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A METHOD OF INTERCHANGING HORIZONTAL AND VERTICAL PHASE SPACE AREA

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The following is a brief description of a method for decreasing the horizontal phase space area occupied by a beam at the expense of the vertical phase space. The problem is of interest for accelerators because the usual multiturn injection techniques employ only horizontal stacking. Therefore, the number of protons injectable into a machine by this method depends only on the horizontal phase space density. Therefore, if the horizontal phase space density can be increased, the number of injectable protons can also be increased.

Consider a linac beam impinging on an electrostatic* inflector as shown in Fig. 1. The left side is bent to the left, the right to the right. The result is that one now has two beams, each with the same vertical phase space area, but half the horizontal phase space area. One then recombines the two beams in the vertical phase, one above the other. The result is a beam of half the horizontal phase space area but twice the vertical phase space area. Fig. 2 shows the arrangement of the various bending magnets, and Fig. 3 shows the relevant phase space ellipse.

In principal the beam could be split into an arbitrary number of segments, and stacked up on each other. The mechanical arrangement of the elements becomes somewhat more difficult. However, the case for triple stacking appears quite simple, since one merely lets the central portion drift through the system and uses essentially identical techniques as with the method described above.

* A pulse ferrite magnet with a septum may be simpler, and according to E. Forsyth, seems to be a quite reasonable approach.

The septums can be made thin enough that a negligible amount of beam is lost in this way ($\sim$ 1%). Ninety percent of the beam can be put into half the phase space area of the original beam, with a vertical dilution factor of about 1.5 (3 times the original emittance). With a linac beam of emittance 1.2 π cm-mr, and a machine acceptance of 4.1 π cm-mr, the vertical dilution should not present any problems.

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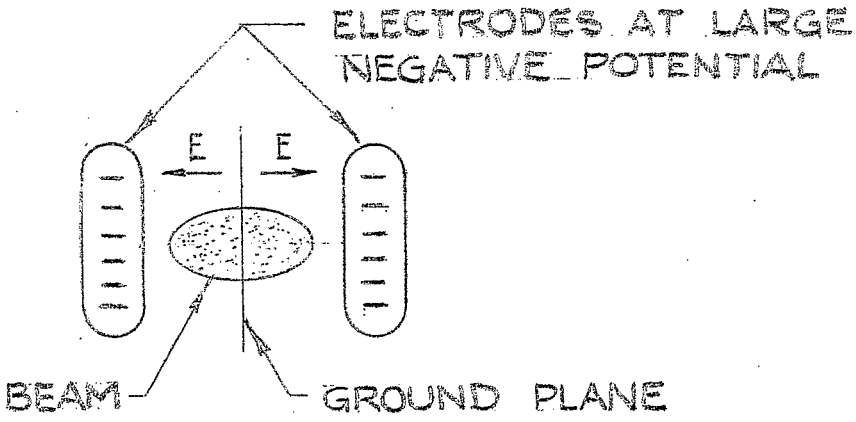
Fig. 1

HORIZONTAL
BEAM SPLITTER



VERTICAL
BEAM SPLITTER

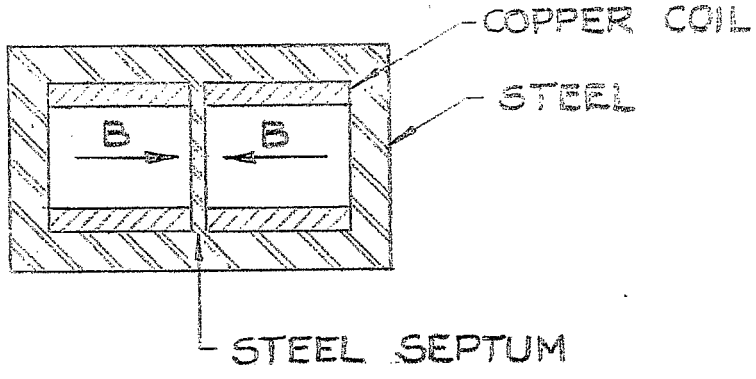
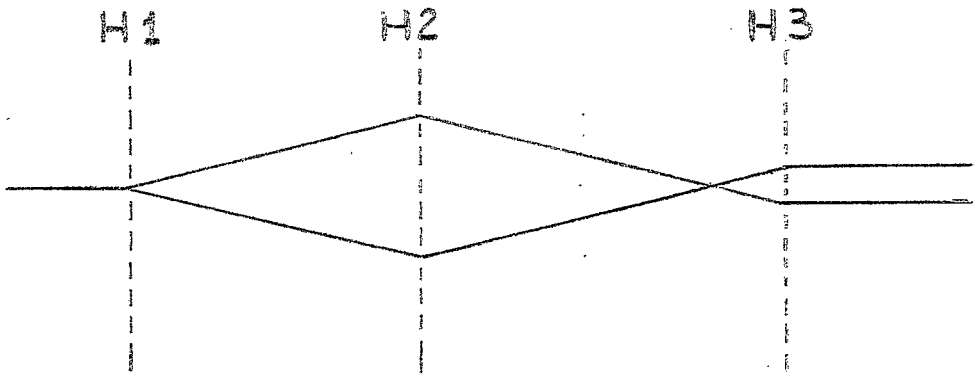
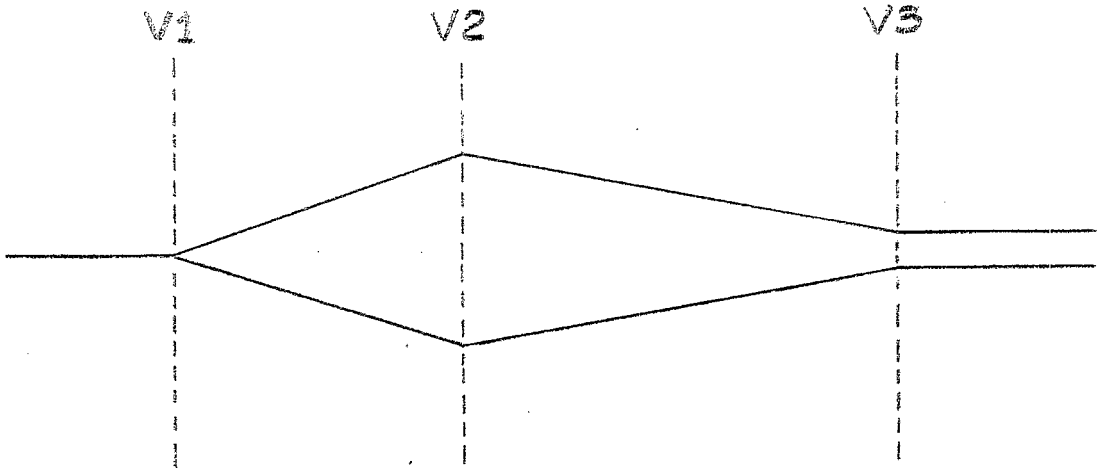


Fig. 2

HORIZONTAL RAY TRACE :



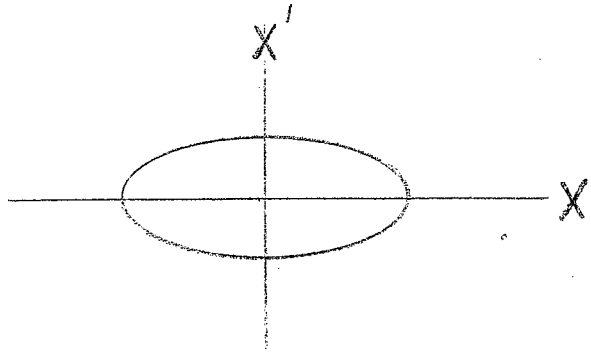
VERTICAL RAY TRACE :



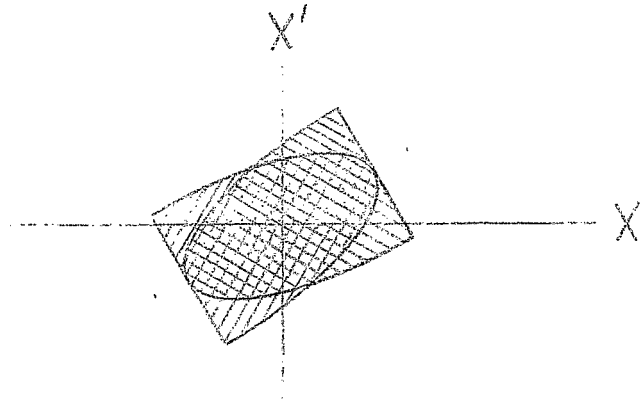
H1 = HORIZONTAL BEAM SPLITTER
V1 = VERTICAL BEAM SPLITTER
H2 = HORIZONTAL BEAM SPLITTER
V2 = VERTICAL BEAM SPLITTER
H3 = VERTICAL BEAM SPLITTER ROTATED 90°
V3 = HORIZONTAL BEAM SPLITTER ROTATED 90°

Fig. 3

HORIZONTAL PHASE SPACE AT H1



HORIZONTAL PHASE SPACE AT H3



VERTICAL PHASE SPACE AT V3