

Start of neutrino experiments

The first data-taking run in the new series of neutrino experiments took place in the week 8-16 April preceding the PS shut-down. (The experiments and the equipment involved are described in CERN COURIER vol. 6, page 211.) 90 000 photographs were taken in the CERN heavy liquid bubble chamber. This was less than had been hoped for, due to the necessity to dismantle the chamber to change the membrane which transmits the pressure to the working fluid. A crack developed in the membrane during the run, perhaps due to the higher temperature at which the chamber is operated when filled with propane. However, all the intricate components of the neutrino beam-line worked successfully and a number of neutrino interactions were photographed in good conditions for measurement. The first scanning of the film has been completed and analysis of the data is in progress.

The fast ejected proton beam, drawn from straight-section 74 of the proton synchrotron, was matched to the target by a pulsed beam transport system. A series of tests had been made before the run to select the most efficient target configuration for the production of the 'neutrino parents' — pions and kaons. Targets of beryllium oxide, tungsten, sapphire, boron-carbide and copper were tested.

The new magnetic horn and the two large reflectors, which serve to converge the neutrino parents towards the detectors, worked throughout the neutrino run despite

preliminary problems with the solid-state power supplies which supply a current of 360 kA to the reflectors.

The elaborate arrangements to measure the spectrum of muons (produced at the same time as the neutrinos in the decay of the neutrino parents) have shown that the shielding had been carefully packed so that its stopping power corresponded with the design value. Knowledge of the muon spectrum gives an additional means to infer the neutrino spectrum, which is vital in any attempt to measure the cross-sections of neutrino interactions.

The shielding is thicker than is necessary for the bubble chamber experiments since it has been adjusted to accommodate a spark chamber experiment which has more stringent requirements for the elimination of muons coming through the shielding. The spark chambers, which are set up in front of and behind the bubble chamber, recorded data which will test the conservation law that in an interaction a muon neutrino always transforms to a negative muon. The spark chamber experiment will also attempt to determine whether the cross-section of the neutrino interactions depends upon the size of the nucleus in which nucleons are bound. In strong interactions in a nucleus, the rate of interactions is dependent on the number of nucleons, because the force between the incoming particle and the target nucleon is influenced by the strong forces acting between all the nucleons. For the neutrino, which is involved only with the weak forces, it is important to determine whether there is any effect on the interaction cross-sections on a nucleon due to the proximity of other nucleons.

About 20% of the bubble chamber operating time was given to a test of the feasibility of an experiment on inelastic muon interactions. By draining mercury from a pipe in the shielding, muons could pierce the shielding and be recorded in the chamber. These muon pictures have already been analysed and the experimenters are enthusiastic about the results of their test.

The next run for the neutrino experiments is scheduled to take place in July and this year's experiments will be concluded with a further run in September.



A photograph taken in the synchrotron ring tunnel at the point (straight section 74) where the fast ejected proton beam is taken out for the neutrino beam-line. The proton beam passes through the tunnel wall (top centre) and is directed onto a target. The positive pions and kaons produced in the high energy collisions are converged by magnetic lenses towards the heavy liquid bubble chamber. They decay after a very short time producing the required neutrino beam.

CERN/PI 40.12.66

Below are two remarkable photographs taken in the neutrino beam-line.

The one on the left shows the ejected proton beam emerging from the end of the vacuum pipe (on the right of the picture) and flying through the air towards the target. The narrow pencil of light is produced as the high energy protons raise the electrons of some of the air molecules in their path to higher energy states from which they return to lower energy states by emitting light.

To record this photograph, the camera was left in the tunnel of the neutrino beam-line and, by remote control, a single frame of the film was exposed during 200 synchrotron pulses. About 5×10^{11} protons passed in front of the film per pulse at this position in the beam-line. This is one of the few photographs ever taken of a high energy proton beam in air.

On the right, is a photograph of the light produced by the ejected proton beam in a Cherenkov counter. The camera is looking at a ground glass screen on the end of the counter, in a direction at right angles to the proton beam. The light has been reflected towards the camera by a thin aluminium foil placed in the beam at an angle of 45° .

The counter was filled with argon gas under pressure. As the high energy proton beam passed through it caused light to be emitted at an angle to the direction of the proton beam which depended on the velocity of the protons and the pressure of the gas in the counter. (This is the operating principle of Cherenkov counters.) The foil intercepted this emerging cone of light and reflected a cross-section of

the cone — a ring of light — to the ground glass screen.

Again, one frame of the film was used to record 200 pulses and during this time, the pressure of the gas in the counter was gradually increased so that the light emerged at wider angles, giving a succession of rings of increasing diameter on the ground glass screen.

This Cherenkov light can be used to measure the intensity of the ejected proton beam by placing a photomultiplier over the end of the counter. This technique has been used to make relative intensity measurements and the system may be calibrated in a slow ejected proton beam to give absolute measurements.

Foils coated with a fluorescent material, zinc sulphide, can also be left in position in the beam and the beam profile observed on the foil by a closed-circuit television camera. The zinc sulphide burns off rather quickly, however, if the foil is left permanently in the beam. Just before the target in the magnetic horn, there is a coated foil which can be flipped in the path of the beam by remote control.

Another method, which has been used in the neutrino beam-line to observe the beam profile and also to measure the distribution of proton intensity over the cross-section of the beam (which the zinc sulphide coated foil does not give) is to insert a mesh of aluminium wires, with wires aligned horizontally and vertically, in the path of the beam. The high energy protons induce radioactivity in the wires. The radioactivity induced in each wire, which is proportional to the number of protons incident on the wire, can be measured when the mesh is later withdrawn.

CERN - USSR discussions

On 10 April, Professor B. Gregory, Mr. G.H. Hampton and Dr. O. Lock went to the Soviet Union to continue talks on the present and future collaboration between CERN and the USSR in the field of sub-nuclear physics. In particular, meetings were held with the State Committee for the Utilization of Atomic Energy (headed by the Chairman, Professor A. Petrosyants) on scientific and technical co-operation at the 70 GeV proton synchrotron nearing completion at Serpukhov.

This visit followed the approval by the CERN Council, at the Session in December 1966, of the possibility of collaboration and the authorization, then given to the Director General to negotiate a Convention between CERN and the State Committee. The latest contacts were very fruitful and the two parties have come to a common opinion on the possibility of conclusion of the Convention.

The CERN representatives also visited the Institute for Theoretical and Experimental Physics, the Lebedev Institute, Dubna, and Serpukhov itself. At Serpukhov, they had discussions with the Director of the Laboratory, Professor A.A. Logunov, and other senior staff. They were able to see the present state of progress in the construction of the 70 GeV machine, the highest energy accelerator in the world. It is hoped to have the first high energy beams accelerated in the synchrotron before the end of the year.



CERN/PI 91.4.67



CERN/PI 195.2.67



CERN/PI 70.5.67

The Emperor of Ethiopia, H.M. Haile Selassie, visited CERN on 9 May. The Emperor was accompanied by three of his children and grand-children and by the Ethiopian Ambassador to the Federal Republic of Germany. The visitors were welcomed by the Director General and by the Director of Administration, Mr. G.H. Hampton. This photograph was taken in the proton synchrotron control room during a tour of the site. Dr. K.H. Reich (on the left) is describing machine operation. Mr. Hampton is on the right.

Other visitors in May included the AERIE Foundation, UK, on 1 May; the Science Research Council, UK, on 18 May; and the Institut des Hautes Etudes de la Défense Nationale, France, on 19 May.



CERN/PI 339.4.67

Professor F. Hoyle from Cambridge University, UK, gave a colloquium on 'Nuclear reactions in a universal fireball', to a packed auditorium at CERN on 27 April.

Academician V.A. Kirillin, Chairman of the State Committee of the USSR Council of Ministers of Science and Technology, paid a brief visit to CERN on 8 April. He was welcomed by the Director General.

The robots are coming ?

A remotely-controlled manipulator has been installed at the proton synchrotron during the shutdown. It will be used for a series of tests on remote handling techniques, which are becoming increasingly important at accelerators. The principle aim behind the use of such a manipulator is to carry out maintenance and modification work in 'hot' areas of the machine (where the radiation levels make it impossible or very difficult for personnel to work). It could also make it possible to carry out some work on the machine while it is in operation, without the necessity to shut the machine down to enter the magnet ring tunnel.

On the synchrotron at present, the hot areas are concentrated particularly at the

regions where internal targets are installed. A significant proportion of the scattered protons and the secondary particles produced in the high energy collisions in the targets do not emerge down the beam-lines into the experimental halls, but hit the walls of the vacuum chamber, the magnets etc. in the region of the target. Other hot areas are those around the magnets used in the ejection systems. The efficiency of the slow ejection system, in particular, is not yet very high and a considerable percentage of the accelerated proton beam is not ejected but is lost inside the magnet ring. High levels of radioactivity are produced in these regions, and when it is necessary to carry out work (such as changing a target) great care has to be taken to ensure that no one receives a radiation dose in excess of the maximum permissible.

These problems have only recently developed to serious proportions on the CERN PS but it is obvious that in the coming years, especially when the repetition rate and the intensity of the machine are increased in the course of the improve-

ments programme, special measures will have to be taken to safeguard components and to ensure that servicing in hot areas can be carried out. One approach, which has been under study at CERN for several years, is to make a remotely-controlled robot capable of carrying out work in these areas. The manipulator now installed in the PS ring is the result of this study.

The manipulator is suspended from a crane bridge which can be moved around the synchrotron ring on rails above the level of the magnets. Another, independent, bridge carries lights and closed-circuit television cameras to observe the work in progress. The actual observation and control is carried out from a control point 100 m away at the centre of the magnet ring.

Three cameras are used; one observes a general view of the environment where the work is taking place, and two (capable of providing two views at right-angles if necessary) observe the work in close-up detail. The position of each camera can be controlled remotely (using motors to drive the cameras with four degrees of

The remotely controlled manipulator which was installed in the synchrotron ring during the machine shutdown. The operating arm (centre of photograph) is suspended from a crane bridge which can travel around the ring. The lights and television cameras used to observe the operation being performed can also be seen.

The motor-alternator set of the new synchrotron power supply photographed at the factory before leaving for CERN. The set arrived at the site on 19 May.

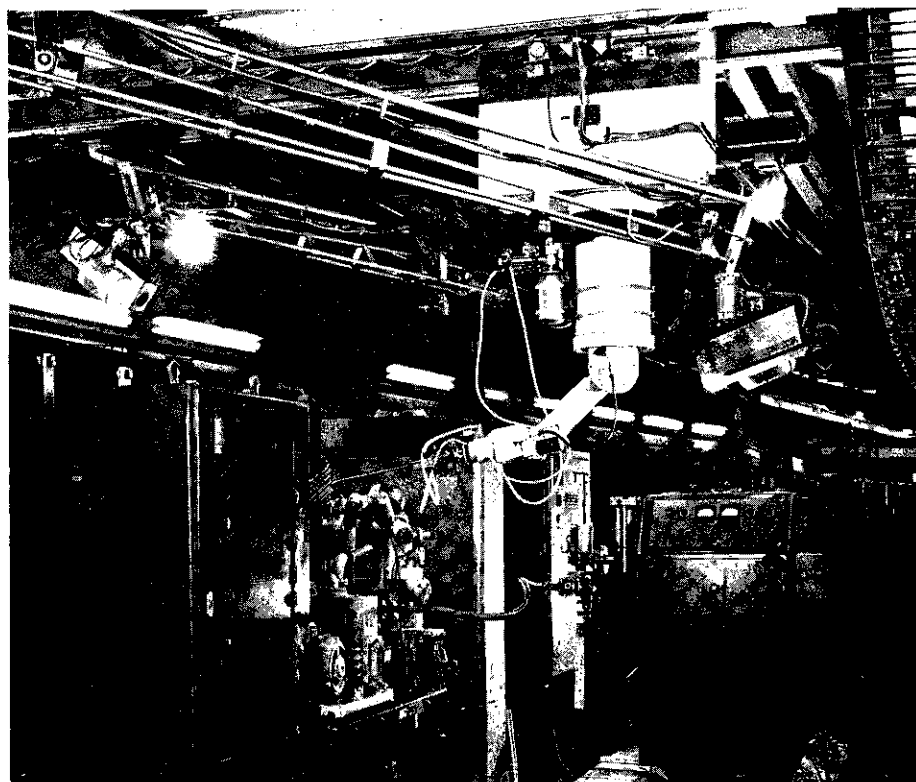
freedom) and their positions are indicated back at the control point.

The crane bridges can be moved into place over 40 m of the circumference of the ring. They move from place to place at speeds up to 0.5 m/s and are manoeuvred into their precise position at 4 mm/s. Five cables, each with 44 conductors, carry signals between the bridges and the control point. The cables emerge from a fixed point on the wall of the magnet ring tunnel and special methods are used to wind the cables in and out according to the position of the bridges.

Prior to installation at the PS, this prototype manipulator has carried out such tasks as changing a special target unit, locating vacuum leaks, and connecting and disconnecting electrical cables.

The experience with this manipulator at the PS will be a very useful guide to the techniques which need to be employed more and more at high energy accelerators.

A more detailed description, by W. Richter, M. Ellesplass and R. Horne, can be found in 'Industries Atomiques' Nos. 1-2, 3-4, 1967.

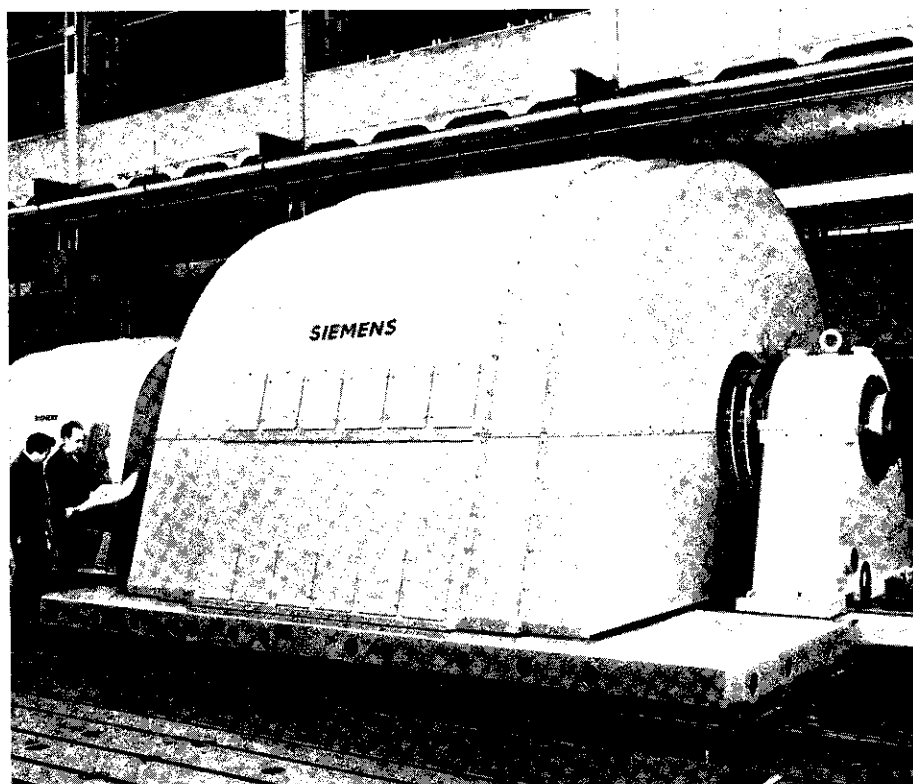


CERN/PI 112.5.67

Colloquia

Two colloquia have been arranged for June:

8 June: Dr. H. Coblans, previously head of the Library services at CERN who is now with ASLIB in London, will talk about 'The computer, the information problem and all that'. The colloquium will cover the achievements and limitations of mechanization in documentation, automatic indexing and machine translation, and the implications of the man-computer partnership in the handling of information. 22 June: Professor U. Schmidt-Rohr from the Max-Planck Institut at Heidelberg, will talk about 'Nuclear structure studies with 52 MeV deuterons'.



(Photo Siemens)

Power supply arrives

Another important stage in the programme of improvements for the 28 GeV proton synchrotron was reached in May when some of the major components of the new main-magnet power supply were delivered to the site. The base plate and the bearings of the alternator and motor arrived on 1 May and installation has already begun in the new power supply building. The motor-alternator set arrived on 19 May.

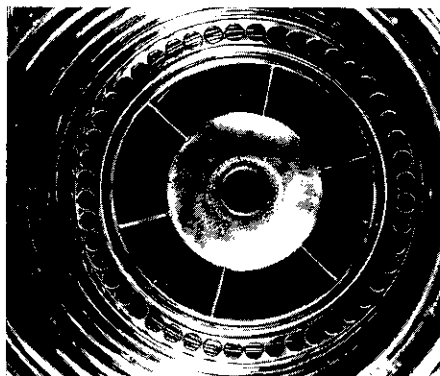
Construction of this large new power supply began at the Siemens factories in Berlin at the beginning of 1966. At the end of March 1967, CERN experts went to the factory to be present at a stringent series of acceptance tests designed to ensure that the plant would meet its specification.

Some of the parameters of the new supply are as follows — It consists of a 1000 rev/min alternator driven by a 6 MW asynchronous motor. The total weight is about 216 t including an 88 t rotor. The mean power is 46 MVA with peak power 95 MVA. The current fed to the coils of the synchrotron magnet is rectified by a converter set with 48 mercury arc rectifiers.

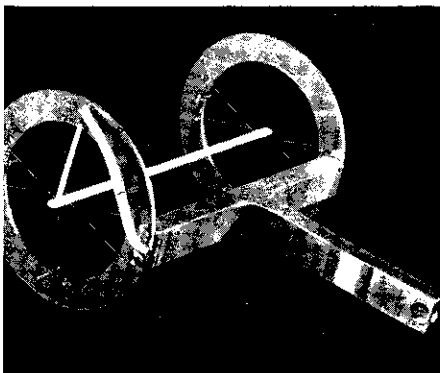
The power supply acts as a buffer between the electricity grid and the magnet, smoothing out the effect of the great surges of power (with the new supply these will be up to 6400 A at 11 kV) which are required for each pulse of the synchrotron. About 5.5 MW of power will be drawn continuously from the mains by the asynchronous motor to make up the losses which occur in the magnet coils and the power supply itself.

The new supply will make it possible to operate the proton synchrotron at two or three times its present pulse repetition rate. It replaces the existing supply (which will, however, stay in commission as a spare) which has now provided over 50 million pulses.

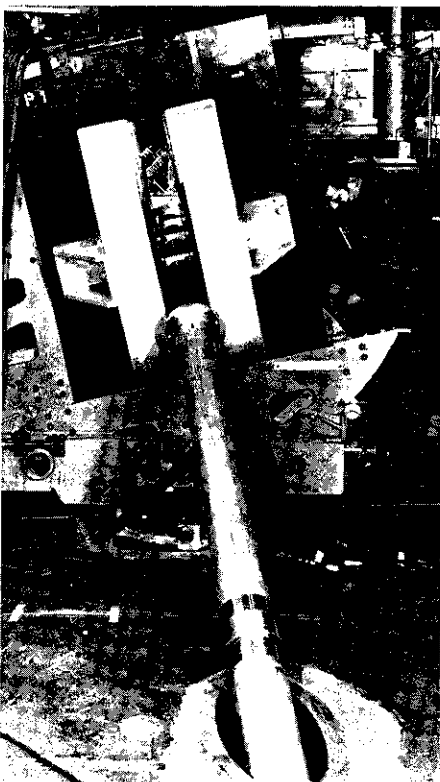
Delivery of the whole plant will be completed in August. It is hoped that installation of the supply will be finished by the end of October. Tests at CERN, without the PS magnet as load, will then begin. Actual connection to the magnet will probably take place during the main shutdown of the synchrotron early in 1968.



1 CERN/PI 110.5.67



2 CERN/PI 88.4.67



3 CERN/PI 313.4.67

1. After being in operation for a year, the new 500 kV accelerating column, at the input of the linear accelerator which feeds the proton synchrotron, was opened for inspection during the shutdown. This photograph of the inside of the column was taken looking from the position of the proton source. The beam passes through the circular aperture at the centre of the electrode (called the intermediate electrode; it carries a potential of 250 kV, half the total potential across the column).

The electrode is constructed of titanium, which is an excellent material from the point of view of high voltage properties in vacuum. Electrical breakdowns do occur, however, from time to time and the small pock marks, which can be seen surrounding the aperture, were produced by the sparks.

2. A typical target used in ejected proton beams at the synchrotron. The target proper is the copper rod $1 \times 2 \times 100$ mm³, (the axle of the two wheels) supported by thin wires. When the proton beam (whose cross-section is of the order of 2×3 mm²) hits the target, a large amount of charge is ejected, mainly as 'knock-on' electrons, and this effect is used for 'burst-intensity monitoring'. The target is simply electrically insulated and connected to a charge measuring instrument. The amount of charge removed from the target gives information about the number of interactions (primary and secondary) that have taken place.

External targets are usually set up in air and not in a vacuum enclosure. The free charges in the heavily-ionized air surrounding the target could therefore partially neutralize the required signal. However, this difficulty is largely overcome by coating the target surface with a thin layer of aluminium oxide, which prevents the low-energy charges in the air entering the target.

3. A view of the first bending magnet in the beam-line from the synchro-cyclotron to the ISOLDE laboratory. The magnet steers the beam down through a hole cut in the floor of the SC hall, to the underground tunnel leading to the target room. The magnet frame was specially designed in the SC drawing offices so that the magnet can be rotated around the axis of the beam. The short shutdown of the SC, when the major components of the beam-line were installed, finished on 14 April. Before the end of the month, beam had been taken as far as the target. Intensities of 3×10^{11} protons per second have been achieved, with a beam cross-section (containing 90 % of the protons) of 3 cm diameter. Tests were carried out to ensure the adequacy of the installed shielding and the results are now being analysed.