

The huge assembly hall at Laboratory II which has a floor area of about 11 000 m². The hall was brought into use in February when the prototype magnets were wheeled in. Some Lab. II staff have moved over from their temporary accommodation in Lab. I to the first office block to be completed, which is alongside the assembly hall.

During this time the magnet, cooled with helium gas, was fed with low current (1kA corresponding to 0.6 T in the chamber) so as to have some magnetic force pulling the two coils together. This avoids possible damage by preventing them from bouncing around when the expansion operates. Some curvature of the tracks was thus achieved as a by-product.

The remaining step in the tests is to operate the chamber in the highest possible magnetic field. This might however be postponed until the next run, because there is trouble with a hydrogen leak.

Mole in the hole

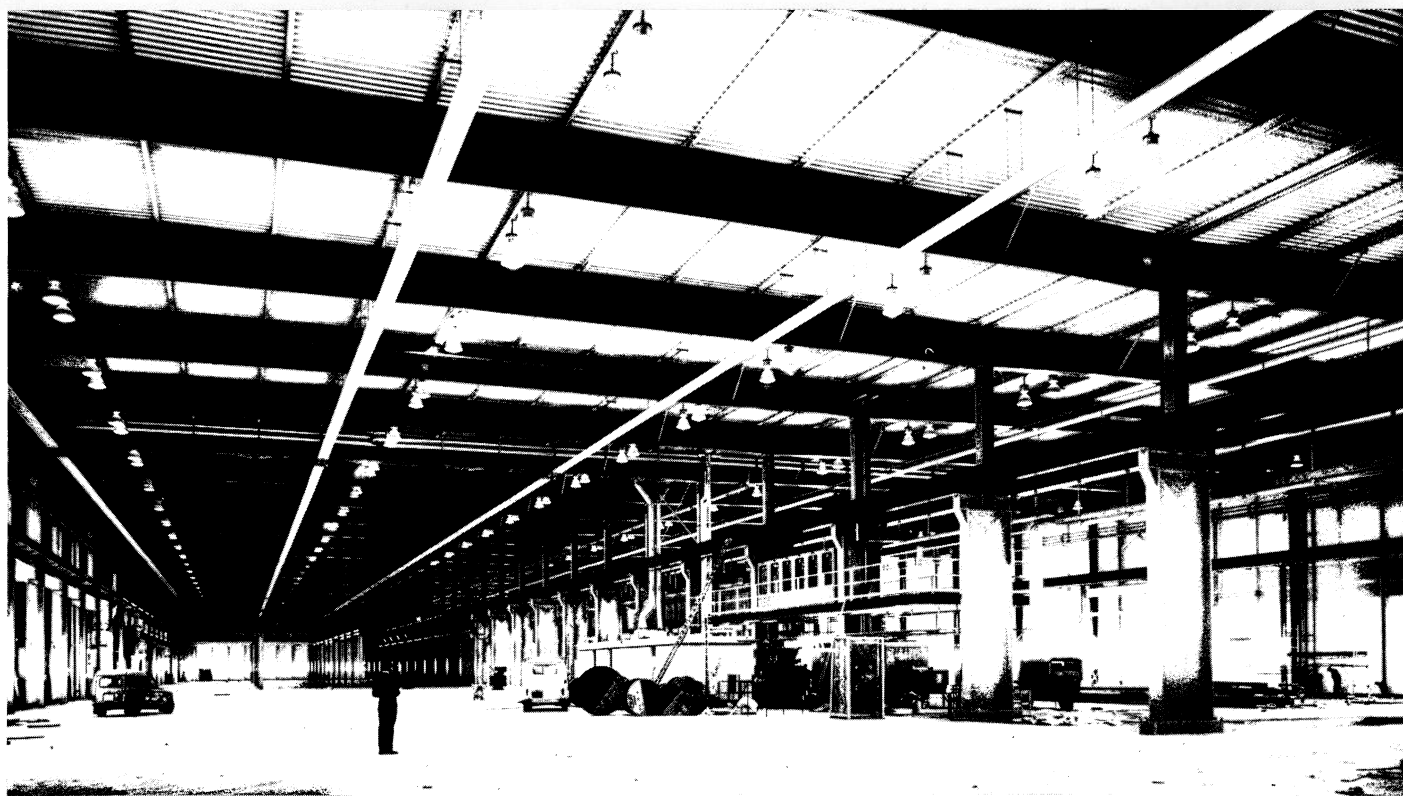
February 19 was the second anniversary of the authorization of construction of the SPS by the CERN Member States. The anniversary was celebrated by a start on boring of the ring tunnel by the 'mole'.

The tunnel for the new proton synchrotron will be 4.8 m in diameter with a circumference 6.9 km and its average depth will be 40 m below ground. Boring this tunnel is probably the most impressive part of the civil engineering programme of Laboratory II.

Among the reasons for selecting a tunnelling scheme (rather than 'cut and fill') was a desire to avoid changing the character of the countryside in a major way so that agricultural and forestry activities can continue much as previously. A second reason is the variation in altitude over the site (45 m between the lowest and highest points) which would have made 'cut and fill' very difficult. To retain a minimum earth shield of 20 m for radiation protection, the tunnel will be bored at a depth which is 65 m below the highest point on the surface. A final point is that the molasse bedrock is solid enough to allow the tunnel to be bored reasonably easily.

A detailed description of the boring machine, known as the mole, can be found in vol. 12 page 124. The machine is a conventional Robbins boring machine built for CERN in a factory in Seattle, where it underwent pre-delivery tests. It came by sea from the Pacific coast of the USA through the Panama Canal to Rotterdam and up the Rhine to Basel, whence it was brought to Geneva by lorry. It arrived at the end of last year.

The head of the mole has 35 cutters. Behind the head on each side, two lateral hydraulic rams push supporting pads against the wall of the tunnel to form the supports for the machine as the head grinds into the molasse. The head is pressed against the rock by means of four axial rams with a stroke of 120 cm and an effective pressure of 480 tons. After boring these 120 cm the machine stops, a foot is lowered beneath the operator's cabin behind the head to keep the whole machine



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The mole being installed underground at the point where boring of the tunnel is beginning. The mole has a 7 km journey confronting it around the circumference of the ring which is expected to be completed by Autumn 1974. The head shown here is 4.8 m in diameter. It was lowered into the tunnel in January and the whole machine was assembled below ground. In addition to the head, the machine comprises pressure and supporting pads, an operator's cabin, electrical equipment, conveyor belts, tunnel lining system, skip changer and spoil removal train. Its total length is 80 m.

in balance, and the two lateral supporting rams are retracted so that the four axial rams can pull the supporting system with them. After this the head can start work with 120 cm of travel in front of it again.

The 14 ton lift of the PGC (civil engineering shaft) could not be used for lowering components of the mole because of the bulk and weight of certain items. They were lowered down the nearby shaft PP1 (45 m deep) using two automatic cranes which could take loads of 30 and 100 tons. The heavy components, weighing more than 10 tons, were assembled at the bottom of PP1, while other less bulky ones were taken to the assembly region from which the tunnel boring starts.

The mole platform (9.5 m long and weighing 32 tons), which carries a 750 kVA transformer, electrical cubicles, oil tanks and the operator's cabin, was lowered in a vertical position by the large automatic crane. It was swung horizontally by means of the second crane and parked at the assembly point. The main shaft, forming the connection between the boring head and the platform and containing, among other things, the lateral support system, was parked in the 'neutron trap' at the back of the access tunnel from PP1. Then the head itself (total weight 53 tons) was lowered after some prior assembly at the surface. It was coupled to the main shaft at the bottom of PP1 and the whole was transported on small Caterpillar trucks to the assembly point. The various assembly operations, which began on 11 January, took about a month.

The 'train', which immediately follows the boring machine and which has the tunnel lining system and the skip changer for the spoil extraction, was set up at the same time. Tests on the complete installation began in the second half of February and the machine was ready to start on its way at the beginning of March.



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The problem of removing the spoil is solved in the following manner. It is carried on conveyor belts from the scoops on the boring head to a hopper (a funnel of about 2 m³). This is the first component of the skip changer located behind the tunnel lining system (shoring erector). The skip changer is a two storey affair—empty skips on the top railway track, full skips on the lower track. The hopper pours the spoil into a skip on the lower level of the changer. Once the skip is full, a ram pushes it on to a railway, still on the lower level, allowing an empty skip to be brought down from the upper level. This empty skip, in its turn, is pushed backwards beneath the hopper, and so on.

The changer can take twelve full skips on the lower track and twelve empty skips above. Once twelve skips at the lower level are full, a train pulls them to the PGC lift, which takes them to the surface two at a time. From there, they are taken to a device which tips their contents into a hopper. Then the spoil is taken on a conveyor belt to an intermediate store from which it is picked up by lorries and taken towards the centre of the site to a little dell which will be filled in.

The mole will operate 24 hours a day, six days a week. Out of these 24 hours, eight are for maintenance of the machines. When half the final length of the tunnel has been bored

(about 3.5 km) the shaft PP4 will take over the task of PGC for spoil extraction. Working at a rate of 20 m per 24 hours, the boring of the tunnel will take 18 to 20 months to complete.

The firms involved in the tunnelling programme are grouped in the ACCEL consortium: Losinger (Switzerland), Prader (Switzerland), Les Grands Travaux de Marseille (France), Forgal (France), Cuénod (Switzerland), and SELI (Italy). The shoring erector and skip changer (Grandori system) were built by SELI and three German firms (Zurnieden, Wolff and Vetter) supplied the spoil extraction system (installed at the PGC and PP4 shafts).

Telling the mole where to go

The survey problems at the SPS are different to those encountered in building the PS or the accelerator at Batavia. These machines were installed in a trench (the 'cut and fill' method) in open flat land. The different problems at Laboratory II are:

- installation of the magnet ring in an underground tunnel;
- links with existing installations at Laboratory I (mainly using the PS as injector and the experimental facilities associated with the West Hall);
- a difference in altitude around the circumference of the ring of about