HARDWARE FOR A FULL APERTURE KICKER SYSTEM FOR THE CPS

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Summary

It is expected that after completion of the CPS improvement programme the existing small aperture plunging kicker magnets may be unable to efficiently eject a high intensity beam because of aperture and rise time limitations. This paper describes a full aperture kicker system which is being developed to permit full exploitation of high intensity fast ejected beams from early 1973 onwards. The design of the magnets and pulse generators is presented, together with their predicted performance. The measured performance of prototypes and the results of extensive life testing are given.

Introduction

The high intensity beam resulting from the improvement programme will make fast ejection from the CPS more difficult, because, firstly, the beam will be fatter and, secondly, the time interval between bunches will become smaller. To overcome these difficulties kicker magnets with greater kick, faster rise time and larger uniform field region are necessary. The degree of improvement in kicker magnet performance needed to deal with this situation was such as to surpass that which could be extracted from the existing plunging magnet system by further development. A decision was taken towards the end of 1969 to develop a new full aperture system of sufficient performance and flexibility to meet the foreseeable future needs for CPS fast ejection. The design and performance specifications for the hardware of this system are now being finalized after an exhaustive period of prototype measurement and testing.

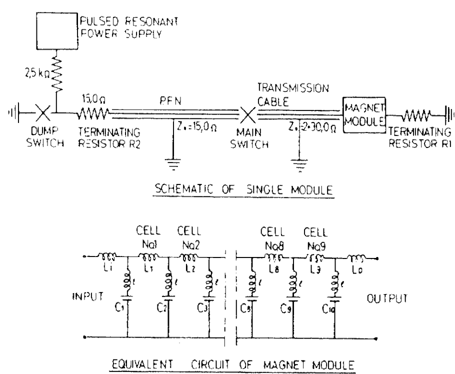

Fig. 1

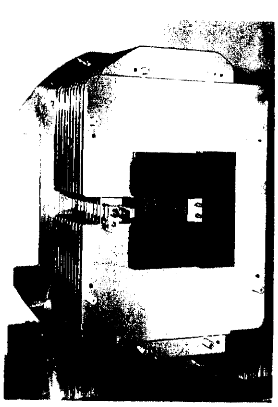

Fig. 2

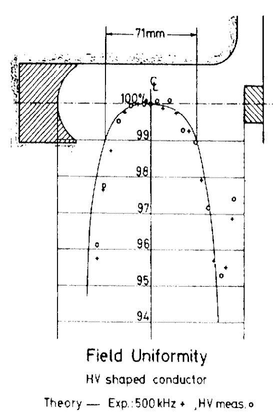

Fig. 3

System specification

A modular system (Fig.1) is proposed in which the full kick strength for 28 GeV/c ejections will be derived from 12 identical magnets, each powered by its own pulse generator. The system is to operate on fixed polarity with ejection on either the first (SS 16) or second turns (SS 58, 74). The possibility of using only 8 modules together with quadrupole kick enhancement [1] is foreseen for SS 16 ejections.

The system is to be capable of ejecting any number of bunches from 1 to 20 at each ejection and to perform up to 6 ejections per machine cycle. A minimum interval of 30 ms is foreseen between ejections. The deflection of the protons of the kicked bunches is not to vary by more than ± 2% and the perturbation to the most disturbed circulating bunch is not to exceed 3.5% of the kick.

Magnets

Construction

The magnets are of the delay line type [2], each consisting of 9 elementary cells. In order to minimize the oscillations associated with the rise and fall of the field, which are harmful to flat top stability and give rise to residual kick, a high characteristic impedance of 15 ohms has been chosen. The delay line inductance is that due to the magnet aperture (length 255 mm, width 147 mm, height 53 mm), the magnetic backleg being ferrite C-cores (Indiana General Corp. H2 material). Capacitance is provided by interleaved aluminium alloy plates, attached alternately to the HT and earth conductors. The PS vacuum will be used as dielectric for the capacitors, the plate spacing of 7 mm being considered adequate to hold off the working pulse voltage of 40 kV without recourse to lengthy conditioning processes.

Performance

A model magnet (Fig.2) has been constructed, similar in configuration to the magnets proposed for the PS. This model has permitted measurement of the component values of the magnet equivalent circuit of Fig.1. The theoretical performance of the model has been computed from this equivalent circuit in respect of kick rise time, flat top ripple, and field uniformity across the aperture. The model has also been pulsed at voltages up to 40 kV, pulse length up to 2.2 μs and measurement made of the same parameters. Very close agreement has been achieved as can be seen from the predicted and measured field uniformity (Fig.3) and wave propagation through the cells of the magnet (Fig.4). Measured waveforms of the kick pulse, both with and without transmission cable between pulse generator and magnet are seen in Fig.5. Small detail improvements are proposed for the magnets to be installed in the PS; their anticipated kick rise is given in Fig.6.

Pulse generators

Construction

The magnet pulse is derived from an SF_6 pressurized polythene tape cable PFN of fixed electrical length. Thyratron switching [3] by coaxially mounted EEV Co. CX 1171A tubes is provided at both cable extremities in order to permit infinite variation of pulse length within the limits permitted by the cable length. The construction of the main switch which is located at the magnet end of the PFN and which operates with floating cathode is shown in

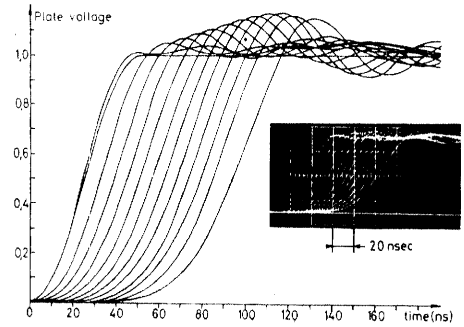

Fig. 4. Pulse propagation along the magnet.

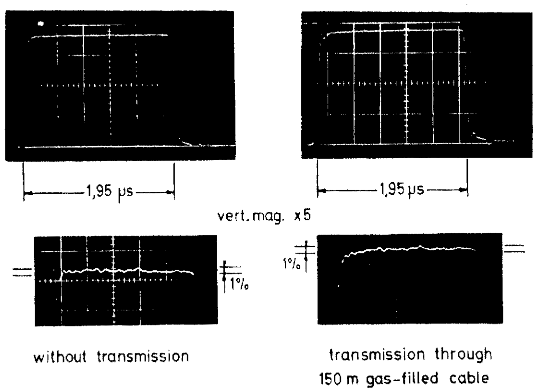

Fig. 5. Kick Pulse at 80 kV on PFN.

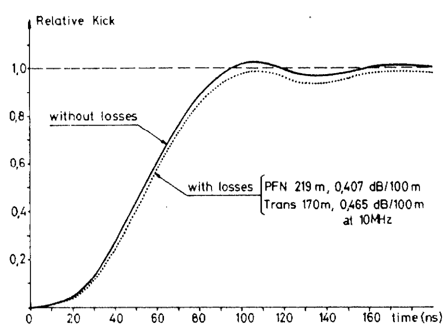

Fig. 6. Final magnet: expected kick rise.

Fig.7. Recharging of the PFN is by pulsed resonant power supply [4]. This operates on the principle of charge transfer from a low voltage electrolytic capacitor via the magnetic circuit of a mains frequency step-up transformer to the PFN cable. Terminating resistors are Morganite carbon mass discs, spring loaded and forced oil cooled. The pulse generators will be located at some distance (up to 150 m) from the magnets. Transmission will be effected over two parallel 30 ohm gas-filled polythene tape cables.

Performance

The working PFN charging voltage is 80 kV, the pulse amplitude 40 kV into 15 ohms and the maximum pulse length 2.2 µs. With correct adjustment of the thyratron gas pressure by control of reservoir voltage, rise and fall times in the terminators of 30 ns can be achieved together with less than one spontaneous firing per 10^5 triggered shots. Overall switch jitter of less than 5 ns is typical (Fig.8) and can be maintained for many million of pulses.

The pulsed resonant power supply recharges the PFN in 4 ms and allows up to 6 pulses per second with minimum interval of 25 ms between pulses. The

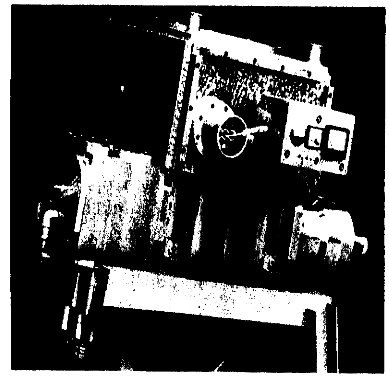

Fig. 7.

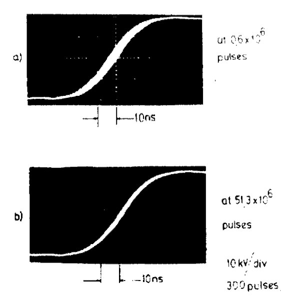

Fig. 8. Main Switch Rise Time and Jitter.

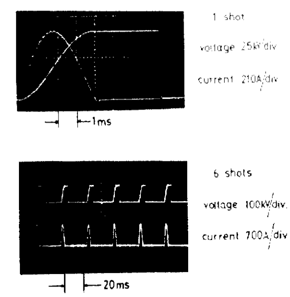

Fig. 9. Power supply secondary voltage and primary current (load=75nF).

short time for which the PFN is under voltage with this type of power supply is the key factor in the CX 1171 A switch operation as it permits the tube to operate at higher gas pressure without noticeable increase in spontaneous breakdowns. Typical power supply waveforms are given in Fig.9.

Life testing

All major components of the proposed full aperture kicker system have been subjected to a life test which exceeds 10^8 pulses. No failures have occurred and there has been no fall-off in performance. Individual thyratrons have completed more than 1.7 x 10^8 pulses and 10 000 filament hours with very little increase in rise time or jitter. The model magnet has pulsed 5 x 10^7 times with fewer than one breakdown per million pulses and withholds the full pulse voltage without conditioning.

References

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