

The first two magnet cores for the intersecting storage rings arrived at CERN from the manufacturers, ASGEN, on 13, 14 August. They are the first of 400 of these magnets which will be used to build up the two interlaced rings. Each of them will be tested in the West experimental hall and the equipment for this has already been installed. The hall itself is nearing completion. The magnet section of the ISR Division has moved over to the ISR site.

The following five items concern improvements around the proton synchrotron taking place during the present shut down.

'Straight flush'

From the beginning of the year until the shut down of the proton synchrotron on 27 May, the performance of the kicker magnet of the fast-ejection system in straight section 97 had been very satisfactory; the time lost through breakdowns was less than 0.3%. Previous difficulties with the hydraulic ram, which, in about a tenth of a second, pushes the magnet into its position around the beam with an accuracy of a few millimetres, have now been almost completely eliminated.

During the shut down a number of improvements have been made to the kicker magnet system. They have been mainly concerned with the magnet power supply and have considerably increased the versatility of the fast ejection system.

Previously, it was possible to select for ejection, combinations of 1, 2, 3, 4, 5, 6, 17, 18, 19, or 20 bunches from the twenty

bunches of protons orbiting the machine. Furthermore, the selection of a combination could only be done once per cycle, so that, for example, it was impossible during one cycle to send three bunches to one experiment and then three to another. It is these limitations which have now been overcome.

The pulse fed to the magnet is produced by discharging a line and the discharge time obviously varies considerably between the ejection of twenty bunches and of one bunch. In the old system, two separate lines were used: one to give a pulse length equivalent to the ejection of six bunches and the other equivalent to twenty bunches. The discharge time for a given line could then be shortened to some extent, to make it possible to select from 1 to 6 and from 17 to 20 bunches. Changing from one line to the other could only be done manually and, as this involved going inside the PS tunnel, operation of the machine had to be stopped for up to 15 minutes at each change over. The time taken to charge the line was of the order of a second, so that not more than one dis-

charge to power the magnet could be used during the flat top of the PS cycle.

The new power supply uses only one line but enables any number of bunches between 1 and 20 to be selected. The line provides a pulse long enough for the ejection of all twenty bunches and a spark-gap between the line and the magnet can be fired to short-circuit the pulse to give the desired pulse length at the magnet. This can be programmed in advance and any changes do not require manual intervention.

A further improvement is that the line recharging time has been reduced to less than 300 ms, so that at least two pulses can be produced per cycle. It will be possible to provide the hydrogen bubble chamber, for example, with at least two pulses per cycle; similarly, a large number of bunches per cycle could be sent down the neutrino beam line, while retaining a few bunches for another experiment.

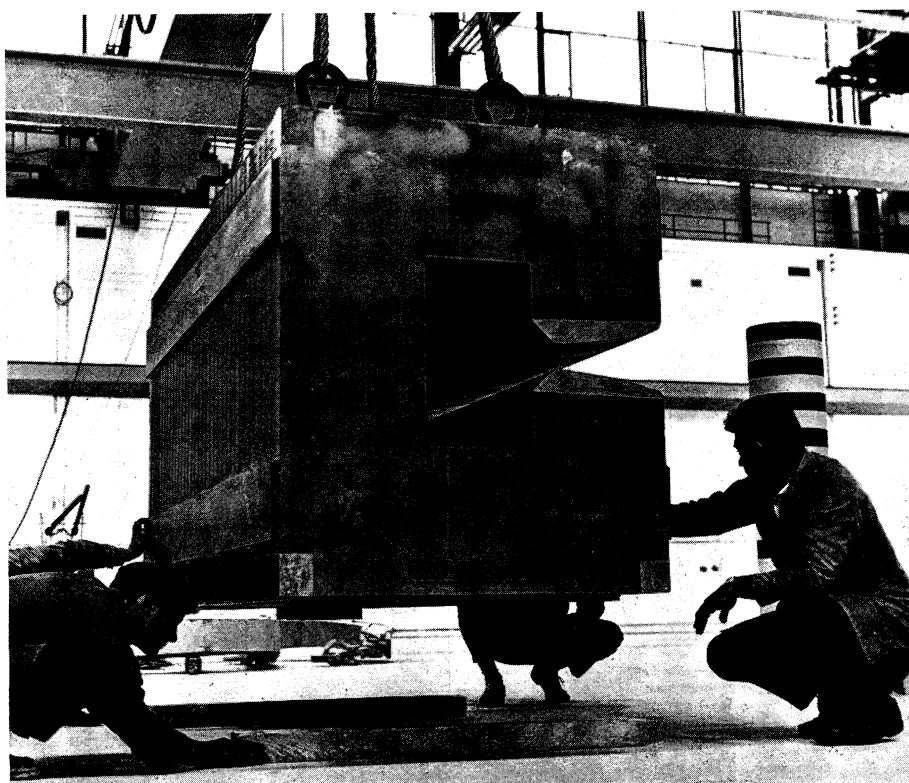
Another refinement concerns improved control for reversing the magnetic field in the kicker. Previously an operator was needed to reverse the field but it can now be done automatically and programmed in advance. The switching time has been considerably reduced and it is possible to reverse the field during a cycle, so that some of the proton bunches can be deflected towards one septum magnet and, after reversing the field, the rest can be deflected to another, perhaps thus feeding experiments in different experimental halls.

With all these possibilities now available, the system has earned the nickname 'straight flush'.

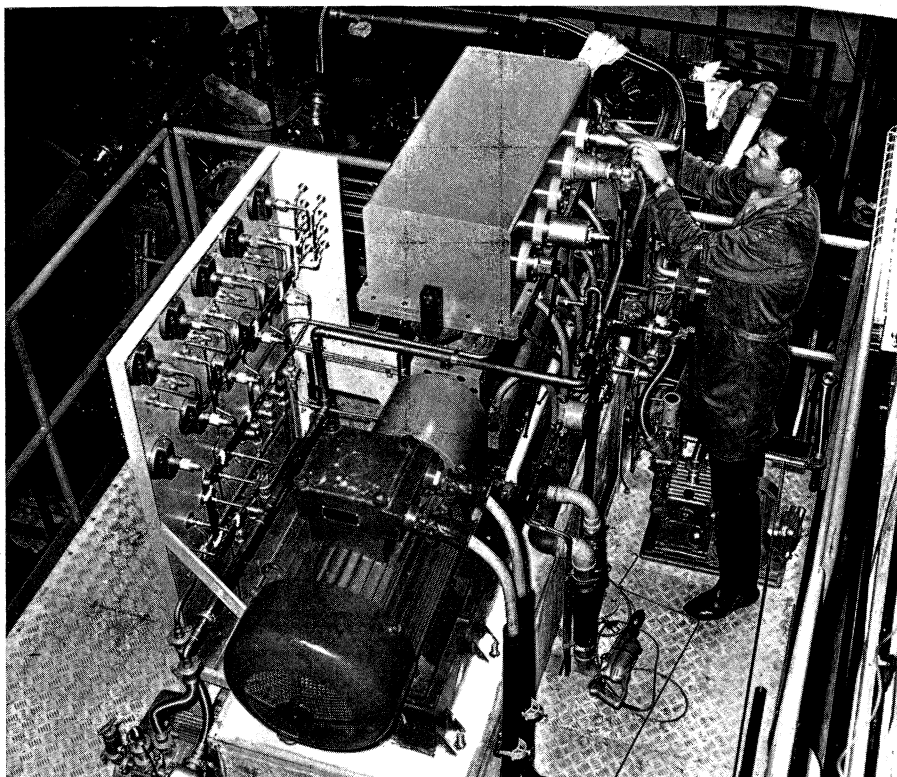
Measuring the beam radius

When protons have a certain energy, they follow an orbit in the magnetic field of the synchrotron, whose average radius is directly related to the frequency of the r.f. accelerating system.

This relationship has been used at the proton synchrotron to measure the average radius. A system of electronic circuits calculated the radius knowing the beam energy and the r.f. frequency. It has thus been possible to obtain readings in the Main Control Room of the position of the



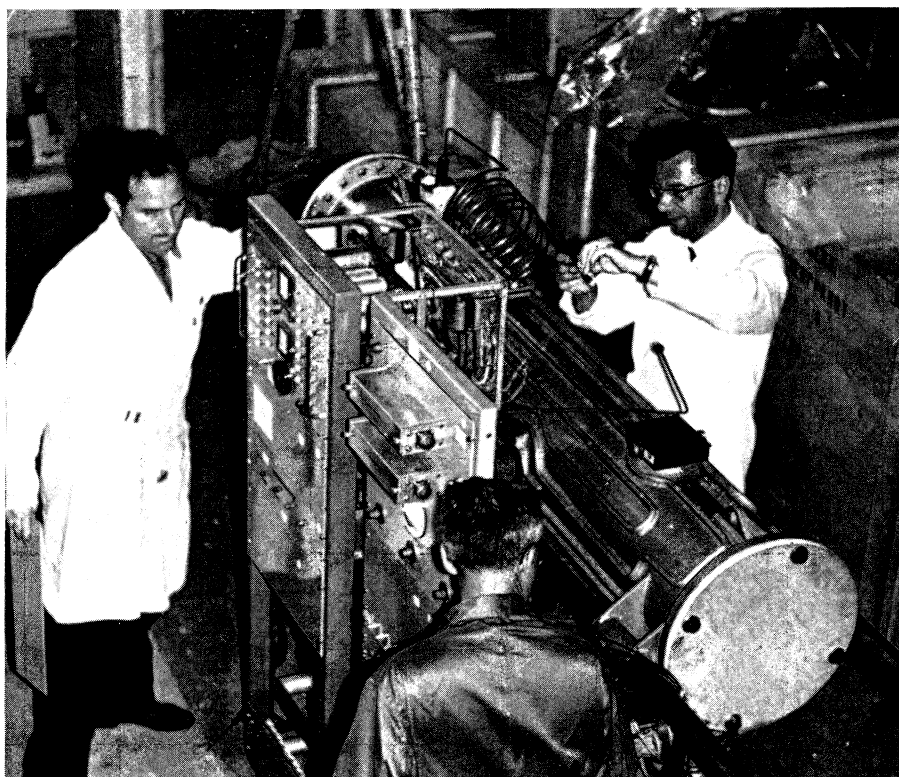
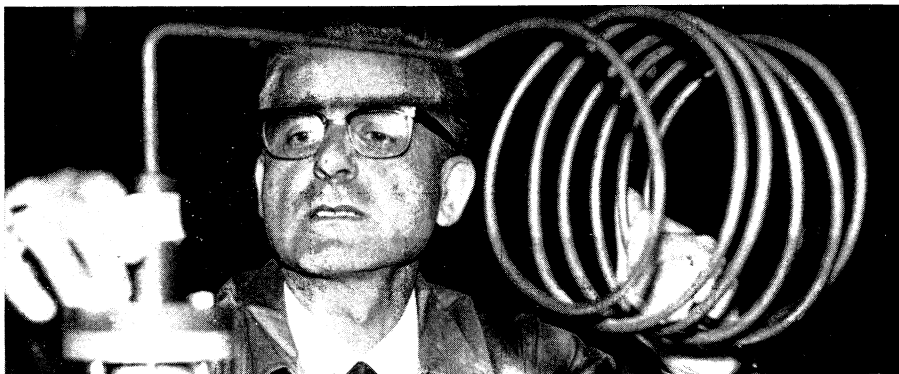
CERN/PI 66.8.68



CERN/PI 250.7.68

The new liquefier to supply the 81 cm hydrogen bubble chamber with liquid hydrogen.

Below, two photographs taken in the experimental hall at Serpukhov when the CERN-Serpukhov experiment was being set up.



beam in the vacuum chamber of the machine. The system has been in operation since 1961.

The acceleration frequency was compared with a reference frequency (selecting from six reference frequencies depending upon the energy range being examined). To achieve an accuracy of about 0.1 mm in the position of the average radius, the measuring time was about a hundredth of a second. The measurement was, however, only precise at 22 GeV, and the error increased the further one went from this energy, due to the use of a fixed measuring time.

In May 1968, following a proposal by E. Schulte, a new method for determining the frequency difference by measuring the period rather than by counting the number of oscillations, was adopted. A prototype was brought into operation quickly to gain some experience of its performance before the shut down began on 27 May.

The new method has shortened the measuring time to about a thousandth of a second while still achieving the same accuracy and, by using a frequency synthesizer, it is possible to perform accurate measurements at any energy above 5 GeV (the transition energy). The reduction in measuring time is particularly important because the beam can change its position in the machine considerably in a hundredth of a second.

When the machine comes back into operation in October, the measurements from the new system will be available as a numerical read-out in the Main Control Room.

New hydrogen liquefier

Up to the time of the PS shut down in May, the liquid hydrogen used in the 81 cm bubble chamber was produced at a central liquefying station and taken to the chamber in dewars, from which it was distributed by long transfer lines. The losses of liquid hydrogen involved on this process, as the liquid was converted into gas by heat, represented more than a quarter of the total consumption and the gas had to be returned to the central station through a long underground conduit.

Recently, a great deal of progress has been made in the design of liquefiers,

1: New beam-observation station. Twenty stations of this type are being installed around the synchrotron ring. The unit on the right remains virtually unchanged, but the electronic units (a valve pre-amplifier in the centre and a variable-gain transistorized amplifier on the left) are new. The units were developed in the Proton Synchrotron Division and they are a considerable improvement on those previously used.

2, 3: Photographs taken in the 1 m model of the European bubble chamber during its first run (see vol. 8, page 129). On the left are tracks of Compton electrons using a gamma source close to the chamber. 'Bright-field' illumination is used

(the tracks appear black on a white background). The gamma source is not pulsed or synchronized with the bubble chamber cycle which accounts for the large number of parasite bubbles and tracks. The black regions correspond to areas of the chamber seen by the camera which are not covered by Scotchlite; the white flare is a direct reflection on flash illuminating the chamber. On the right, is a photograph taken during one of the first tests ever made of the use of laser beams in a bubble chamber. The beam crosses the chamber at right angles to the axis of the camera and the black region in the centre is due to a thermocouple attached to the camera lens. These tests are investigating the possibility of using

crossing laser beams to fix the fiducial marks (the distance measuring reference points) in a chamber. A continuous emission argon laser (4880 Å) built at the Institut für Angewandte Physik, Heidelberg, was used.

and there are now machines available that are lighter, less bulky and easier to maintain. It was decided in June 1967 to install one of these machines close to the 81 cm chamber and this has been done during the shut down. The initial trials on the machine were satisfactorily completed on 15 June and the liquefier will be fully operational when the PS is restarted in October.

The advantage is threefold: it relieves the central liquefying station the capacity of which became inadequate with the bringing into operation of the 1 metre model of the large European chamber (see vol. 8, p. 129); there is no need for dewars, with all the handling involved; the liquid hydrogen consumption is reduced.

The assembly

To keep the liquid hydrogen in the 'useful volume' of the bubble chamber at its operating temperature of about 26°K, cooling is required to compensate for the heat produced by the movement of the piston and for heat transferred. The temperature is controlled by means of an intermediate hydrogen circuit, the 'jackets',

surrounding the useful volume of the chamber. Excess heat in the chamber is transferred to the 'jackets' which, in turn, pass it to an external circuit connected to the liquefier.

This external circuit is closed. The hydrogen liquefied by the machine passes to the exchanger of the chamber, where it is heated and reverts to the gaseous state. It then returns to the machine to be liquefied again, and so on. The operating pressure is close to atmospheric.

The flow of liquid hydrogen is effected by gravity, and the first thing that strikes the eye in the bubble chamber hall is the sight of the liquefier perched six metres above the ground on a pile of concrete blocks.

The liquefier

The liquefier was manufactured by Philips in the Netherlands. It is driven by a 45 kW synchronous motor and has a capacity of about 35 litres per hour at 20°K, representing an average power of 310 W. The overall efficiency is therefore no more than 7%, but this is a normal figure for a cryogenic installation.

The liquefier generates only enough

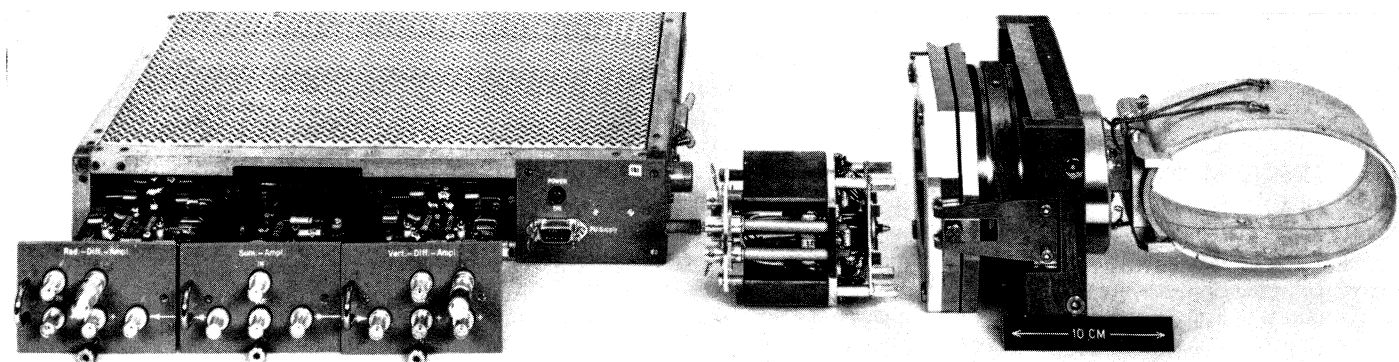
hydrogen to keep the chamber supplied during normal operation. Whenever a major filling of the chamber is needed, for example at the start of a period of operation, the hydrogen is supplied, as before, from the central liquefying station.

CODD

It was decided two years ago to install a Closed Orbit Digital Display (CODD) system at the proton synchrotron. Using beam-observation stations liberally distributed around the machine, it makes it possible to observe the behaviour of the beam in great detail. It could lead to almost instantaneous control of the trajectories of the proton bunches.

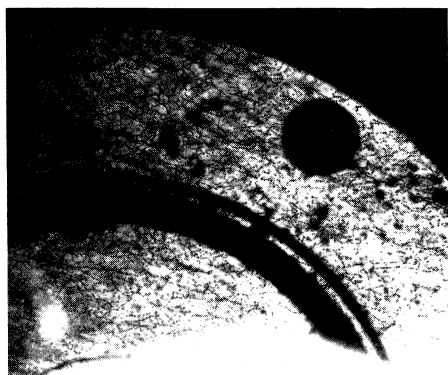
The first tests on the system took place in August 1967 and showed that various improvements would be necessary to achieve the desired precision. It was decided to link the improved CODD to the IBM 1800 computer which was installed in the Main Control Room in 1967 (see vol. 7, page 183).

Twenty new beam-observation stations (the units of one station can be seen in



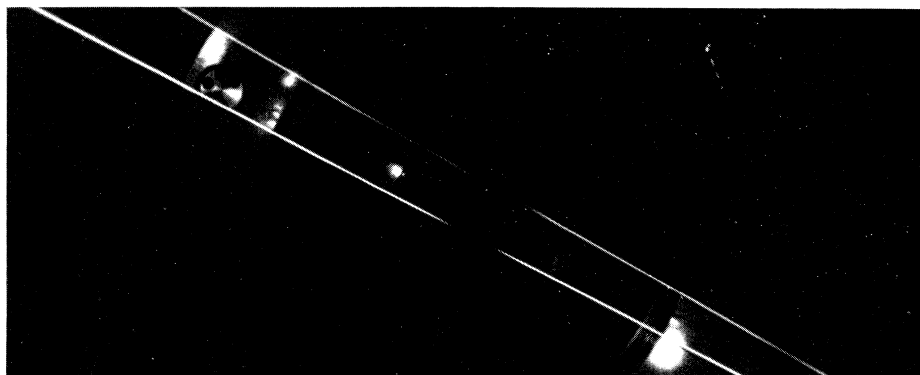
CERN/PI 81.8.67

1



CERN/PI 20.6.68

2



CERN/PI 216.6.68

3

Professor T.D. Lee, who is one of the visiting scientists working at CERN during the summer months, lecturing to the vacation students on 9 August. The subject of his talk was 'Symmetry principles in physics'.

the photograph) are scheduled to be put in place around the synchrotron by 1 October, so that CODD can be brought into operation using some of the old stations and some of the new ones. If the latter produce the results expected, the electronics of the old stations will be brought into line with the new ones.

Initially, CODD will make it possible to study the effects of adjustments to the machine controls on the orbits followed by the protons. When this has been done, CODD could be linked directly to an automatic system for closed orbit correction. The protons could be tracked around the machine at the beam-observation stations and then, via CODD and the IBM 1800, any necessary correction could be calculated and applied.

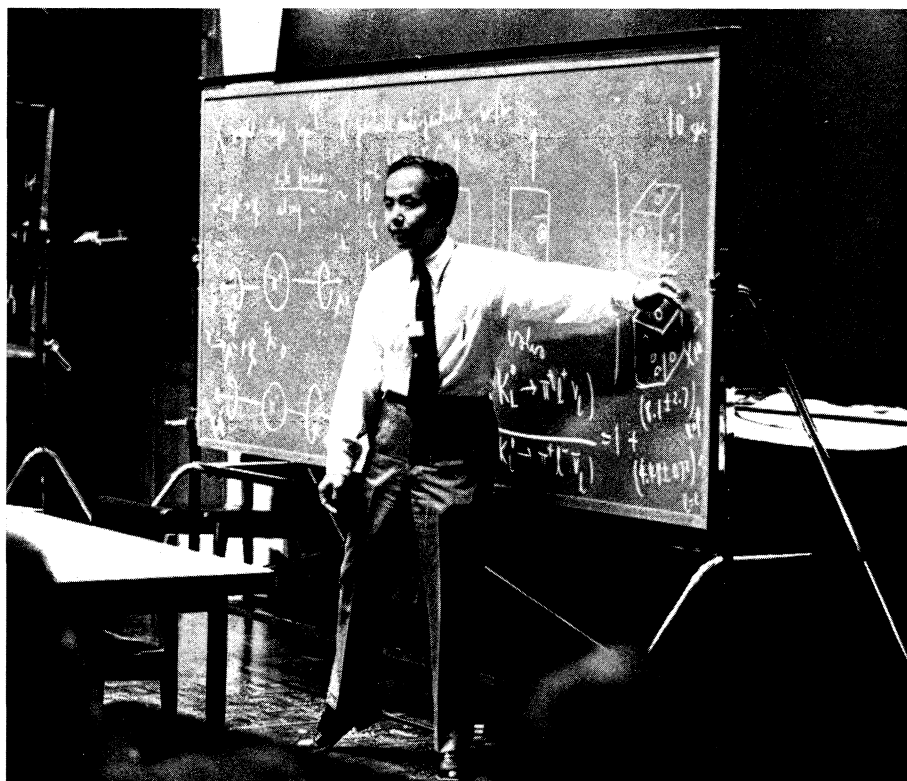
The new stations

The electronic units which amplify the pulses coming from the electrodes in the observation stations have been improved. The amplifiers have a gain which can be switched to values from 1 to 10. The variable gain makes it possible to measure the position of the beam precisely whatever its intensity. The amplifiers are transistorized and must be protected from radiation. They are positioned in narrow trenches 1.5 m under the floor of the PS tunnel.

CODD

A main feature of CODD is that it can follow the trajectory of a given bunch of protons as it goes round one turn in the machine. In this it differs from the system already in operation at the Brookhaven synchrotron which gives the average orbit of all the bunches over a large number of turns.

Each station has circuits, known as 'linear gates' to select the pulse corresponding to a particular bunch. The sequential opening of the gates as the bunch goes round is controlled by a delay line to which are connected as many outputs as there are observation stations. A particular delay line corresponds to a particular beam energy, which limits the number of energies at which this type of measurement can be made (the number of delay lines available). As a further development it may be possible to link the gate-opening controls to the radio-frequency



CERN/PI 33.8.68

system of the accelerator so that measurements could be taken at all energies.

The difficulty of bringing into operation a system as complex as CODD will be compensated for by the ability to observe the behaviour of the proton beam in the machine in detail never achieved before. A similar system is being planned for the Booster.

Reinforcement of shielding

The shielding covering the proton synchrotron ring in the region of the internal targets, which supply particles to the North and South experimental halls, is being reinforced. This precaution is needed in preparation for the increased intensity of the machine.

The tunnel was already covered at this point with earth 2.3 m deep but this could not be made deeper without increasing the support. It was decided therefore to build an additional roof, 2 m above the first, to support another 2 m of earth. Its frame consists of 13 pre-stressed beams, 30 m long and 2 m wide coupled along their length covering a total surface area of 750 m².

A pre-stressed assembly has been used because of the limited time available to build the extra roof (the four months of the PS shut down). This made it possible to prefabricate the beams over a longer period of time.

Each beam has eight sections (of which the largest weighs four tons) cast on the site and assembled on a tubular steel platform near the tunnel from which they are moved on small caterpillar trucks. The eight sections are cemented end to end

with a special quick setting colloidal mortar, and are threaded together by twelve cables each consisting of twelve steel wires with 160 kg/mm² breaking stress. They exert a pressure of 68 tons on the beam. The method of anchoring the cables was developed by the former SB Division Leader Ch. Mallet, using self-locking pins.

Vacation students

The annual invasion by a group of over a hundred students is taking place at CERN. They come from Universities and Engineering Colleges throughout Europe to follow the summer vacation course.

The students have been drawn from a list of applicants about four times longer than the list of places available. The selection is usually done at Divisional level on the basis of questionnaires filled in by the students and reports from their lecturers.

Applicants come from Member States and must have completed at least three years study at University level. Travelling expenses are reimbursed and a grant of 25 Swiss francs per day is paid for the duration of the stay at CERN. The Housing Section helps to find accommodation and as many students as possible are housed in the hostels usually occupied by the students of the University of Geneva, for part of their stay. The course usually lasts from two to four months.

While at CERN, the students work directly with the groups carrying out experiments or developing research equipment. They can also follow a series of lectures on the scientific activities of CERN, including courses in physics and computer programming, which is specially arranged.