

A schematic circuit diagram of the scheme proposed for very rapid pulsing of a septum magnet such as might be used to eject from the PS to the 300 GeV. Enough charge is stored initially for twenty magnet pulses and selective switching of the thyratrons picks out sufficient charge for a single pulse so that the magnet can be pulsed every 50 μ s.

Kicking faster for the 300 GeV

The possibility of using the 28 GeV proton synchrotron as injector for the 300 GeV machine is an important part of the proposal to build the machine alongside the existing CERN Laboratory. There would then be no need to construct a separate linac and booster for the 300 GeV which could both reduce construction time and save money. However to use the PS in this way, is not without its problems. An ingenious solution to one of these problems — that of 'kicking' the beam from the PS to the 300 GeV efficiently and quickly — has been proposed by A. Bruckner.

There are several possible variants as to how the ejection-injection process might go. We will describe just one of them since in terms of the topic we want to discuss they are all essentially the same.

The characteristics of the accelerated beam in the PS are obviously a fixed starting point. The beam is in the form of 20 bunches evenly spaced around the circumference of the ring 200 m in diameter. The probable diameter of the 300 GeV is 2.2 km (as mentioned in the last issue, page 277) and what we would like to do is to transfer the twenty bunches so that they are evenly spaced around the circumference of the 300 GeV which is eleven times larger than the PS. (The transfer will probably take place at an energy of 10 GeV.) There they will be given time to smear out into a ribbon beam (debunch) probably taking about 0.5 s. The r.f. system of the 300 GeV will then

be switched on for further acceleration, imposing its own bunch pattern on the beam.

Obviously if we powered a kicker magnet in the PS for a long enough time that all twenty bunches were ejected immediately one after another during one PS revolution, they would take up only one eleventh of the 300 GeV circumference. What we want to do is to power a kicker magnet for just sufficient time to eject one bunch, wait until that bunch has time to move around the 300 GeV and then power the kicker again to eject another single bunch. Repeating this procedure twenty times would then distribute the bunches evenly around the 300 GeV ring.

However, the conventional powering systems for kicker magnets take some hundreds of milliseconds to recover from one pulse before they can switch the magnet on again. With such powering systems it could take several seconds, if only one kicker magnet were used, to eject all the PS bunches in the way we want. It had therefore been proposed to use the massed kicker magnets of the PS, probably including some new specially installed kickers, to serve one after another to eject bunch after bunch.

The new idea concerns a way of powering a single magnet with pulses separated by only about 50 μ s. The operating principle is illustrated in a simplified way in the diagram.

In the interval between accelerator cycles enough power for twenty kicker magnet pulses is stored in the slow storage line on the left. When we are ready for ejection we close thyatron switch No. 1 (thyatron switch No. 2 is still

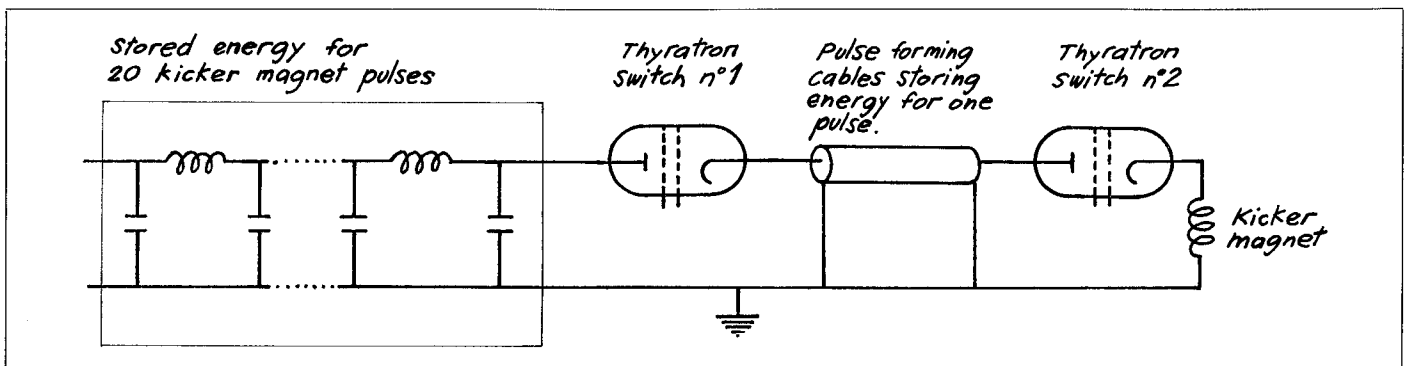
open) and pass charge for a magnet pulse, long enough to eject one bunch, into the pulse forming cables. Switch No. 1 is then opened and switch No. 2 closes to discharge the cables through the kicker magnet. The magnet is thus powered for long enough to pick out one of the orbiting PS bunches and bend it out of the ring towards the 300 GeV. Switch No. 2 opens again and switch No. 1 closes to pass charge for another magnet pulse and so on.

The time necessary for this process will be about 50 μ s per pulse. During this time the remaining bunches will orbit the PS about 25 times. By arranging the timing of switch No. 2 we can select the bunch to be ejected in the following sequence — bunch number one, bunch number twelve, bunch number three, bunch number fourteen... and so on (an eleven bunch interval, though other intervals would also work).

The main difficulty is likely to be keeping the thyatron switches operating independently of one another; the ionization in one thyatron has to die down before the other is fired. A method of 'despiking' the anode of thyatron No. 1 while No. 2 fires should overcome this. It is probable that a model of the powering system will be built in the near future to test the technique.

A heavy lepton

A paper by C.A. Ramm, published in Nature 26 September page 1323, presents evidence for the possible existence of a neutral heavy lepton with a mass of about 430 MeV. In examining data from three



The new source for the synchro-cyclotron (see CERN COURIER vol. 8, page 6) and its associated components, which is being installed as part of the SC improvement programme, will pass through the yoke and lower pole of the magnet through a distance of 2.75 m into the centre of the machine (an aperture is drilled in the steel). There was insufficient height beneath the SC for installing all the components involved, and a rectangular pit 5 m deep (seen in the photograph) has been dug beneath the centre of the machine for this purpose.

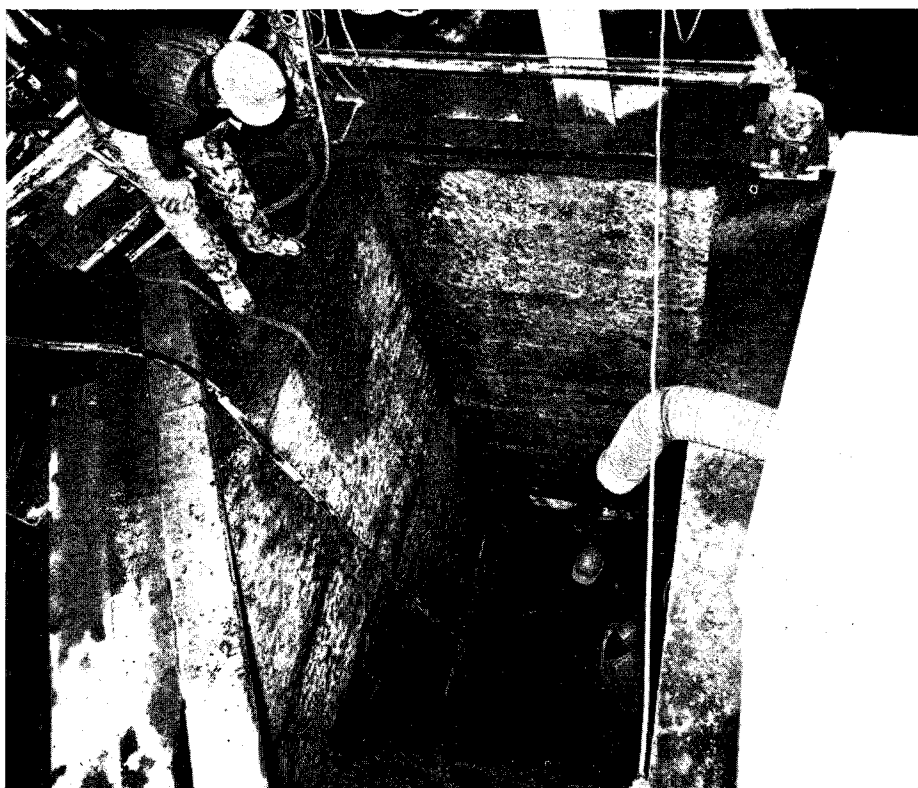
different experiments phenomena compatible with the existence of a particle which decays into a pion and a muon appear at this mass value in each case.

Very short-lived particles cannot be observed in a high energy physics experiment in the same ways as their more stable brethren by tracing their passage through detectors (for example, via bubble chamber tracks). Their existence is deduced from observing other features of the particle interactions in which they are involved, in particular by observing the particles into which they decay. By looking at the particles flying out from an interaction it can be deduced whether some of those particles had clung together in the interaction, i.e. whether for a short time they formed a distinct particle which then decayed into the particles observed. This deduction comes from totting up the masses (including converting energies back into mass) of emerging particles and plotting the number of observations against mass. A graph is thus produced which can show peaks at particular mass values suggesting the existence of short-lived particles corresponding to the mass values. The interpretation has to be done with care because there may be something built into the detection system which makes it more sensitive to particular mass values so that there are a large number of observations not due to the existence of a particle but to a bias in detection.

The heavy lepton story began in examining the results from the 1963 neutrino experiments at CERN but the data was then too sparse to do more than intrigue. More data, with greater precision, came from the CERN 1967 neutrino experiments carried out in the 1.1 m³ heavy liquid bubble chamber filled with propane. From interactions which were identified as being of the type — neutrino plus proton gives muon, pion plus proton

$$\nu + p \rightarrow \mu + \pi + p$$

it was possible to plot graphs of the number of observations of the muon-pion combination against mass. When this was done a small peak emerged at about 430 MeV. This could correspond to a short-lived particle which was formed in the interaction and immediately decayed into a muon and pion. Since the muon is a



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lepton and we believe 'lepton number' is always conserved, the particle would be a lepton. Since the muon and pion are always oppositely charged, the particle would have zero charge.

The study was carried further in examining data from two other experiments in which a muon and a pion emerged from an interaction — these were the X4 experiment, also in the heavy liquid bubble chamber at CERN, which looked at the decays of the neutral kaon, and an experiment in a hydrogen bubble chamber at Brookhaven which also looked at neutral kaon decays. In both sets of data the same type of small fluctuation appeared at the 430 MeV mass position.

People have speculated for some time about the possible existence of a lepton spectrum — the possibility that the familiar leptons (electron, muon and neutrino) have heavier relatives that have not yet been seen. This may be the first indication of their existence and there are less prominent clues to other heavy leptons from the same study. However, to put in the opposite scale pan, a team conducting a CERN kaon experiment, which has high statistics on interactions producing a muon and a pion, claims not to have seen any peak at the 430 MeV mass value. The possible existence of the particle obviously needs further investigation.

A search for charged variants of such a heavy lepton is now being undertaken by Ramm by looking at muon-gamma and muon-neutral pion decay modes in neutrino interactions and at muon bremsstrahlung. Again there is some evidence of their existence near the mass of the proposed neutral heavy lepton.

Gargamelle optical system

All the sub-assemblies for the Gargamelle heavy liquid bubble chamber built by Saclay for CERN are now complete and are being installed at CERN. This article concerns the optical system which was briefly mentioned in the article on the scanning and measuring tables for the chamber (vol. 9, page 36). Its design was dictated by the configuration of the chamber itself and by experimental requirements.

To provide the maximum possible coverage in terms of photographable volume of the long cylindrical chamber, eight wide-angle (110°) lenses are used in two horizontal rows of four. The cameras had to be placed outside the magnet yoke where the fringe field is weak, and thus the image needs to be transferred over a distance of 1.9 m inside a 20 cm diameter tube. Systems in which the film is taken inside a tube into the immediate vicinity of the liquid were rejected because of their complexity.

The optics are designed to introduce very little distortion (less than 1%) and to project the rays of light onto the film at an angle as close to the perpendicular as possible (with a deviation of less than 8%). Although considerable distortion can be allowed for by drawing up distortion charts, it is nonetheless desirable, for example to speed up the scanning of photographs of neutrino events in which there are a large number of gammas (materializing as positron-electron pairs), to use an optical system where straight lines in the chamber are rendered by