0.75 and 5 MeV and 1.55 MeV m^{-1} between 5 and 50 MeV.

The vacuum inside the cavities will be obtained by means of ion pumps with an output of 200 l s^{-1} per running metre and at least three turbomolecular pumps making it possible to obtain a vacuum better than 10^{-6} torr.

At a time when magnetic tapes are very much in the news here is a sight to give any judge a headache. This is just part of the stock of 40 000 tapes which has been moved to the new computer building at CERN. It also illustrates the problem of data storage which is one of the present headaches in the field of high energy physics.

CERN 246.9.73

The r.f. system is designed to obtain a high quality beam. Unlike the present linac, where a modification to an accelerating cavity involves modifications to the other two as well, the systems in each cavity are separate from the point of view of the r.f., each with its own control arrangement. This will allow the phase and level of the r.f. to be maintained within very close limits (better than 1 % for the amplitude and 1° for the phase).

The protons leaving the new linac will join the beam-line from the present machine. A beam measuring system will be installed at the output of the new linac making it possible to monitor the beam quality independently of the present linac. This system will include transverse and longitudinal emittance measurements.

With its operational flexibility and the quality of the beam which it will provide, the new linac should satisfy the foreseeable requirements for years to come. In spite of the decision to build a new one, the present linac has not yet been abandoned. Its performance should still improve and it is required to accelerate protons for another four years — 30 % of its total working life so far. Thereafter, it will be allowed to collapse into well-earned retirement.

Computers

After a running-in period which was expected to last about a year, the new central computer, the CDC 7600, can now handle more work than all the other computers at CERN put together. However, it is difficult to measure the work load of a computer, whose state of health can be compared to that of the economy of a country — a different opinion comes from each expert consulted.

A sector now giving cause for concern is that of magnetic tapes (mere coincidence). Difficulties arise in computing for high energy physics because they are so numerous and differ in format. The large quantity of tapes poses problems in machine operation because the mass of information they transmit can saturate the information transfer channels. The diversity of format, creates software problems, since each type has to be processed separately in a different way.

However, a solution seems to be gradually emerging and the use of magnetic discs will help to deal with the tape bottle-neck. At the end of October a third large capacity disc was connected to the 7600. It will be used to store the data from several tapes in frequent use and will considerably lighten the operators' task. Furthermore, the work load of the channel linking the tape units and the central memory is considerably reduced.

For the multi-computer move to the new computer centre (see vol. 13, page 257), the difficult stages are over and the last computer, the 6500, is now being brought into operation in its new home.

And one for sale

An SDS 920 computer, nine years old by now, is no longer needed at CERN and is for sale at a very low price. Old age strikes quickly in the world of computers!

It has a core memory of 8000 words, a typewriter, a paper tape reader and punch, two magnetic tape units and 16 priority interrupt levels. Its dotage may still be of use to someone, particularly in the field of education, and further details may be obtained from CERN, 1211 Geneva 23; telephone 41 98 11, extension 2180.

SCIP progress

In our October issue we published two topical photographs (page 299) concerning the improvement programme at the 600 MeV synchrocyclotron. This work colloquially known as SCIP — Synchro-Cyclotron Improvement Programme — is now well under way.

The machine came into action at CERN in 1957 and has supported a very lively series of experiments for fifteen years. During this time the needs of many of the experiments (and the abilities of machine technology to meet these needs) have developed to the point where a rejuvenation of the synchro-cyclotron has become necessary. The improvement programme was accepted in 1968 and its main aims are to increase the circulating current from 1.5 to 10 μA and the ejected beam from 5×10^{11} to 10^{13} protons per second. After a long

Welding, on 14 November, of the metal joint between the vacuum chamber and the pole piece of the synchro-cyclotron magnet.

CERN 46.11.73

period of preparation, installation work began in June 1973 and has reached the following stage:

The magnet has had a series of mechanical modifications which are now complete. A vertical hole has been drilled through the yoke and the pole pieces, to allow a new ion source to be introduced from below. New coils are mounted and the vacuum chamber is installed. For the previous chamber, O-rings were used to seal the vacuum chamber but were not very satisfactory. Flexible metal joints are therefore being used and their welding, which is now taking place, is one of the most delicate operations of the reassembly. First tests on the revamped magnet have taken place on schedule.

In parallel, work has been going on to replace almost all the cabling between the machine and the control room and also the cooling system. The new r.f. system, the most complicated item of the SCIP, is being run in and the second rotary condenser is expected at CERN soon.

At the beginning of January, magnetic field measurements will begin and field corrections will be applied. This will involve around ten weeks of work. In March 1974 the r.f. system and ion source will be installed and, if the present rate of progress is sustained, it is hoped that the rejuvenated SC will be tested in May and June.

CERN School of Physics

The 1974 CERN School of Physics is being organized together with the Daresbury Laboratory and will take place at Cartmel Fell, Windermere, United Kingdom, from 16 to 29 June. The basic aim of the School is to teach various aspects of theoretical high energy physics to young experimental physicists from the CERN Member States although some non-Member State, participants will also be accepted.

The Programme is devoted to electromagnetic and weak interactions and courses will be given on — Phenomenology of weak interactions by C. Jarlskog, CERN, with K. Kleinknecht, University of Dortmund, as discussion leader; Deep inelastic processes by P. Landshoff, University of Cambridge, with A. Hey, CERN, as discussion leader; e^+e^- by R. Gatto, University of Rome, with K. Schilling, University of Bielefeld, as discussion leader and Unified theories by J.S. Bell, CERN, with M. Veltman, University of Utrecht, as discussion leader. There will also be some additional lectures on special topics and reviews of the experimental programmes of some of the major physics Laboratories.

Further information may be obtained from Miss D.A. Caton, Scientific Conference Secretariat, CERN, CH-1211 Geneva 23, Switzerland.

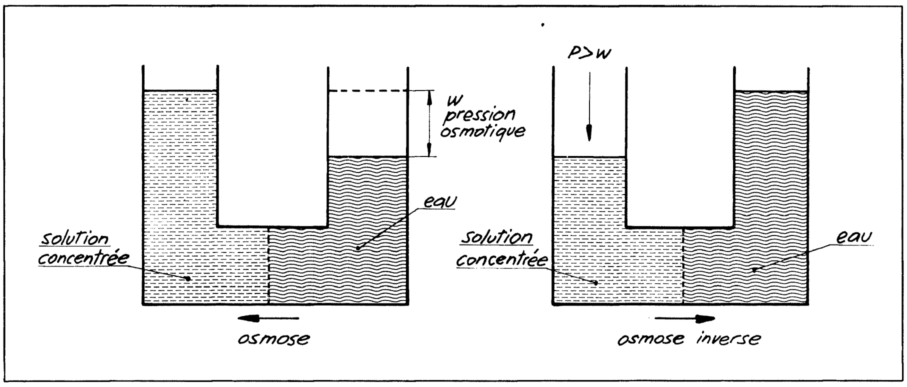
Demineralised water on tap

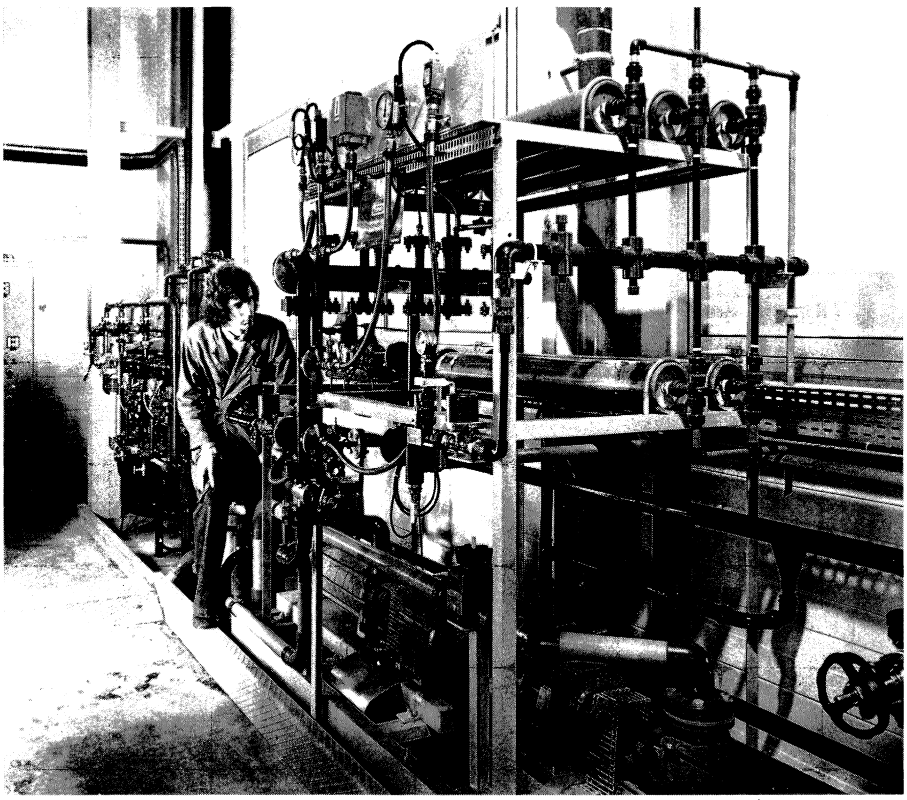
Laboratory II is using a new method to demineralising the water for cleaning components to be used in the SPS vacuum system. This method makes use of the principle of reverse osmosis.

When two liquids are separated by a porous membrane, water passes by osmosis from the more dilute to the more concentrated solution. The difference in level after osmosis corresponds to the osmotic pressure. In the reverse direction, if a higher pressure than the osmotic pressure is applied to the more concentrated solution, water will pass towards the more dilute solution. This is used at Laboratory II for the primary demineralisation of water

Principle of reverse osmosis. On the left is the well-known osmosis sequence where water passes through a membrane into a concentrated solution with an osmotic pressure W. On the right is shown how applying a pressure P, greater than W, persuades water to pass from the concentrated solution. This is to be used at the SPS as a step towards achieving demineralized water.

The demineralized water plant which uses the principle of reverse osmosis. The control panel and water softening units are at the rear. In the foreground is the pump which raises the pressure to 28 bars and the reverse osmosis takes place in the five cylinders above.





CERN 3.11.73

before it passes to a secondary exchanger which produces water of high resistivity.

Although the principle has been known for a long time (through the work of Abbé Nollet in 1748), its application to the demineralisation of water has been fraught with difficulties because of the quality of the membranes used. The latest type of aromatic polyamide membranes are compatible with solutions with a pH from 4 to 11, while cellulose acetate types, for example, are compatible with solutions with a pH of 4 to 6 only and water has then to be acidified before being treated by osmosis. The purpose of acidification is to prevent the deposition of calcium salts on the membranes but it also increases the ionic strength of the solution. With aromatic polyamide membranes, however, a simple softening treatment is sufficient. (It should be remembered that softening water consists in replacing the Ca^{++} ions by Na^{+} ions, without the addition of any chemical product.)

The reverse osmosis method has considerable advantages over the chemical ion-exchange methods so far used:

– less maintenance is needed, involving merely the annual cleaning of the membrane, whereas the ion exchange columns required periodic regeneration;

– the water flow-rate is constant if the pressure on the solution is kept constant;

– there is no need to treat the waste water since it is subject to no chemical action;

– the cost price of each cubic metre of water has proved to be almost half that for water obtained by ion exchange.

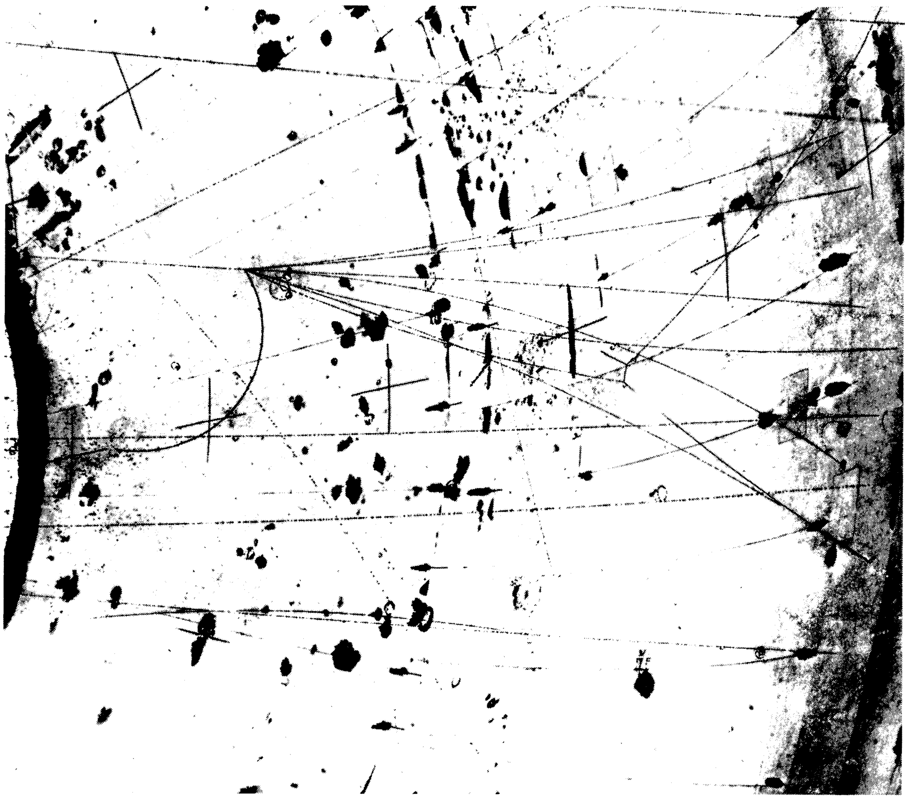
The Laboratory II installation comprises five reverse osmosis units, four of which are in operation, the fifth being kept in reserve. After the water has been used for cleaning components, it is fed back into the demineralisation circuit, which is thus closed. The flow-rate is 1.5 m^3/hour. Some of this water is also used to cool SPS magnets.

Reverse osmosis is going up in the popularity stakes. It is used in industry for desalinating sea-water. It is recommended for concentrating sugar solutions (in the sugar-beet industry) and it is becoming more and more popular for purifying hospital effluents, since the osmotic membranes retain microbes.

Late news (15 November): For the Gargamelle neutrino experiment, the booster is in operation and, over the first eighteen hours has resulted in an average accelerated beam intensity of 5×10^{12} protons per pulse — about three times the usual beam intensity. Details next month.

Around the Laboratories

Photograph taken in the 15 foot bubble chamber during a test run on 22 October. The incoming beam was of high energy pions. This particular picture was with the magnet field at about 1 T. The part of the black circle on the left is the location of the piston.



BATAVIA
First tracks in 15 foot chamber

As we reported briefly in the last issue, on 29 September photographs of charged particle tracks were taken in the 15 foot bubble chamber at the National Accelerator Laboratory for the first time.

The bubble chamber project began in the summer of 1970 and absorbed ideas from the designs of large chambers at other Laboratories (Argonne, Brookhaven, CERN and Stanford) in order to speed construction and to bring the chamber into operation as quickly as possible. The final design was described in vol. 11, page 358.

The chamber contains 30 000 litres of liquid in an almost spherical vessel with a length along the beam direction of 15 foot. It will be able to operate with hydrogen, deuterium or neon (or mixtures). A superconducting magnet provides a field of 3 T at the centre of the chamber. The expansion system operates from below and can produce the necessary pressure swing once every second (so that several pictures can be taken on each accelerator cycle). Six cameras are installed on top of the chamber and can operate in two groups of three for separate experiments.

The superconducting magnet was operated up to peak field about a year ago but operation of the chamber was delayed due to problems with the plastic piston. As a result, a metal piston has been installed as a temporary measure. A similar measure was taken with the 3.7 m European chamber, BEBC, where fortunately it has proved possible to have quite high fields in the chamber without running into eddy current heating problems with the metal piston.

In July of this year the 15 foot systems began to come together again for another try at chamber operation. The hydrogen circuits were then checked and, in August, the expansion operated successfully though not linked to the other systems. In September the chamber was brought on very quickly. Filling with hydrogen while checking all the safety circuits took only eleven hours. The expansion was carefully brought into action, increasing the piston stroke gradually. As soon as the necessary calculated pressure swing was reached, tracks appeared in the hydrogen.

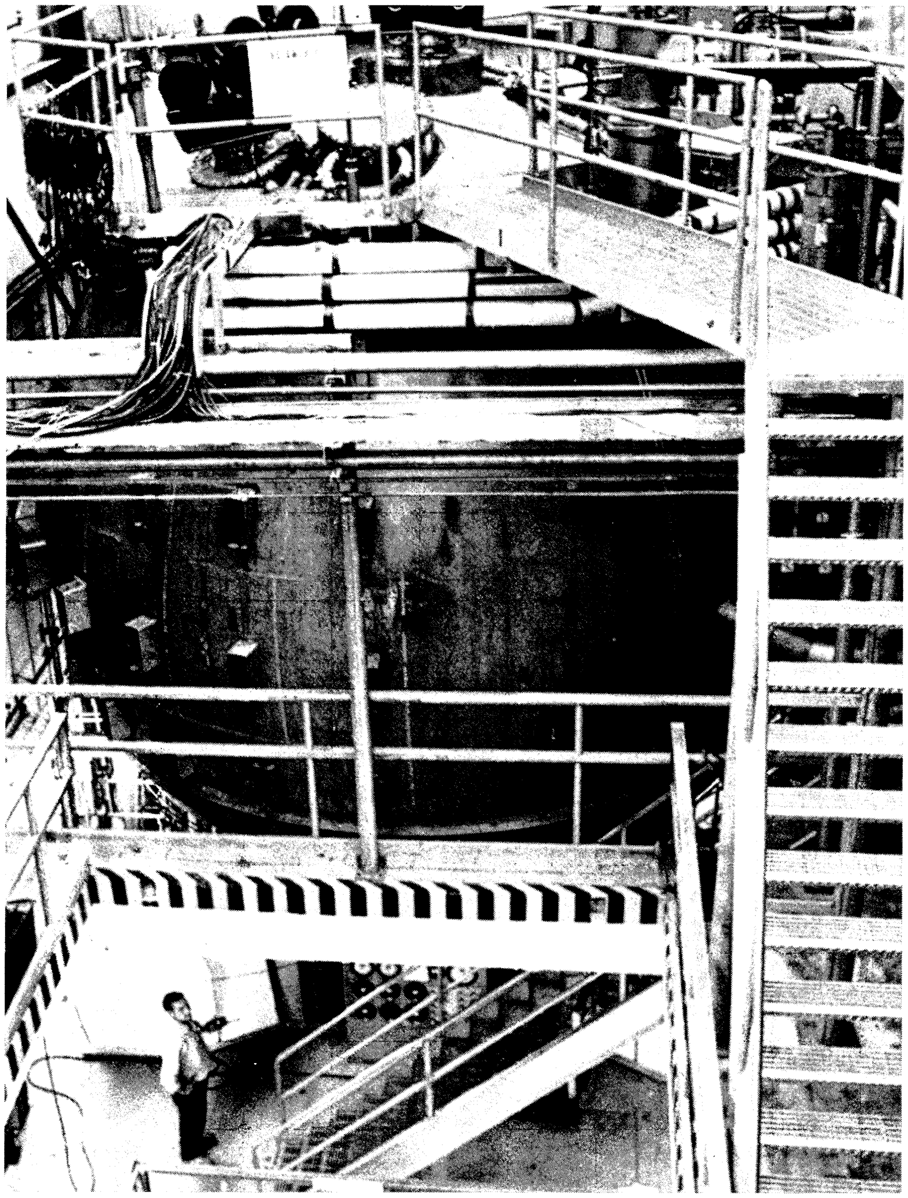
No magnetic field was applied during this first test to simplify the operating procedures but the superconducting magnet was brought on during October and track curvature resulted. The magnet was again powered to its design current of 5000 A, corresponding to 3 T field, but there is some evidence of expansion system problems (possibly due to eddy currents in the metal piston) at currents above 4000 A. Some pictures were taken with a 50 GeV negative pion beam into the chamber. The magnet was then operating with only 1500 A because of difficulties with the camera system which have since been cleared.

The bubble chamber team are very happy. There are a series of minor things to tidy up, obviously, in the light of the operating experience in October but all the important aspects of the operation of the bubble chamber are going well and it is hoped that its experimental programme can start soon. Two years worth of experiments are already lined up with a strong levening of neutrino experiments. With nice timing, the neutrino horn was successfully tested on 22 September, taking 150 kA currents very rapidly after being switched on, so that more intense neutrino beams are now available for experiments with the 15 foot chamber.

The large spherical vacuum tank containing the 15 foot bubble chamber which has been brought into operation at Batavia. The mass of surrounding equipment includes supplies for the superconducting magnet, the camera systems (viewing from on top of the chamber) and the expansion system (below).

Inside the bubble chamber control room during the period of first operation. Pictures were achieved for the first time on 29 September.

(Photos NAL)



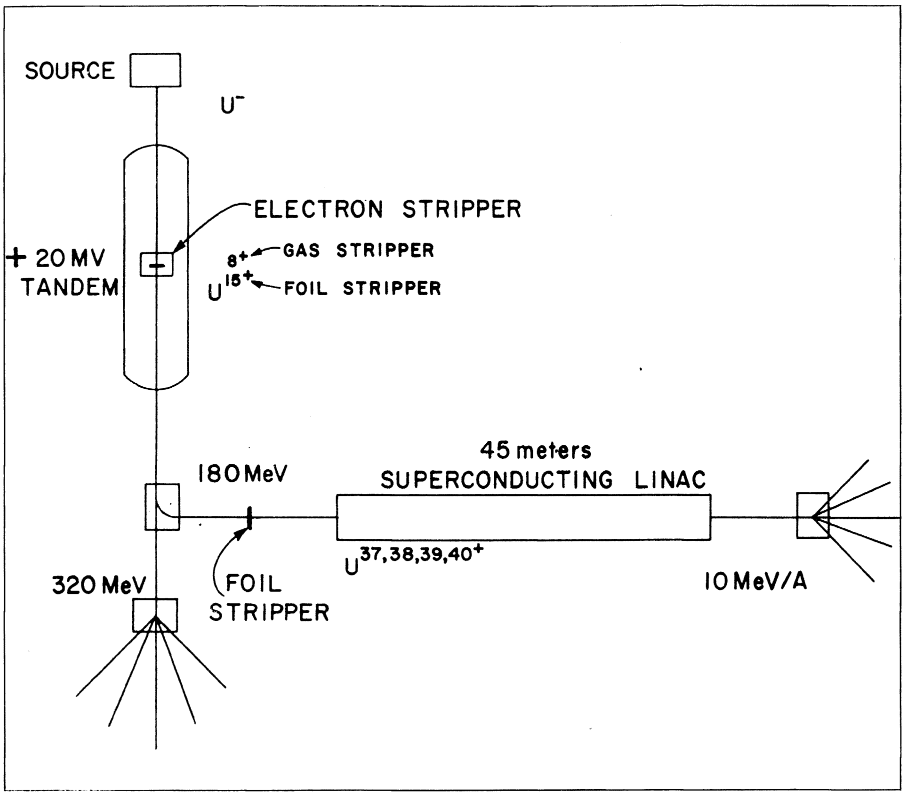
ARGONNE: Heavy ions from superconducting linac

The Argonne National Laboratory has put forward a proposal for the construction of an accelerator system to yield high energy heavy ions. There are many variants of heavy ion accelerators under study and the Argonne design has concentrated on achieving high quality beams of precisely known momenta and of variable energy through to a peak energy of 10 MeV per nucleon. This is seen as a national facility for research in atomic, nuclear and solid state physics and for isotope production.

The system includes a tandem Van de Graaff, with 20 MV on the centre terminal, using the pelletron design of National Electrostatics Corporation. Beams from the Van de Graaff could be used directly or further accelerated in a superconducting linear accelerator to as high as 10 MeV per nucleon. The superconducting linac was selected in preference to a conventional linac (expensive to build and to operate) and to a cyclotron because of very encouraging progress with superconducting r.f. structures at Argonne.

The linac design consists of a series of helix type resonators (in five half-wave-length or three half-wave-length sections) mounted in pairs in separate cryostats. The superconducting helices are of anodised niobium and should experience surface electrical fields of less than 20 MV/m and magnetic fields of less than 0.1 T.

Focusing is achieved by interspersing superconducting quadrupoles with the resonators. The total electrical length is 45 m. The resonators operate at 75 MHz and the r.f. power dissipation is foreseen as below 0.2 kW. Cooling is achieved by a refrigerator with a capacity of 600 W at 4.2 K.



Proposed scheme for heavy ion acceleration at Argonne. A tandem Van de Graaff would be supplemented by a superconducting linac and prototype helices for such a linac have been successfully operated.

The technological problem is to achieve the high performance which in principle is possible with superconducting niobium. Thanks particularly to the work at Stanford and at Karlsruhe, the main difficulties have been identified as — to achieve superconducting surfaces of high quality and to prevent vibrations of the helical structure.

At Argonne the helix is composed of hollow niobium tubing through which superfluid helium circulates. The external surface of the tubing is anodized with a protective coating of Nb_2O_5, 400 angstroms thick. Such helices show no deterioration of r.f. properties during extended runs at full power even after being exposed to air for hours. Also, helixes can be reproduced in quantity with the same properties.

The vibration problem is serious because it causes the resonant frequency to change, which makes it virtually impossible to accelerate through a series of resonators strung together. By minimising externally induced vibrations and by an electronic control technique which modulates the resonant frequency so as to keep the average frequency constant, it is hoped to overcome this problem.

Two prototype helices have been built and successfully operated to accelerate heavy ions from a small Van de Graaff. The design of a multiple helix system has begun. It will incorporate the two helices already operated plus a large resonator containing several half-wave-length sections. This will enable the surface treatment technique to be checked in the production of a much larger structure and also to check vibration control in a resonator with higher stored energy.

DARESBURY Making light

Research using the synchrotron light emerging from electron accelerators or storage rings has grown considerably in scale and importance during the past few years. A review of the major facilities appeared in the April issue of last year (page 130). In the USA the work has concentrated particularly at the Wisconsin storage ring, Tantalus. An improved version, Tantalus II, has not received support however and neither did the idea of developing the Cambridge accelerator as a national synchrotron radiation facility. Instead the wave-length range covered by higher energies will be made available at the Stanford storage ring, SPEAR. In Europe, the DESY synchrotron has done much of the pioneering (to be extended on the storage ring DORIS) and has been joined by facilities at Frascati, Orsay and at Daresbury.

The research at Daresbury now involves about forty scientists from Universities and other Laboratories with experiments in metallurgy, atomic spectroscopy, molecular biology, glass fluorescence, etc... On the two beam ports from the 5 GeV electron synchrotron, NINA, six experiments are installed and collect data parasitically during the operation of the accelerator for high energy physics.

The future high energy programme in the UK foresees the gradual phasing out of NINA. With this in view, the question of how to sustain the research of the developing synchrotron radiation community was discussed at Daresbury. The possibility of continuing to use NINA itself was considered but a much better source can be provided by a storage ring. An alternative use for NINA is as injector in the EPIC project (of which more next month). A storage ring specifically built as a synchrotron radiation source, SRS, is therefore being proposed.

With a tailor-made source the parameters can be adapted to give as high a radiation flux as possible (for this a stored current of 1 A will be the ultimate aim) covering the wave-length range of greatest interest (for this a 2 GeV ring with a critical wave-length of 3.9 angstroms will give good flux down to 1 angstrom).

The proposed machine has an average radius of 15 m. The bending magnets curve the beam around a radius of 5.5 m with fields of 1.2 T and are distributed around the ring interspersed with quadrupole and sextupole magnets. The bending magnets are C-shaped, to ease the problem of getting the synchrotron radiation out easily, with an aperture preliminarily fixed at 150×60 mm².

The energy loss from such a ring is 240 keV per turn per electron and

Location of a 2 GeV, high current storage ring for experiments using synchrotron radiation which is being proposed by the Daresbury Laboratory. The storage ring would be located within the inner hall of the NINA electron synchrotron and have many beam ports for the synchrotron light outlets.

four r.f. cavities are installed to replace the power, having the capability of a peak voltage of 600 kV per turn (installed power of 400 kW).

At least ten beam ports are foreseen for the emerging light and at two of them, shorter wave-lengths are made available by incorporating 'wigglers'. The wiggler idea came from Wisconsin where a version is now being tried on Tantalus. As its name suggests, it involves additional magnetic fields which locally distort the path of the electron beam. The radius of the wiggler so introduced dictates the wave-length spectrum of the light emerging at that point. Rutherford have studied a superconducting version of a wiggler for the Daresbury SRS. At the moment superconducting magnets giving a 5 T central field (about 7 T at the magnet coils) are regarded as feasible. This could give good radiation flux down to about 0.1 angstrom.

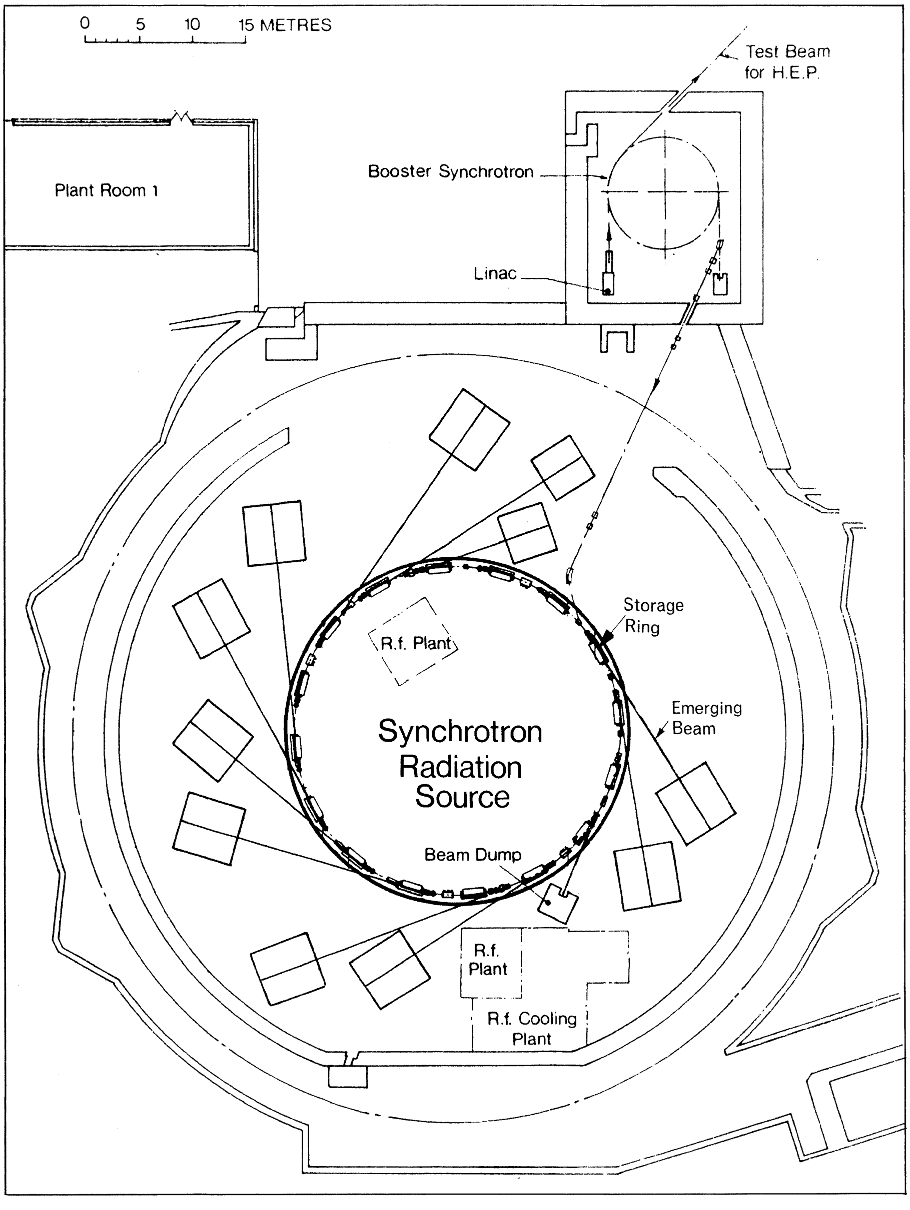
The electron beams are provided by a 500 MeV synchrotron, itself fed by a 8 MeV electron linac. The synchrotron is required to provide 20 mA beams probably about three times per second.

The SRS would fit into the existing NINA building and could use many of the NINA supplies. Taking this into consideration the cost of the project is estimated at £ 2 million. Since the accelerator physics involved is well understood a 'paper study' is considered adequate to confirm this figure without prototype models. The superconducting wiggler is a challenging aspect but could be added at a later date if it took longer to realize than the rest of the machine.

It is hoped that authorization for the project could come in 1975. Building could begin in the NINA inner hall before the accelerator was closed down and the SRS could be ready at the end of 1978. Since the physics covered by a synchrotron radiation facility is in different fields to high energy physics, approval for the project will be sought from the Science Board rather than the Nuclear Physics Board of the Science Research Council.

If the SRS is authorized it will obviously alter the balance of activities at Daresbury considerably by the 1980s. It would join the Nuclear Structure Facility — the tandem Van de Graaff described in the May issue (page 150) — which expects the 'go-ahead' very soon.

Nevertheless high energy physics is retained as an important part of the future of the Laboratory. Within the UK, there is full participation with the Rutherford Laboratory in developing the EPIC project and in Europe the Laboratory is involved in several big programmes at CERN, for example at the ISR, and foresees its participation in such collaborations growing in the



years to come. With the advent of the SPS, Daresbury is proposing collaboration in research with muon beams in the North Area and experiments involving a tagged photon beam to Omega in the West Hall.

Financial restrictions mean that the resources to support the growing programme at CERN have to be found at the expense of the existing programme at NINA. Most of the money for major new equipment will be required for the programme at the SPS.

The NINA operating hours are being cut from 6000 to 5000 per year and the idea of having higher energy injection has been dropped. However, 'programmed quadrupoles', which will enable the operators to play tunes at high energies and thus avoid vertical beam blow-up on crossing resonances (leading to lower ejection efficiency), will be installed next year. There are four pairs of quadrupoles giving control of both horizontal and vertical working points with power supplies which can be fully programmed through computers.

The addition of a sextupole and septum following the installation of these quadrupoles will make 'separated function ejection' possible. This will replace the regenerator ejection system which, because of the regenerator strip fields, causes orbit distortions making simultaneous ejection difficult. Thus NINA will still manage a minor face-lift in her final years of independent operation for high energy physics.

PEP Summer Study

A Summer Study on the problems involved in proton-electron-positron colliding beam systems was held in the San Francisco area from 6 to 31 August. It was organized by the Lawrence Berkeley Laboratory and the Stanford Linear Accelerator Centre and pulled in participants from CERN, DESY, Frascati, Orsay and Rutherford, as well as from the U.S. high energy physics Laboratories.

Systems currently under study for e^+e^-p include PEP, which is being investigated jointly by LBL and SLAC; EPIC, which is being investigated by Rutherford and Daresbury; ISABELLE which is under study at Brookhaven and the DESY programme for DORIS. Results from existing storage rings (ISR, SPEAR, ACO, ADONE, etc.) were reviewed and a number of experiments with them were suggested to help clarify the present understanding of the machine physics involved.

Lattice design problems received considerable attention. These included synchronization of bunched electron and proton beams over a range of operating energies with maximum luminosity. There was considerable discussion on methods of achieving head-on collisions and collisions at a small crossing angle with their respective merits and demerits including the effects of unbunched and tightly bunched beams. Other questions concerned injection, acceleration, resonances, cell structure and coupling effects.

Among the single beam phenomena which were studied were bunch lengthening and multi-bunch longitudinal instabilities. Discussions on transverse and longitudinal beam-beam limits led to lively controversies on the roles of simple isolated resonances, many resonances, stochasticity, and Arnold diffusion. In connection with longitudinal motion, the benefits from exciting higher order modes in r.f. cavities were considered and schemes were devised in which cavities driven by the beams might be used to achieve very short proton bunch lengths. Some aspects of superconducting systems for protons were also considered. Work from the study will be reported in internal LBL-SLAC PEP notes and subsequently will be compiled into a report.

Photon-photon Colloquium

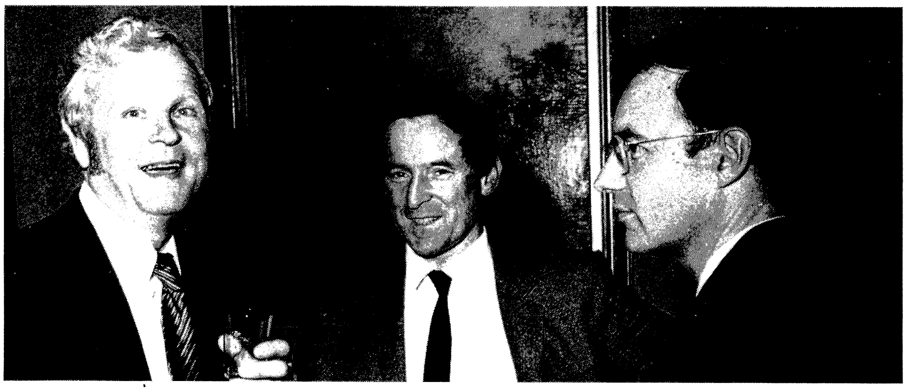
An International Colloquium on Photon-Photon Collisions in Electron-Positron Storage Rings was held at the Collège de France (Paris) on 3-4 September. It was attended by about a hundred physicists (theorists and experimentalists). The subject concerns those processes where the electron and the positron in the storage ring beams, instead of annihilating each other, act as generators of quasi-real photons. It is as if two photon beams (with large momentum spread) are colliding with each other.

The first pioneering studies on this subject date back to 1960 (F. Low, M. Calogero and C. Zemach) but had been forgotten to some extent for a number of years. It is back in vogue since 1969 particularly due to the work of three independent groups of theorists at the Collège de France, Novosibirsk and SLAC-Cornell. A large number of theoretical papers have been published in the last four years and the first experiments have been performed on VEPP-2 (Novosibirsk) and ADONE (Frascati). Their results are very encouraging although they are limited for the moment to the study of pure quantum electrodynamics. Other photon-photon collision experiments are being prepared for the high energy, high luminosity storage rings which have been recently brought into operation or are under construction — SPEAR at Stanford, DORIS at DESY, DCI at Orsay and VEPP-4 at Novosibirsk.

The programme of the Colloquium was divised in an experimental and a theoretical part. In the experimental part, reports on past and future experi-

Some well known faces from the accelerator world brought together by the DESY meeting on storage rings.

(Photos DESY)



ments were presented by G. Salvini and R. Santonico (Frascati), V.A. Sidorov (Novosibirsk), H.B. Newman (Cambridge), G. Feldman (SLAC), P. Waloschek (DESY) and A. Courau (Orsay). J. Parisi (Paris) talked about background problems in photon-photon collision experiments. In the theoretical part, various aspects of the processes when photon-photon collisions yield hadrons were treated by H. Terezawa (Rockefeller University), S.J. Brodsky (SLAC), and T. Walsh (DESY).

In addition, L. Stodolsky (Munich) extended the subject by discussing one and two photon exchange processes in reactions involving hadrons. Finally, a Discussion Panel on the 'Equivalent photon approximation in one and two-photon exchange processes' was organized with the participation of P. Kessler and F. Martin (Paris), D.H. Lyth (Lancaster) and K. Subbarao (Cornell). The Proceedings will be published in a special Volume by the 'Journal de Physique'.

DESY Meeting on Storage Rings

In Spring 1974 the first experiments are scheduled to start at DORIS (DOppel-RIng-Speicher) the electron-positron double storage ring at DESY. The end of December is still the date on the cards for first injection of electrons and positrons into the rings. (For a description of the rings, see vol. 8, page 289.)

While the last technical preparations for this important stage in the history of the 3 GeV storage rings were still in progress, some of its initiators discussed further possibilities for developing the machine's physics potential. They concluded that the amount of money which is necessary for a normal experiment in high energy physics would be sufficient to add the ability to carry out electron-proton collisions (vol. 12, page 281) within the rings.

The original plans were to have a 1 GeV proton booster but it has now been decided to do the main acceleration of the protons in the DESY electron synchrotron. For this, different r.f. accelerating cavities have to be installed and fortunately it has been possible to borrow appropriate cavities previously used on the fast cycling synchrotron at Princeton. These units recently arrived at DESY.

Protons will be injected into the DESY synchrotron at an energy of 4 MeV by a Van de Graaff accelerator. One second will be required to accelerate about 10^{11} protons to an energy of 2 to 4.5 GeV and to stack them into the storage ring. Calculations indicate that it should be possible to accumulate and to store up to 3×10^{13} protons; at the two intersecting regions they will collide with 5×10^{12} electrons circulating in the second storage ring resulting in luminosities as high as 10^{31} per cm^2 per s.

This experiment will be an excellent opportunity to study machine physics problems which will be important for the proposed next generation of e-p storage rings. In particular, it will be possible to study in detail the question of space charge limits in the interaction of an electron beam with bunched and unbunched proton beams. Because of the importance of these topics, the DESY team invited other experts working on storage ring problems to discuss them. From 8 to 12 October, machine physicists and experimentors went to DESY from all Laboratories in Europe and the United States where storage rings are being planned, or are under construction or already operating.

During the first two days, talks were held about experiments which can be carried out with the storage ring energies available up to now and about those experiments which will be possible in the future with storage rings of a higher energy range.

The physics interest in storage rings of higher energy spurred the last three days of the meeting which were dedicated to the projects to realize these energies. Many studies have been carried out already. Berkeley/Stanford presented the latest version of the PEP project (15 GeV electrons, 150 GeV protons), Brookhaven the ISABELLE electron-proton option (15 GeV electrons, 200 GeV protons), and Rutherford/Daresbury the EPIC project. ORSAY gave details of the electron-positron storage ring, DCI (2 GeV), and Frascati gave their thoughts about a Super Adone. The DESY team presented a feasibility study to store electrons of 15 GeV/c and protons of 120 GeV/c. This scheme is known as PETRA (Proton Electron Tandem Ring Accelerator).

The meeting confirmed that multi-Laboratory discussions on the different machine problems are a necessary and stimulating exercise to exchange information and to check the practicability of future projects. The local stimulation at DESY may have been responsible, a few days after the meeting, for bringing the first electrons and positrons from the DESY synchrotron to the injection points of DORIS.

BERKELEY
The heavies at the Bevatron

The experiments involving the acceleration of heavy ions are taking an increasingly important part of the experimental programme at the Bevatron. During September, for example, three weeks of operation were given to the acceleration of carbon and of oxygen ions to 265 MeV per nucleon which fed fourteen experiments.

The experiments were predominantly in the field of biology and medicine. They covered such topics as the response to heavy ions of protein in nerve tissue, the chemical species produced in water by heavy ion bombardment, the amount of damage to DNA caused by heavy ions, etc.

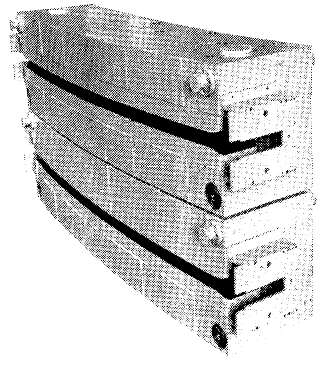
The Bevatron is now capable of accelerating intensities up to 5×10^4 for neon, 5×10^6 oxygen, 5×10^7 nitrogen, 10^8 carbon . . . These figures will be taken much higher when the link to the SuperHILAC is in action. The combination is known as Bevalac and is expected to deliver high energy beams of heavy ions in the Spring of next year.

Beam intensities are anticipated to rise to 5×10^8 argon, 10^{10} neon, 3×10^{10} oxygen and nitrogen, 6×10^{10} carbon . . . with energies in the range of 0.25 to 2.5 GeV per nucleon at a repetition rate of ten pulses per minute. A 'Users Association' is being formed to cover the interests in nuclear physics, chemistry, cosmic ray physics, biology, medicine and particle physics. The first meeting will take place on 19 January 1974. (Anyone requiring further information about Bevalac or the Users Association can write to the Lawrence Berkeley Laboratory, Building 50, Room 149).

The research programme with heavy ions was the subject of a Summer Study from 9-20 July. Already some intriguing results have emerged and the possibility of attacking other important question is clear. The most surprising result concerns the momentum spectrum of the fragments emerging from the heavy ion collisions with nuclei. Regardless of the mass of the fragment the same momentum distribution law appears to apply and this law does not seem to be built into any of the current nuclear theories.

For the future there are other aspects of nuclear theory which could be illuminated by heavy ion research — forming new nuclei by throwing heavy nuclei together (with the formation of the 'superheavies' as a particularly intriguing possibility), the effect on a nucleus of drilling a hole in it with a heavy ion, the effects of throwing high Coulomb fields together, etc. In astrophysical research, knowledge could emerge which is relevant to understanding stellar phenomena — element distribution etc. In medicine and biology a long list of experiments is already under way.

Nuclear transmutation



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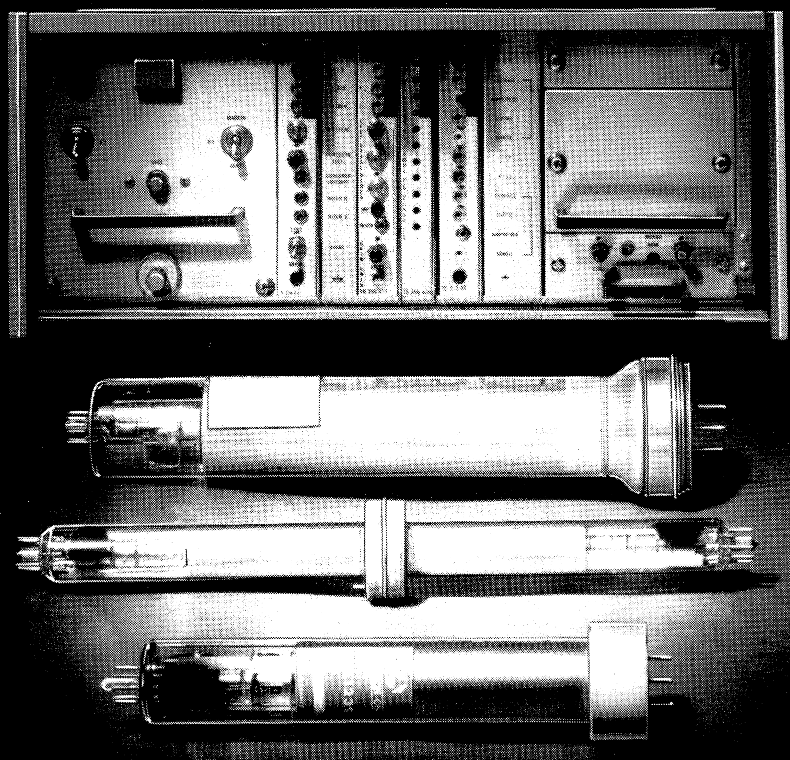

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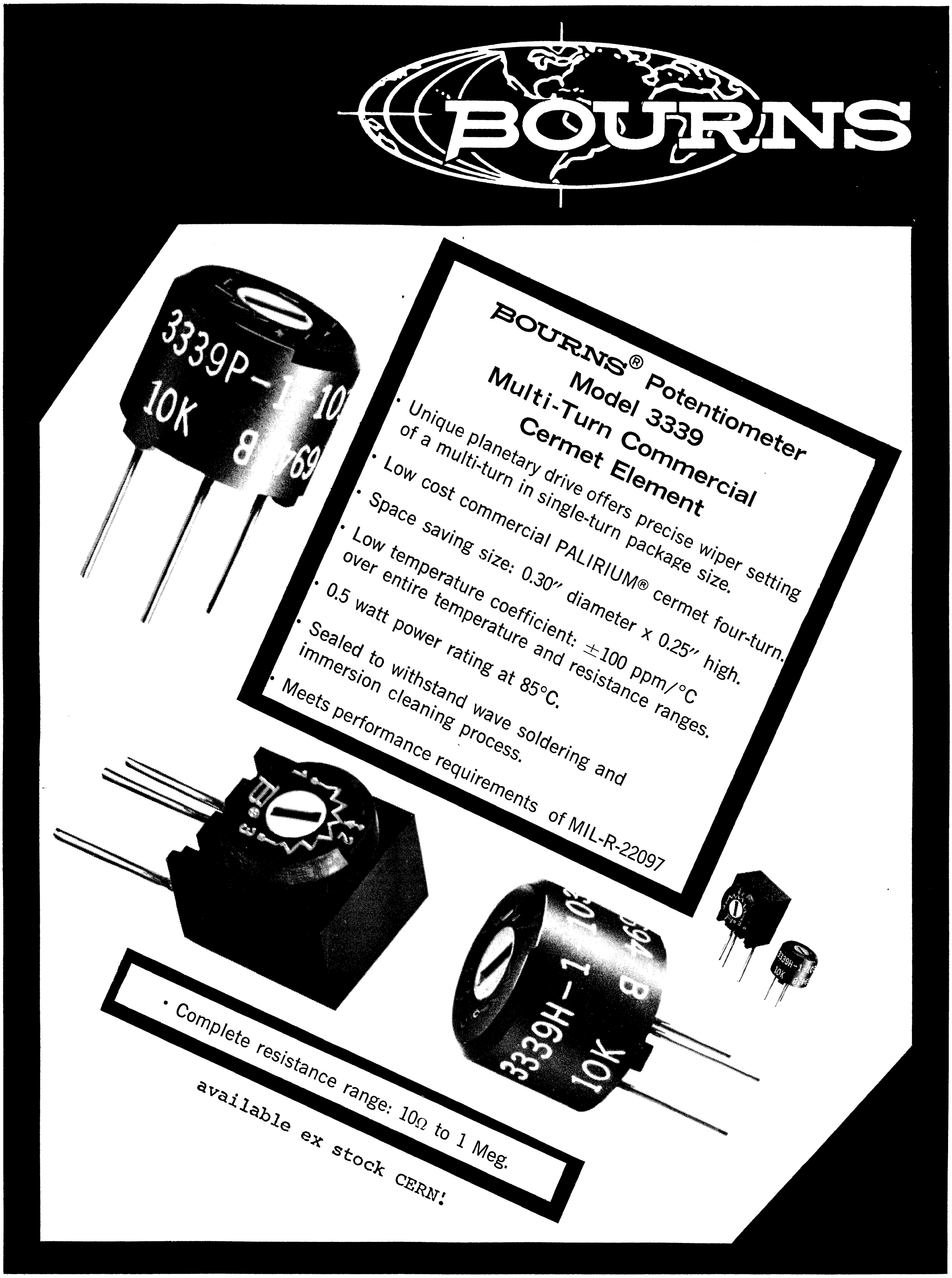
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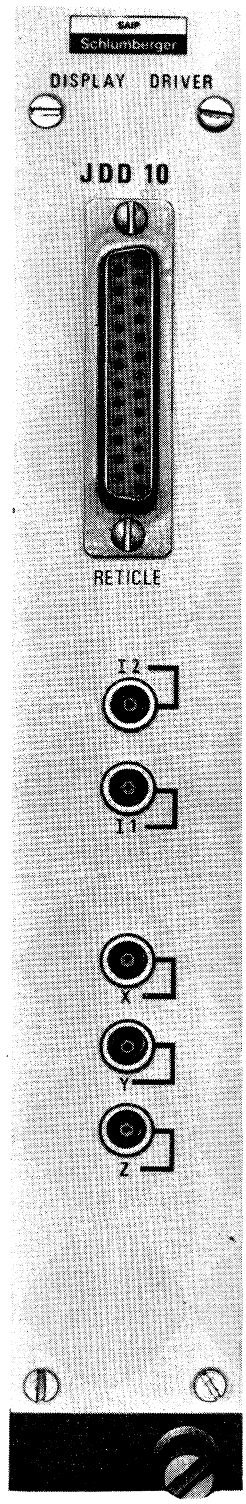

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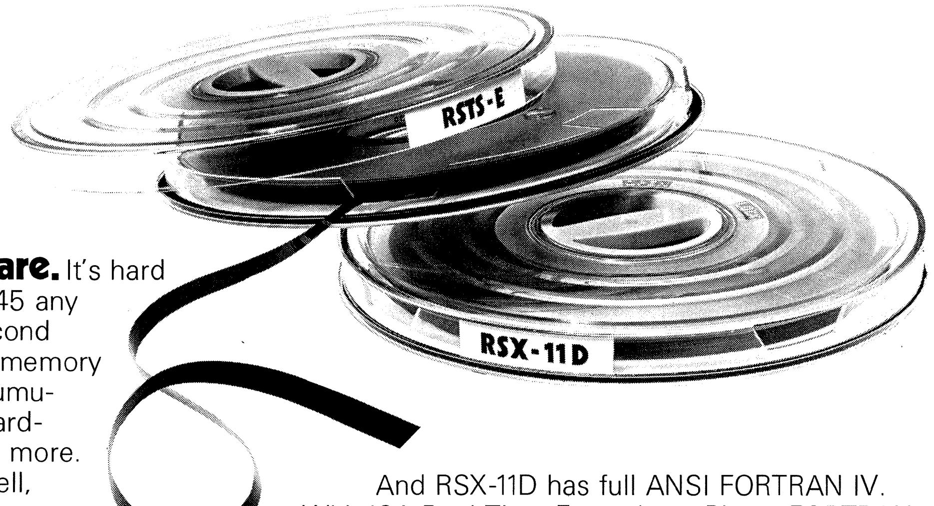

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Timesharing. The RSTS-E software system. It handles up to 32 users at one time, each with up to 16K words. With RSTS-E, everyone can use the peripherals on line. Large scale peripherals like 20-million-word disc packs and high-speed line printers. Plus magnetic tape drives, paper tape and card equipment.

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Real time. That's RSX-11D. An integrated real time software system that can control a whole process or automate an entire laboratory with power to spare. Real time response is measured in microseconds. Even with hundreds of tasks going on simultaneously.

Memory is used with maximum efficiency. RSX-11D is the first low-cost system to use dynamic memory management. Yet security is absolute because every task is individually hardware protected.

And RSX-11D has full ANSI FORTRAN IV. With ISA Real Time Extensions. Plus a FORTRAN IV compiler, macro-assembler, and full utility programs all running on-line simultaneously with real time operations.

RSTS-E and RSX-11D are also available on the PDP-11/40.

Learn what this new software can do for you.

Digital Equipment Corporation International – Europe, 81, route de l'Aire, CH-1211 Geneva 26, Tel. (022) 42 79 50.

Offices in Reading, London, Manchester, Birmingham, Bristol, Edinburgh, Munich, Cologne, Frankfurt, Hannover, Stuttgart, Vienna, Stockholm, Oslo, Copenhagen, Helsinki, Paris, Grenoble, The Hague, Brussels, Zurich, Milan.

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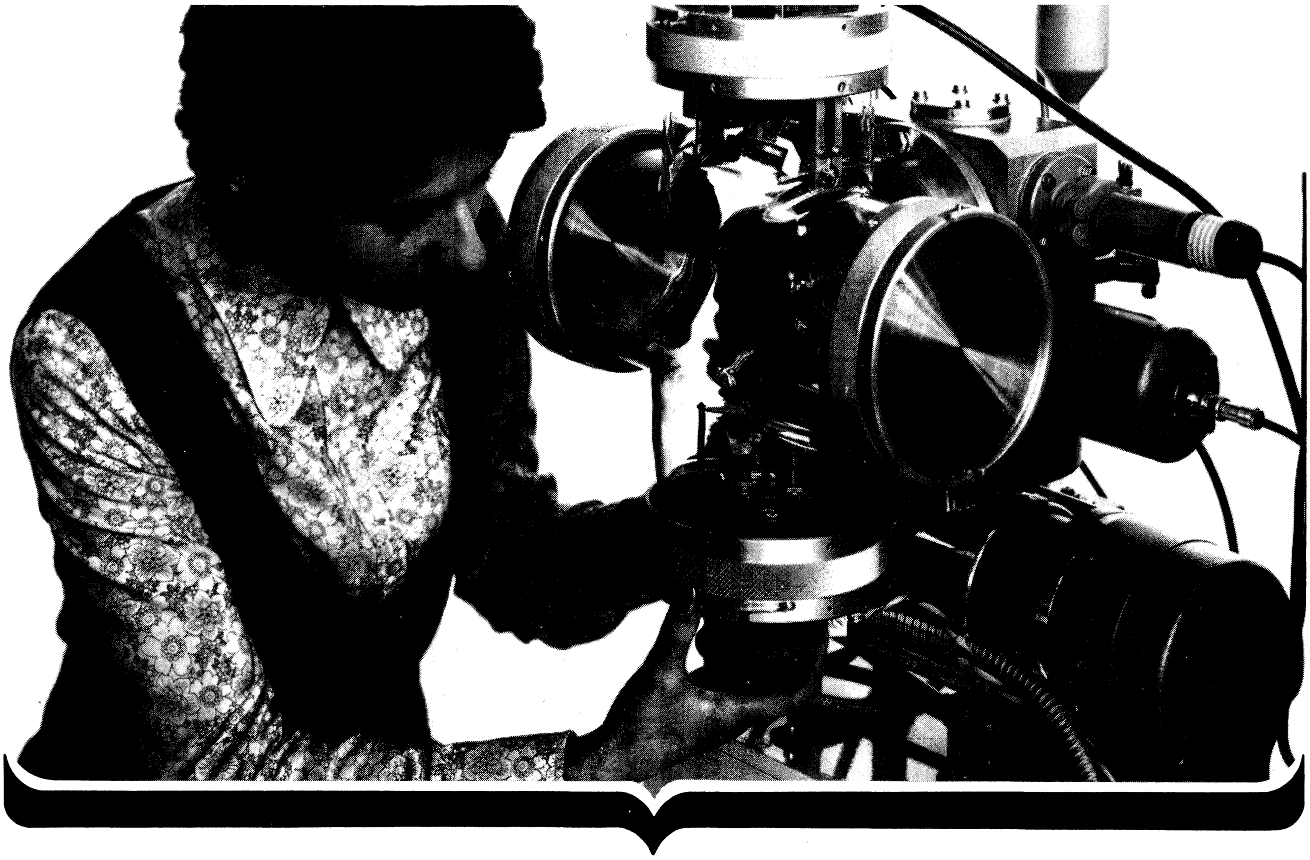

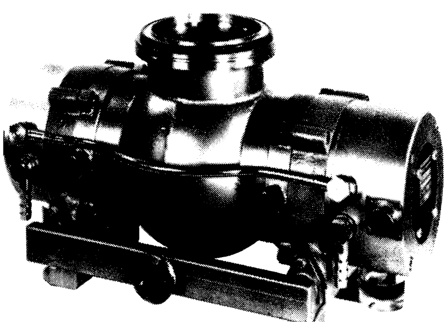

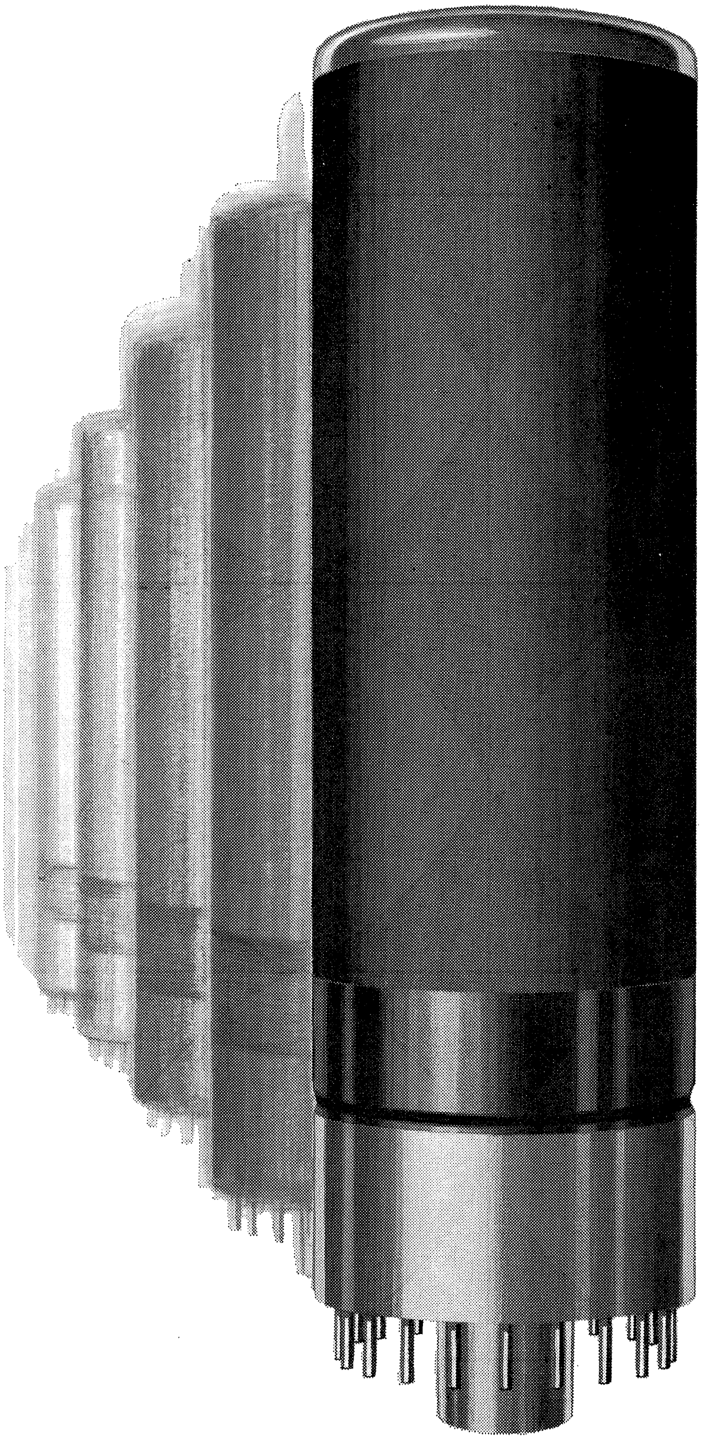

FAST, FASTER, FASTEST

0,3 ns transit time fluctuation is the new standard in photomultipliers.

The new XP 2020 sets the state-of-the-art for high speed photomultipliers. A transit time fluctuation of only 0,3 ns and a 1.5 ns rise time makes it ideal for fast coincidence techniques or Cerenkov detections. Moreover it is competitive on price with slower equivalents.

Almost as fast is the new PM 2203, a 12-stage linear-focused tube with a bi-alkali photocathode. It is ideal for applications having low luminous fluxes, such as single photon counting, as well as for time measurements.

The table below gives the main specs. Data sheets and samples for evaluation are available on request.

	XP 2020	PM 2203
Spectral response	type D	type D
Useful cathode diameter	42 mm	45 mm
Quantum efficiency at 400 µm	25 %	30 %
Cathode sensitivity at 400 µm	85 mA/W	100 mA/W
Rise time	1,5 µs	1,6 ns
Transit time fluctuation	0,3 ns	0,35 ns
Gain at 2,6 KV	10^8	10^8

Type PM 2203 is a direct replacement for type 8575 and a near equal to the 9814B.

For more information on these new tubes plus an updated product survey of the extensive Philips range write to :

Philips Industries, Electronic Components and Materials Division, Eindhoven - The Netherlands

Distributed and sold in the U.S.A. by : Amperex Electronic Corporation
230 Duffy Avenue, Hicksville N.Y. 11802

In Canada : Philips Electron Devices
116 Vanderhoof Avenue Toronto 17 - Ontario

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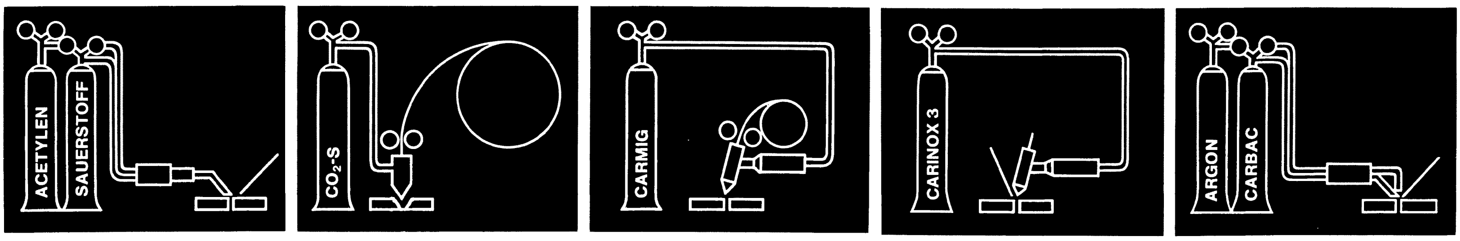
5 Procédés de soudage avec les gaz Carba



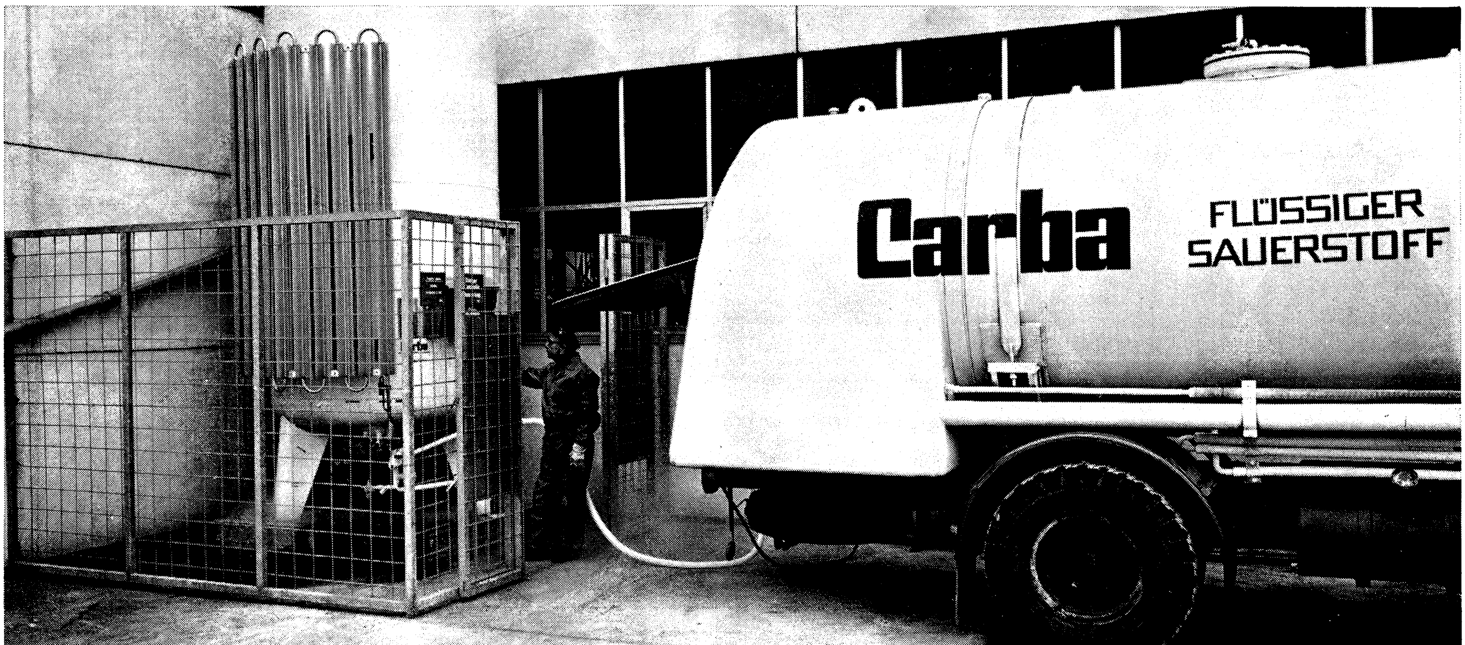
Techniques autogènes
avec l'acétylène-dissous et l'oxygène soudage: tôles minces, tubes, métaux non ferreux brasage, oxycoupage, chauffage, redressement, trempe, projection et décapage à la flamme.

Soudage MAG
avec CO_2 "S", l'acide carbonique de Carba avec pureté garantie pour: les aciers de construction, les aciers chaudière, les tubes, les aciers à grain fin.

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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