

The European Organization for Nuclear Research (CERN) came into being in 1954 as a co-operative enterprise among European governments in order to regain a first-rank position in nuclear science. At present it is supported by 13 Member States, with contributions according to their national revenues: Austria (1.92 %), Belgium (3.78), Denmark (2.05), Federal Republic of Germany (22.47), France (18.34), Greece (0.60), Italy (10.65), Netherlands (3.87), Norway (1.46), Spain (3.36), Sweden (4.18), Switzerland (3.15), United Kingdom (24.17). Contributions for 1963 total 92.5 million Swiss francs.

The character and aims of the Organization are defined in its Convention as follows

'The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.'

Last month at CERN

At about 5 p.m. on the afternoon of Tuesday 6 August, another important stage in the evolution of the proton synchrotron was reached, when a beam of protons was extracted from the accelerator for the first time by means of the **slow ejection system**. This success greatly enlarges the possibilities of the synchrotron and means that when all the tests have been completed, in a few

months' time, the physicists should have at their disposal in the South experimental hall a beam of protons whose characteristics can be varied, to a large extent, to suit their requirements. Added to the fast ejected beam, achieved a few months ago, and the versatile system of internal targeting developed during the last three and a half years, the slow ejected beam completes a range of operating possibilities which is unique. The champagne drunk in celebration was well deserved.

It should perhaps be pointed out that the description 'slow' applies to the method of extraction of the beam, and not to the speed of the protons. In principle, protons of any energy produced by the accelerator can be extracted, and a distinguishing feature of the system developed for the PS is that it does not involve a degradation of the proton energy, by scattering in a target for instance. The first tests were carried out with a proton energy of 16 GeV and later ones a 12 GeV.

As described in the June issue of *CERN COURIER* (vol. 3, no. 6, p. 79) the acceleration process of the synchrotron produces 20 bunches of protons travelling around the ring at practically the speed of light. The 'fast' ejection system directs these bunches in rapid sequence on to a target outside the accelerator, in a time of only 2.1 microseconds. In contrast, the 'slow' system directs a more constant flow of protons on to the target for a period of time which is ten thousand times as long. Such conditions are much more suitable for the operation of counter arrays and spark chambers. Both systems depend on the excitation of betatron oscillations in the circulating beam, but otherwise their methods of operation are quite distinct. Slow ejection, as its name implies, is a much more gradual process, and in fact is much more closely linked to the functioning of the accelerator as a whole.

Under normal operating conditions, if a proton is slightly deflected from its path because of, say, a non-uniformity in the guiding magnetic field, it 'oscillates' about its former line of flight,

in other words its distance from the centre of the ring changes slightly as it goes round. Because of the design of the magnetic field, the proton never comes back to exactly the same place after each complete revolution and so the oscillation can never build up to any great amplitude. This feature of the magnetic field is, of course, extremely important for the operation of the synchrotron, and so a number of quadrupole and sextupole magnetic 'lenses' were included in the original construction so that the field could be corrected if necessary. In fact it was not necessary, but these same lenses now form the basis of the slow ejection system.

When the protons in the ring reach the desired energy, the radiofrequency accelerating field switches off and the protons continue to circulate as a beam, a few millimetres wide, under the influence of the ring magnets. At this stage, the currents in the correcting lenses are adjusted so that for one particular orbit, larger than that on which the beam is circulating, protons would be subject to unstable betatron oscillations — each time they completed a circuit of the ring they would be deflected further and further out.

The main magnetic field is then slowly and steadily reduced, causing the average proton orbit to expand. When a proton reaches the 'unstable' orbit it is set into rapidly growing oscillations by a quadrupole situated in straight-section no. 99 of the accelerator. Slightly further round the ring is the slow ejection magnet, of the 'septum' type so that its field does not disturb the beam circulating past it. After relatively few turns round the ring, the radial oscillations of the proton is sufficient to carry it into the magnet aperture, where it is deflected out of the accelerator. Because of the spread of the beam, individual protons reach the point of instability at different times, so that the circulating beam is slowly extracted and directed to the external target.

As with the fast ejection system, the ejection magnet is positioned (in this case electromechanically) towards the

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The cover photograph shows a comparatively rare view both of CERN and of Mt. Blanc, some 70 km distant. From the French side of the border, only CERN's Administration building appears above the trees while, recording one of this year's few clear days, Mt. Blanc can be seen rising to its snow-covered peak, 4800 metres high, above the mountains of Savoie. Less far away, Mt. Salève stretches across the picture on the other side of Geneva.

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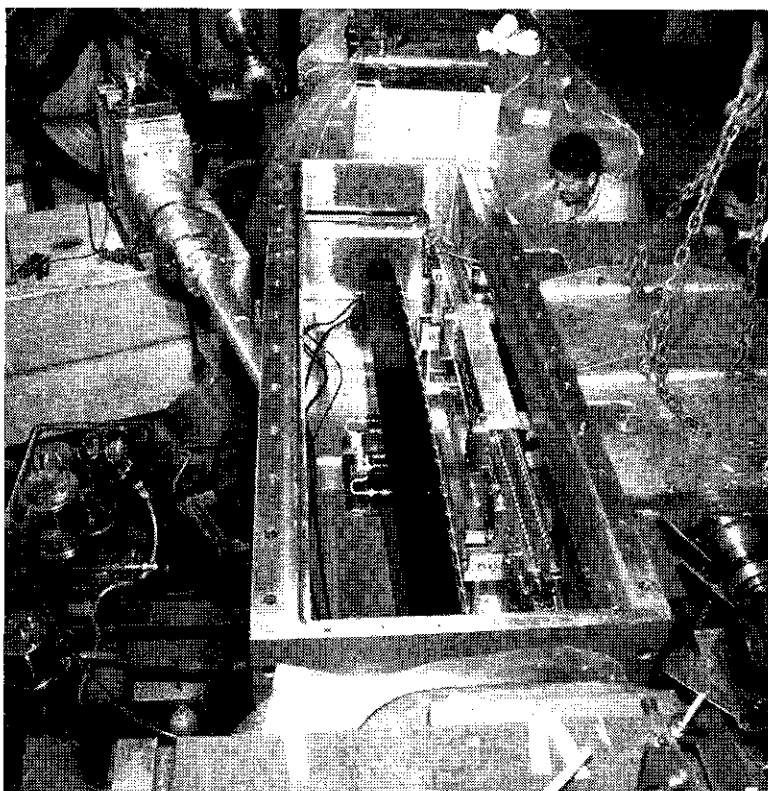
Roger Anthoine

Editor:

Alec G. Hester

CERN, Geneva 23, Switzerland
Tel. 34 20 50

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This photo shows how the two ejection magnets are arranged inside their vacuum box. The long black object is the fast ejection magnet, which moves up and down when in use, while above and to the right of it is the slow ejection magnet, which moves from side to side. Part of the hydraulic equipment for the fast magnet can be seen to the left of the box; the mechanical positioners for the slow magnet are in the casing to the right. The ejected beam travels very close to its undeflected trajectory at first, and the two tubes seen leading from the vacuum box are for conventional beams of secondary particles.

end of the acceleration part of the cycle, and the current in it is pulsed because of the high values required. The whole process described above takes place in about 20 thousandths of a second, though the actual time for which the external beam exists can be varied to some extent.

Successful use of slow ejection system, which is being developed by members of the Proton Synchrotron Machine Division, depends on very fine control of the accelerator and many detailed improvements have been and are being made to that end. Since the position of the beam circulating on its 200-metre-diameter circle must be accurate to a few tenths of millimetre, extremely precise and reproducible operation is required. All the magnetic fields must be reproducible from pulse to pulse of the accelerator and have the minimum of 'ripple'.

For the first and subsequent observations during August, the ejected beam was directed along the track normally used by the fast ejected beam and stopped at the entrance to the first bending magnet of the pulsed transport system. Television cameras, photographic paper, x-ray film, nuclear emulsions, scintillation counters and solid-state ra-

diation detectors were all used in investigations on the trajectory and its dependence on the various parameters involved.

The synchrotron itself continued to run very satisfactorily, and several new records of **beam intensity** were set up. On 21 August (by coincidence, the first day of the Dubna conference), currents of over 60 mA were being injected from the linac into the accelerator, and for one period of 1000 pulses (nearly an hour) the average accelerated beam intensity (at 24.8 GeV/c) was 8.3×10^{11} protons per pulse. The highest single pulse registered that morning was of 9.06×10^{11} protons.

As in the previous month, half the time scheduled for nuclear physics was devoted to further runs for the **neutrino experiment**. The main experiment during the other two weeks, in the North hall, used a pion beam striking a liquid-hydrogen target to study the production of **'strange-particle' resonances**. Eighty per cent. of the circulating proton beam was used by the internal target giving rise to this pion beam, the remaining twenty per cent, in each pulse striking another target to give rise to secondary particles collected into four different beams serving experiments in the South hall.

In the East hall, the **new beam, α_2** , which is to provide separated particles for the 1.5-m British bubble chamber, was installed, using new survey methods for the alignment. Three reference marks were used, in line and separated from each other by a distance of 40 metres, each being positioned with reference to three of the permanent grid points previously set out for the hall. The misalignment of the central reference mark with respect to the line joining the outer two was measured as only 0.2 mm. Moreover, no misalignment could be detected between the reference point in the East hall itself and those in the East target area inside the ring.

There, a new target, operating within the gap of magnet unit no. 60, was successfully tested mechanically. Later, for about 16 hours, the target was arranged to be struck by the beam once every twenty seconds, enabling the calibration beam for the future α_2 beam to be tested.

Around the middle of the month, CERN's Director-general, Prof. V.F. Weisskopf, and twenty other physicists and engineers of the Organization left for the U.S.S.R., to take part in the **International conference on high-energy accelerators** held at Dubna during 21-27 August.

This conference at present takes place every other year, alternating with the International conference on high-energy physics, which was held at CERN last year. It deals with the large machines that make the experiments possible rather than with the results of the experiments themselves. Like the high-energy-physics conference, it is held in turn in the U.S.A. (at Brookhaven National Laboratory in 1961), the U.S.S.R., and CERN (scheduled for 1965).

The largest group of CERN participants (eight people) went from the Accelerator Research Division, and others from the Proton Synchrotron Machine, Synchro-cyclotron Machine, Nuclear Physics Apparatus, and Engineering Divisions. Among the twenty-one papers contributed from CERN were a number dealing with design aspects of both a possible 300-GeV proton synchrotron and storage rings for the present synchrotron, as well as the electron storage-ring model in the Accelerator Research Division. Other papers dealt with the changes that have occurred at the 28-GeV synchrotron during the past two years, the two beam-ejection systems, particle separators, and the separated beam designed for the 1.5 m bubble chamber ●