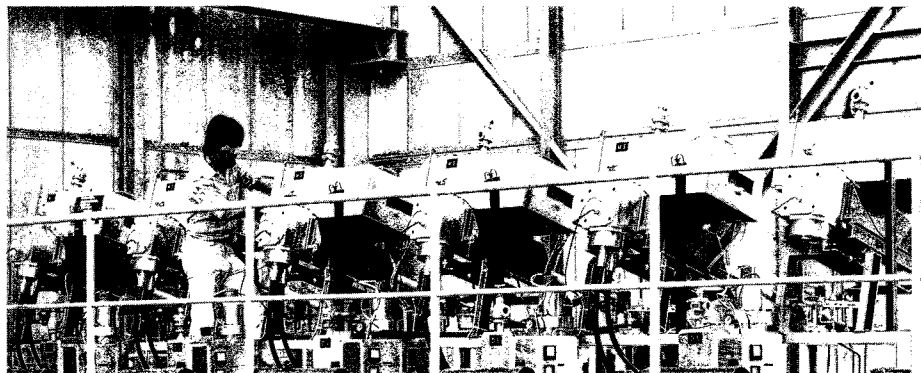
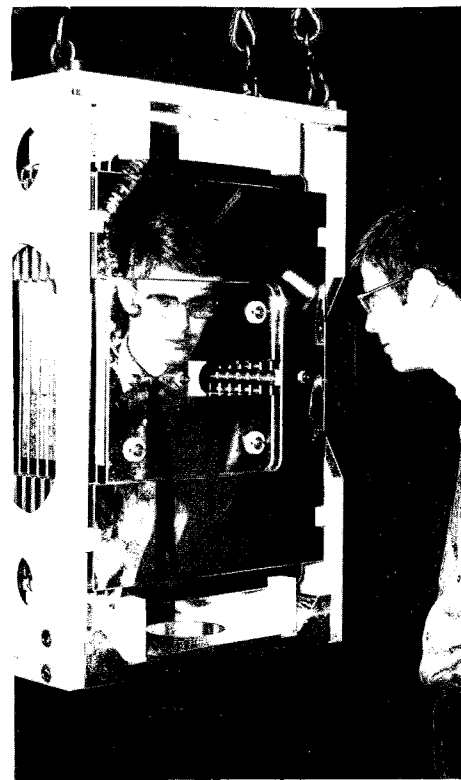


Part of the pulse generator system which powers the FAK. Six of the generators (each feeding a different module) can be seen. They are located in a building at the centre of the PS ring and are connected to the FAK via high quality cable. Each generator is capable of supplying a 100 MW pulse for up to 2.2 μ s.



CERN 82.9.73

One of the nine modules of the Full Aperture Kicker. The capacitor plates, which determine the characteristic impedance of the module, are polished to a mirror finish. They hide the ferrite around the magnet aperture.



CERN 94.2.73

(see vol. 8, page 26) but it was not successful mainly because of attempting to use araldite impregnated ferrite to serve as the vacuum chamber and high voltage dielectric as well as the magnetic circuit. The new kicker has a separate vacuum chamber surrounding the ferrite. It is built in nine modules each fed by its own pulse generator. The aperture available to the beam is 147×53.5 mm and the total length is about 2.4 m. Each module has a characteristic impedance of 15 ohms.

The reason for the division into many modules is the need to fill the FAK with field (and empty it) in the 0.1 μ s interval between the passage of successive bunches at full energy in the PS. The pulse is derived from a cable pulse forming network charged to 80 kV. Thyratrons are used at each end of the network — one to switch power to the kicker, bringing on the required field in about 75 ns, and the other to switch the power to a dump to bring the field off in the same time interval. By adjusting the firing times of the thyratrons the pulse length at the FAK can be varied to eject from one to twenty (i.e. all) bunches in the PS. The pulse forming network can be recharged in 4 ms and the kicker can be powered to perform up to four ejections per machine cycle.

The most difficult aspects of the FAK design and construction have been connected with the ferrite. The

magnet has about 500 kg of ferrite inside the vacuum vessel. To lessen the outgassing problem the ferrite was immersed for two months in boiling demineralized water to remove hygroscopic salts and then vacuum baked. With nine ion pumps on the vessel, a pressure of better than 10^{-7} torr is achieved. The remanent field of the ferrite was measured using an electron beam and some of the material proved to be a little outside the specified limit. This caused no noticeable disturbance to the beam in the proton synchrotron.

Another lengthy pre-operation procedure concerned the thyratrons. High reliability is needed and has been well achieved — six tubes withstood a life-test of a hundred million pulses.

The FAK is intended to take over all the fast ejection system operations from the present small aperture kickers. During the PS run, the FAK was used for ejection from straight section 74 towards the heavy liquid bubble chamber Gargamelle and for high intensity filling of the ISR. This involved manually changing the magnet polarity in the accelerator ring.

The kicker operated reliably throughout the run and achieved ejection with no discernible beam loss. Its abilities were particularly noticeable when it was required to eject nineteen bunches; it was able to leave a single clean bunch orbiting quietly in the proton synchrotron ring.

Annual shutdown

As usual at this time of the year, the PS and ISR are shut down for maintenance and modifications. This means the interruption of all experiments while the equipment of the PS, ISR and experimental halls is inspected and overhauled methodically.

There are more than 500 jobs to be carried out at the PS and we pick out only the major tasks: At the linac, in addition to the maintenance work, the flexible power supply cables for the r.f. cavities have been replaced by rigid one. This will improve the reliability which is crucial to the whole CERN accelerator complex.

At the Booster the tasks include:

- replacing a defective vacuum chamber in a bending magnet unit
- replacing a vacuum vessel and its four septum magnets for injection by septum magnets of an improved type
- installing four wide-band radial pick-up stations
- re-aligning the injection system
- surveying magnet positions and alignment of the quadrupoles.

At the PS ring, as is the case every year, the work to be carried out on the magnets is considerable because of radiation damage. Of the 100 magnets in the ring, two will be replaced by reconditioned units and eight others will be repaired by strapping the end blocks on which the adhesive has

suffered damage. Another stage of the installation of the auxiliary correction magnets has now been completed and this work will be reported in next month's issue.

A new large-aperture septum magnet (vertical aperture measuring 30 mm instead of 20 mm) for the ejection of a high intensity beam has been installed for the neutrino area, necessitating modifications to the vacuum chambers in the upstream and downstream magnets. New power lines have been installed for this magnet.

Special attention is being paid to the vacuum systems since 75 out of the 100 straight sections must be opened up. Fifteen of these straight sections are being modified. Special attention is also devoted to the control room where 25 racks will be converted in order to change from manual to automatic control. New consoles are being installed for this purpose and the equipment is being modernized.

For the main magnet power supply a system has been installed enabling one of the two rectifier units to be bypassed. During the flat top of the acceleration cycle, the second unit will operate at double voltage, thereby reducing blow-up of the beam. This will improve the power factor and the increase in reactive power will result in flat tops between 20 and 30% longer, depending on the cycle used. This system should be operational for Easter.

At the experimental halls: In the West Hall, the only modification is the installation of a d.c. superconducting lens in the u7 beam for tests. In the North Hall, the main job is to dismantle the k16 beam to the Hybuc bubble chamber which has finished its experiment on the magnetic moment of the sigma hyperon. In the South Hall, to allow access to the PS ring, nearby beam-line components must be moved and some separators, which

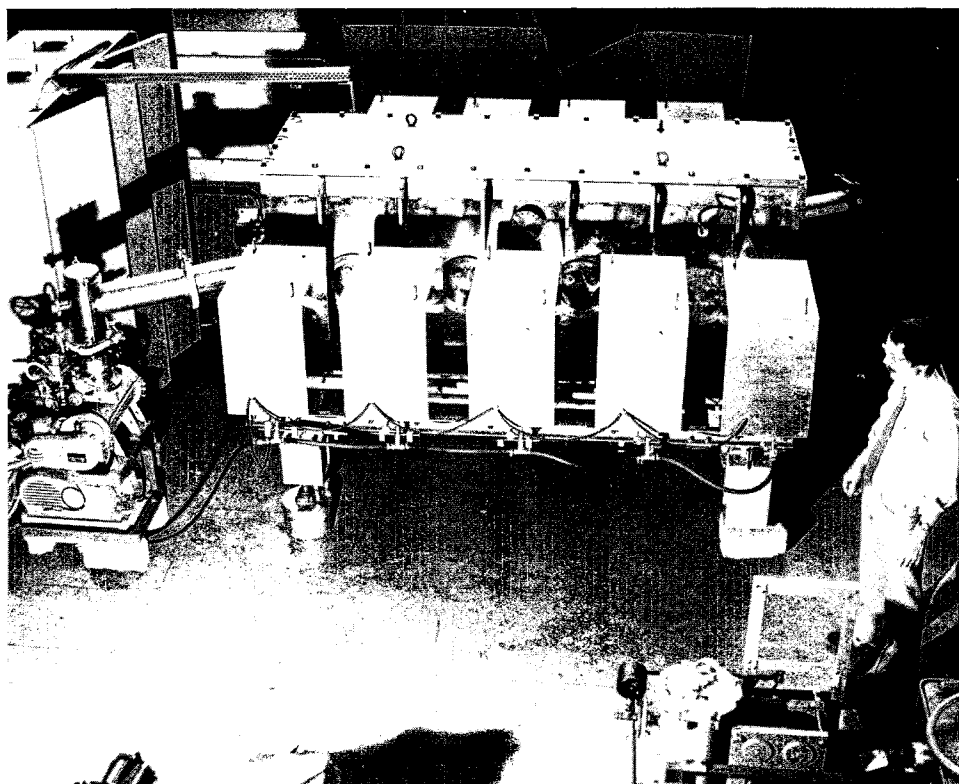
have not been operating well, are being taken out and reconditioned. In the East Hall, certain beam-line magnets which have been exposed to radiation are being removed for overhaul and replaced by reconditioned components.

In addition, some reorganization of the East Hall beam-lines is under way. The medium energy p8 pion beam is being replaced by a b20 neutral particle beam for an experiment to study neutral kaon-proton interactions. The p13 beam is being modified and will be known as p14. Its particle production angle will be smaller thus increasing the beam intensity. At the end of the u5 beam-line, bending magnets are being replaced by more powerful versions in order to separate neutral particles which will feed the 2 m bubble chamber. It is estimated that the operations in the East Hall will involve moving and re-positioning more than 3000 tons of equipment

(iron, concrete shielding and beam transport components).

At the ISR, the shutdown began on a note of satisfaction because the high intensity run using the Booster resulted in a better feed to the ISR than had been anticipated. On 7 December, 20.6 A were stored in Ring 2 and 22.1 A in Ring 1 with high luminosities also being achieved. The average pressure over the two kilometers of vacuum chamber is less than 2×10^{-11} torr, with even lower values of 10^{-12} torr in certain regions. This followed the installation of 500 titanium sublimation pumps and 47 bake-out operations in 31 different sectors.

In order to confirm this performance and continue improvements during 1974, a programme has been carefully worked out to take full advantage of this third major shutdown of the ISR. In view of the wide range of possibilities, a list of priorities was drawn up as a compromise between work



devoted to development, installation, experiments and maintenance.

New apparatus is being installed to make possible better studies of the beam behaviour. A number of lenses (sextupoles and octupoles) are being introduced around the two rings to compensate non-linear beam resonances. A special observation station will be used for monitoring the horizontal beam profile. A damping magnet will correct vertical errors in the injection system. Titanium jackets are being installed in the vacuum chamber to prevent pressure bumps and it is planned to use several gas discharges in an argon atmosphere to clean out certain chambers in twelve sectors, which will be baked out during the machine shutdown.

Most activity will, however, centre around the intersection regions where certain experiments are being replaced by new ones.

In intersection 2, the programme of experiment R203 using a wide-angle spectrometer has been completed and it will be converted to experiment R205 by the addition of a central hodoscope composed of 120 scintillators around the intersection.

In intersection 4, the detectors used for five experiments have been dismantled for inspection of the Split Field Magnet and baked out of this intersection region. It is hoped that all the detectors can be re-installed before the end of the shutdown period.

In intersection 5, chamber modifications are being carried out which should help to improve performance and be particularly useful for the measurement of beam luminosity.

In intersection 6, experiment R603 has been dismantled and a new vacuum chamber is being installed to continue studies on small-angle elastic diffraction scattering with experiment R602. New detectors are also being installed by this group.

In intersection 8, the vacuum cham-

ber is being modified for experiment R801 in order to be able to check the total cross-section by simultaneous measurement of the overall number of interactions and the small-angle elastic diffraction scattering rate. The vacuum chamber for experiment R802 is being completed by the installation of a special chamber known as the 'flying bedstead'. Finally installation of a new experiment, R803, should also begin.

Gamma-transition jump

The 'gamma-transition jump' system used in the 28 GeV proton synchrotron proved to be particularly effective in coping with the increase in intensity recorded before the machine shutdown.

In a synchrotron, the principle of phase stability, discovered by V. Veksler and E. McMillan, makes it possible to achieve stable acceleration of many particles because of synchrotron oscillations. A synchronous particle orbits the ring exactly in rhythm with the accelerating fields while a bunch of other particles oscillate around it sometimes arriving at the r.f. accelerating station sooner, sometimes later.

A particle which has a higher energy than the synchronous particle acquires a higher tangential velocity resulting in two conflicting effects — an increase in its angular velocity around the ring and an increase in its orbit radius. In a strong-focusing synchrotron, the former effect is the more important at low energies. It cuts down the time taken to travel around the ring and the particle arrives ahead of the synchronous particle at the r.f. accelerating field and must therefore receive less energy from that field than the synchronous particle in order to keep it in the bunch.

At high energies, on the other hand, the latter effect is predominant — the proton has further to travel in going around the ring and this increases the revolution time. A particle arriving later than the synchronous particle has then to receive less energy from the r.f. field in order to remain in the bunch.

Between this low energy and high energy behaviour, there is an energy at which the increase in angular velocity exactly counters the elongation of the orbit. The time taken to orbit the ring is independent of the momentum of the particle and the corresponding energy is known as the transition energy. The r.f. accelerating voltage has to change phase when the transition energy is reached to adapt to the changing particle behaviour.

Space charge phenomena also undergo radical changes when the transition energy is crossed since the behaviour of the particle bunch is completely different below and above this energy. Below transition energy, the forces of repulsion between particles cause the bunches to lengthen. Above it, these forces cause the bunches to shorten. This results in oscillations in the shape of the bunches and can lead to dilution or even considerable losses. Moreover, just after transition, the slight statistical fluctuations in the bunches increase and cause them to expand laterally (negative mass effect).

The transition region must be crossed fairly rapidly in order to avoid damaging effects from these two phenomena. The solution consists in abruptly changing the transition energy just before crossing the transition region, by acting directly on the focusing forces which dictate the transition energy.

Since 1969, the transition region has been crossed by provoking a 'jump' in the number of horizontal betatron oscillations per turn, Q_H ,