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NOTE ON INJECTION SYSTEMS

by

M. C. CROWLEY-MILLING

National Institute for Research in
Nuclear Science,

Electron Laboratory,

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The purpose of this note is to examine a number of possible systems for the injection of positrons into the synchrotron. No attempt is made to assess the relative merits and costs of the various systems at this stage, but rather to determine whether any increase of space round the injection area in the ring building is necessary to allow for all possibilities.

Electron Injection.

The simplest scheme for matching the injected beam in both momentum and phase space is shown on the left-hand side of Fig. 1. This uses two bending magnets and a number of quadrupoles, not all of which are shown on the diagram. This is similar to the original plan for DESY, before the injection point on the ring was changed.

Positron Injection.

The injection path shown in Fig. 1 can be unaltered if the positron conversion target, P, together with the electron beam focussing system, F, and the accelerator sections for the positrons, A, can be placed in the path where positron injection is required, and moved out of the path when electron injection is required. Varian claim that it is possible to detune an accelerator section so that, when it is not energised, it will not absorb power from a pulsed electron beam. This is being investigated. If feasible, it would remove the necessity for moving the accelerator sections, and the focussing device could be turned off, so it would then only be necessary to remove the positron conversion system. It would be necessary to arrange for this to be done remotely, due to induced radioactivity.

An alternative system, which does not require movement of any apparatus when changing from electrons to positrons, is shown in Fig. 2. Here the positron target and accelerator are off-set from the electron injection path and non-dispersive systems are used to deflect the electron beam on to the positron target, and to deflect the positrons, after acceleration, back on to the injection path. The deflection system shown, which uses four bending magnets and two quadrupoles, is non-dispersive for beams of small divergence, but it is only shown by way of example, since it should be possible to devise a simpler system which has the required properties.

Since the positron current available for injection depends on the range of positron momenta acceptable, there may be some advantage in adding a debuncher magnet system and additional accelerator section to the positron injection path, to reduce the momentum range at the expense of increasing the phase width of the bunch. Such an addition is shown in Fig. 3. The debuncher magnet system is indicated by the three magnets, D, but in practice this number might be increased to five. The additional accelerator section A' may operate at the same frequency as the electron linac, but if the beam in the latter is pre-bunched at the synchrotron frequency, it may be preferable to run this accelerator section at that frequency. In such a case, a multiple cavity, as used on the synchrotron, would serve.

Simultaneous injection of electrons and positrons.

A scheme for the simultaneous acceleration of electrons and positrons in opposite directions in the synchrotron has been proposed previously. The previous proposal assumed a FOFDOD magnet configuration, and was completely symmetrical. A layout suitable for the present FODO configuration is shown in Fig. 4.

The beam from the electron linac, modulated at 816 Mc/s, is passed through cavity C, operating at 408 Mc/s in a deflecting mode. It was shown that about 100 KW pulse, 500 watts mean power would be needed to set up a field sufficient to displace the pulses by about $\pm$ 3 in. at 10 ft., allowing for beam loading. This separation is sufficient to allow a bending magnet, S, to deflect half the beam into the positron target, without causing appreciable extra deflection of the other half, which passes through the bending magnets, C, being brought back into line for injection along the normal path. The positrons, after acceleration, and possibly passing through a de-buncher system, travel through a similar matching system to that used for the electrons, and are then bent through 180° before being injected through the fringe field of a "D" magnet. Since a 180° uniform magnet affects only the position/momentum characteristic of the beam, the effect can be compensated by variation of the parameters of the bending magnets in the matching system.

With this scheme, simultaneous acceleration of electrons and positrons can be achieved, at the expense of halving the electron beam current, assuming that the electron linac could not be loaded to a greater current.

One further possibility should be considered at this stage, that of storing the positrons before injection. It might be possible to run the electron linac at 500 pulse per second, deflect nine pulses into a positron target and store the positrons produced, after acceleration, in a ring. The tenth pulse from the linac would be injected, as electrons, into the synchrotron, and simultaneously the positrons from the storage ring would be injected in the opposite direction. If feasible, this would enable the full electron beam current to be obtained, and increase the positron current by a factor of 18 (assuming no losses) over the system of Fig. 4.

However, a scheme for a suitable storage ring with multi-turn injection has yet to be devised, and the problem is made more difficult by the lack of radiation damping, due to the comparatively low energy. Storage is only required for 20 ms, so the vacuum requirements should not be difficult to meet. In considering the space required, a guess has to be made of the maximum likely size of such a storage ring. Fig. 5 shows a possible arrangement which will fit in with the building plans.

If feasible, such a storage ring could also be used with the systems shown in Figs. 1 to 3, in which case the positron current could be increased by a factor up to 10.

From the sketches it can be seen that all the schemes discussed will fit within the building outlines, shown by the heavy dashed lines, up to the expansion joint where the injector building joins the ring building.

Regarding the injector building, obviously detail design will depend on the design of injector, but some estimate can be made whether the suggested overall length of 100 ft. from the expansion joint is likely to be correct.

If we assume that the positron accelerator sections are each 3 m long, and we take the approximate figure given in the CSF preliminary proposal (which is likely to be the longest of any of the quotations) for the length of the electron linac, and allow 6 ft. clearance, the approximate inside length of the injector building for the various schemes is shown as follows :-

Fig. 1.	90 ft.
Fig. 2.	100 ft.
Fig. 3.	110 ft.
Fig. 4.	100 ft.
Fig. 5.	100 ft.

The scheme for Fig. 3, if used with a storage ring, would require a length of 120 ft.

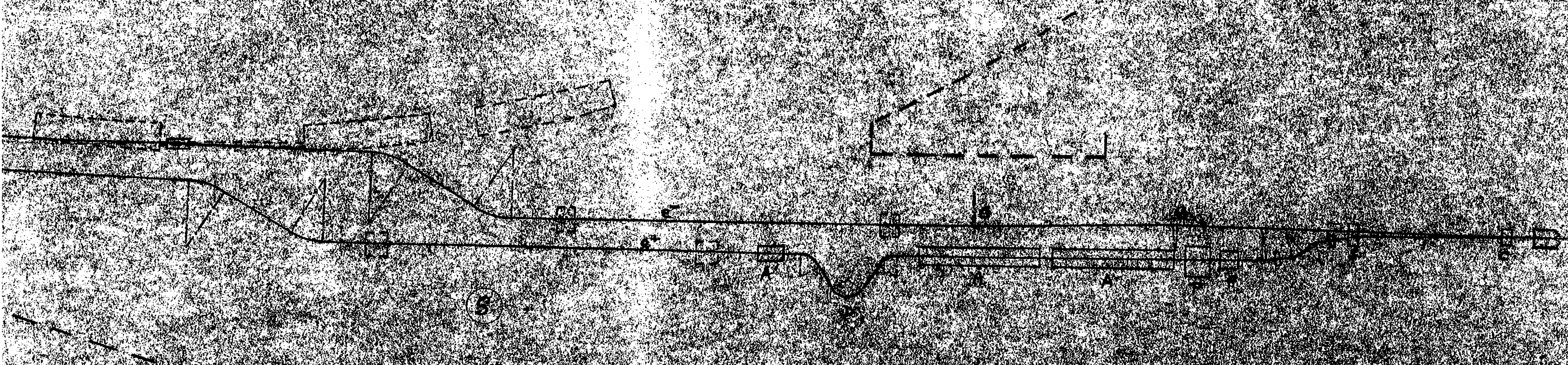

Fig 4

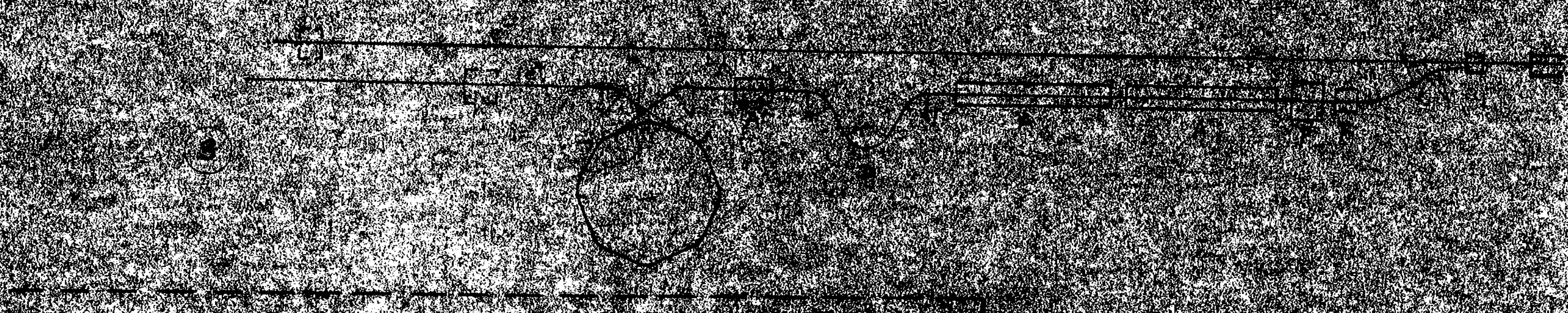

Fig 5

Injection Schemes

Scale 1/8 = 1ft

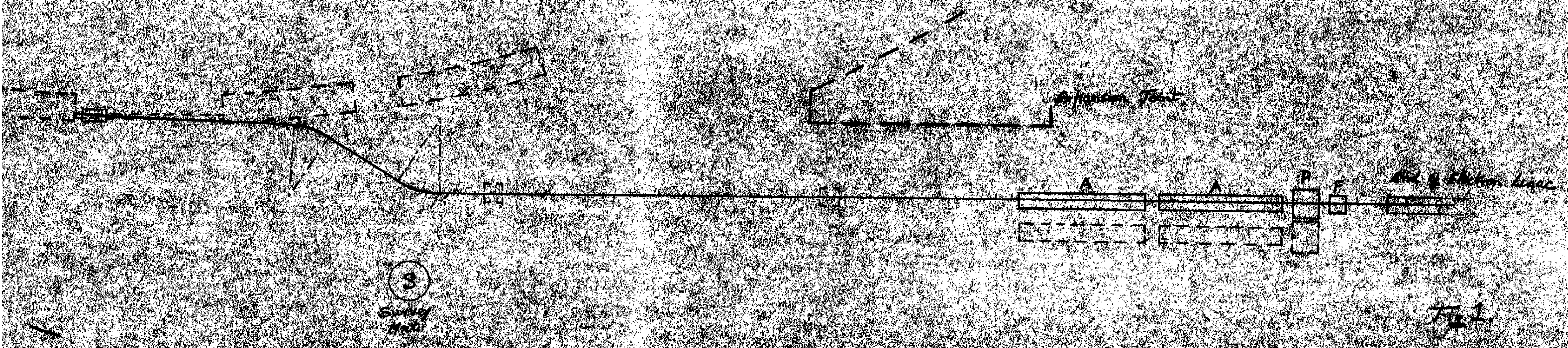

Fig 1

Fig 2

Fig 3

Injection Schemes

Scale 1/8" = 1 ft