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# AN IMPROVED F10 SWITCHYARD DESIGN

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AGS DIVISION TECHNICAL NOTE

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# AN IMPROVED F10 SWITCHYARD DESIGN

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In a recent note[1] discussing options for improving the slow extracted beam, a design is given for a high efficiency switchyard to deliver beam from F10 to the existing A, B and C lines and to a new D line. Despite space limitations, this design is practical to build, and it should give excellent performance. Further study,[2] however, has led to an improved design based on Lambertson (steel septum) magnets. This improved design is more cost effective and less tightly constrained than that of Ref. 1.

A plan view of the improved switchyard is given in Fig. 1 and the component parameters are given in Table 1. The beam optics and the systematic procedure for adjusting the quadrupoles to get the desired beam sizes are the same as in the previous design. The beam splitting and switching uses both the horizontal and the vertical planes, as shown in expanded views in Fig. 2.

The initial split is in the horizontal plane, and is made by electrostatic splitters $E_{1-3}$. These make a four-way split as shown in Fig. 2a. Next come Lambertson magnets $L_{1-2}$, which bend in the vertical plane. Figure 3 is a view of the upstream end of $L_1$, showing the four horizontally split beam components at the entrance of $L_1$. This magnet bends the B and C beams up, as shown in Fig. 2b. Magnet $L_2$ is similar but oriented with its field on the opposite side; it bends D down. The striped parts of the beam components in Fig. 3 indicate the effect of beam divergence. The clear separation between shadows is 0.15 inches and the septum thickness at the top and bottom of the beamspots is 0.06 inches; the separation is therefore greater than the septum thickness by a factor of 2.5, compared to a typical value of 1.5 in the previous design.

The beams are next separated horizontally by Lambertson magnets $L_{3-7}$. A view of the upstream end of $L_3$ is given in Fig. 4, which also shows the separated beam spots at this point. This magnet is essentially a conventional dipole magnet with a hole drilled in its upper pole piece. Magnets $L_3$ and $L_4$ bend D and A to the left, while B and C pass undeflected in the hole in the upper pole piece. Magnets $L_{5-7}$ are similar but bend D only.

The beam vacuum pipes for the Lambertson magnets are not shown in Figs. 3 and 4, but they are arranged in one of several possible ways to put the coils outside the vacuum.

Following the Lambertson magnet section, the D beam is made level by pitching magnet $P_1$; then it enters low powered magnets $H_{1-3}$ which bend seven degrees each. The A beam is brought onto its existing line by $C_{1-5}$. The B and C beams are bent both horizontally and vertically by $P_{2-3}$ and $C_{6-9}$ to put them on the original B line; thick copper septum magnet $S_1$ then bends C onto the original C line.

Splitting ratios are changed by remote horizontal motion of $E_{1-3}$ and $L_{1-2}$ and current variation in $C_{6-9}$. The beam steering through the thick septum Lambertson magnets $L_{3-7}$ does not need to change with splitting ratio.

The main advantages of the improved design over that of Ref. 1 are:

1. The septum clearances are greater.
2. The Lambertson magnets are less expensive than copper septum magnets, and they consume less power.
3. The electrostatic splitters are located together, which is advantageous from the point of view of vacuum and shielding.
4. Any beam, including the C beam, can be turned off for access while the other beams are on.

References and Footnotes

1. H. Weisberg, AGS Division Technical Note No. 131.

2. Suggestions by H. Brown and J.W. Glenn were crucial.

Table 1

Switchyard Components and Parameters

| Element | | Length | Field | Aperture, HXV |
|---|---|---|---|---|
| $V_{1-3}$ | Combined horizontal and vertical vernier magnet | 1 ft | 5 kG (each plane) | 3 X 3 in |
| SEC | Secondary emission chamber | | | |
| $M_1$ | 3H36 | 3 ft | <16 kG | 3 X 3 in |
| $Q_{1-4,6}$ | 3Q52 | | | |
| $Q_{5,7}$ | 3Q36 | | | |
| $W_{1-4}$ | SWIC profile monitor | | | |
| $E_{1-3}$ | Electrostatic splitter, 0.002 in wire septum | 10 ft | ±35 kV/cm | ±0.8 X 1.5 in |
| $L_{1-2}$ | Thin-septum Lambertson magnet (see Fig. 3) | 10 ft | 2.5 kG | 2 X 2 in |
| $L_{3-7}$ | Thick-septum Lambertson magnet (see Fig. 4) | 6 ft | 13 kG | 6 X 3½ in |
| $P_{1,3}$ | 3H18 bending vertically | 1.5 ft | <16 kG | 3 X 3 in |
| $P_2$ | 3H36 bending vertically | 3 ft | <16 kG | 3 X 3 in |
| $H_{1-3}$ | 6H288 | 24 ft | 16 kG | 6 X 1.5 in |
| $C_{1-9}$ | 5C90 | 7.5 ft | 13 kG | 5 X 1.5 in |
| $S_1$ | 0.33" copper septum magnet | 12 ft | 2.8 kG | 3 X 1.25 in |

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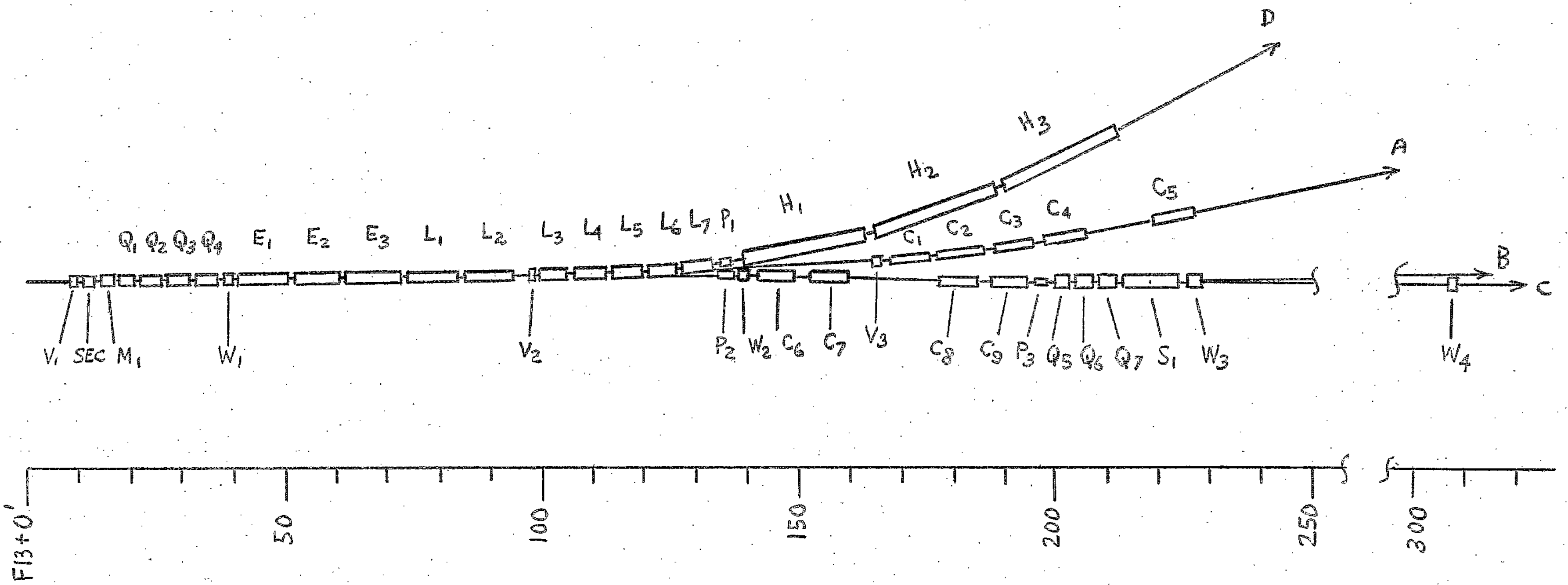


FIG. 1 - Improved F10 switchyard layout

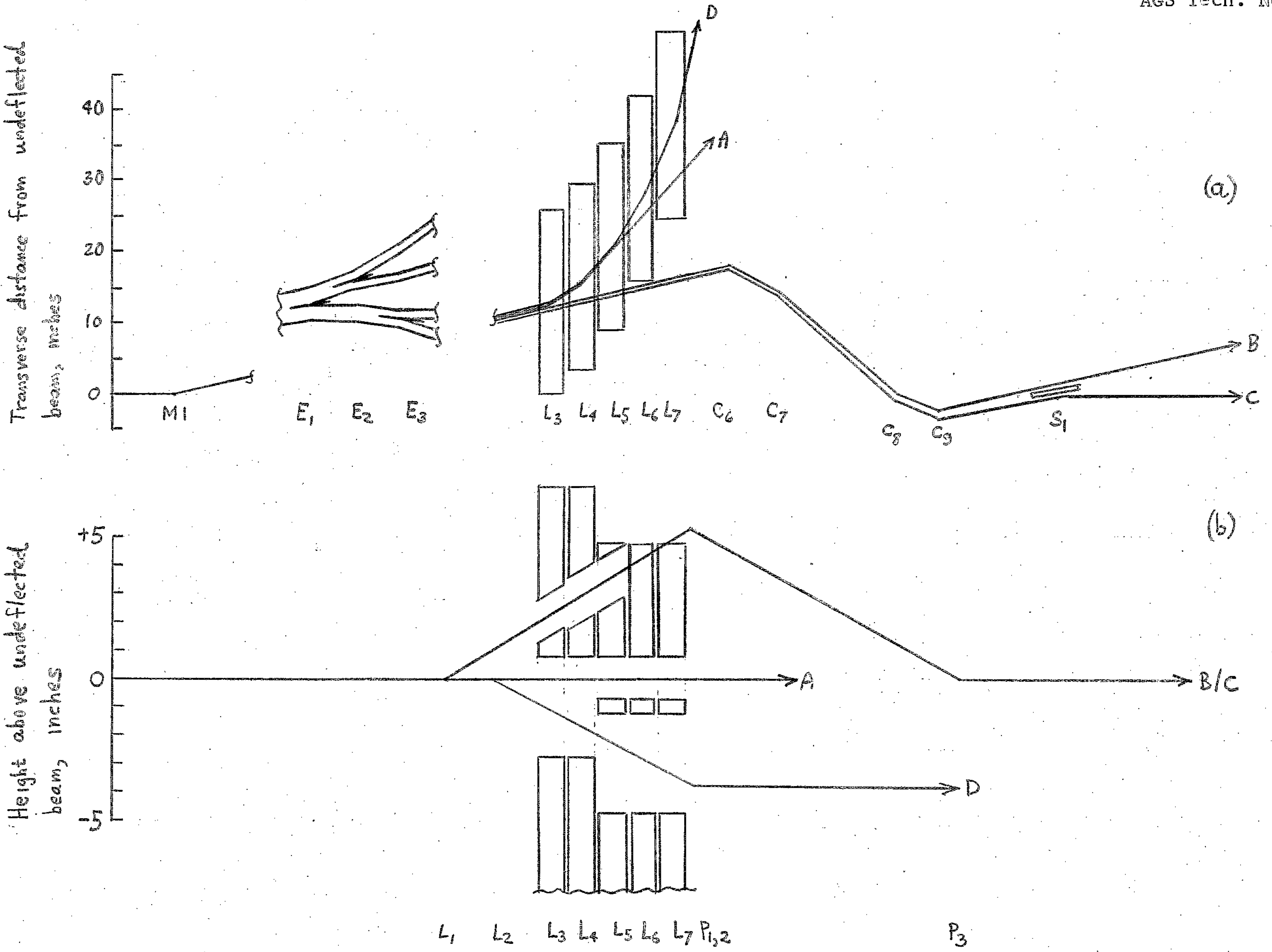


Fig. 2 - (a) Horizontal and (b) vertical beam trajectories

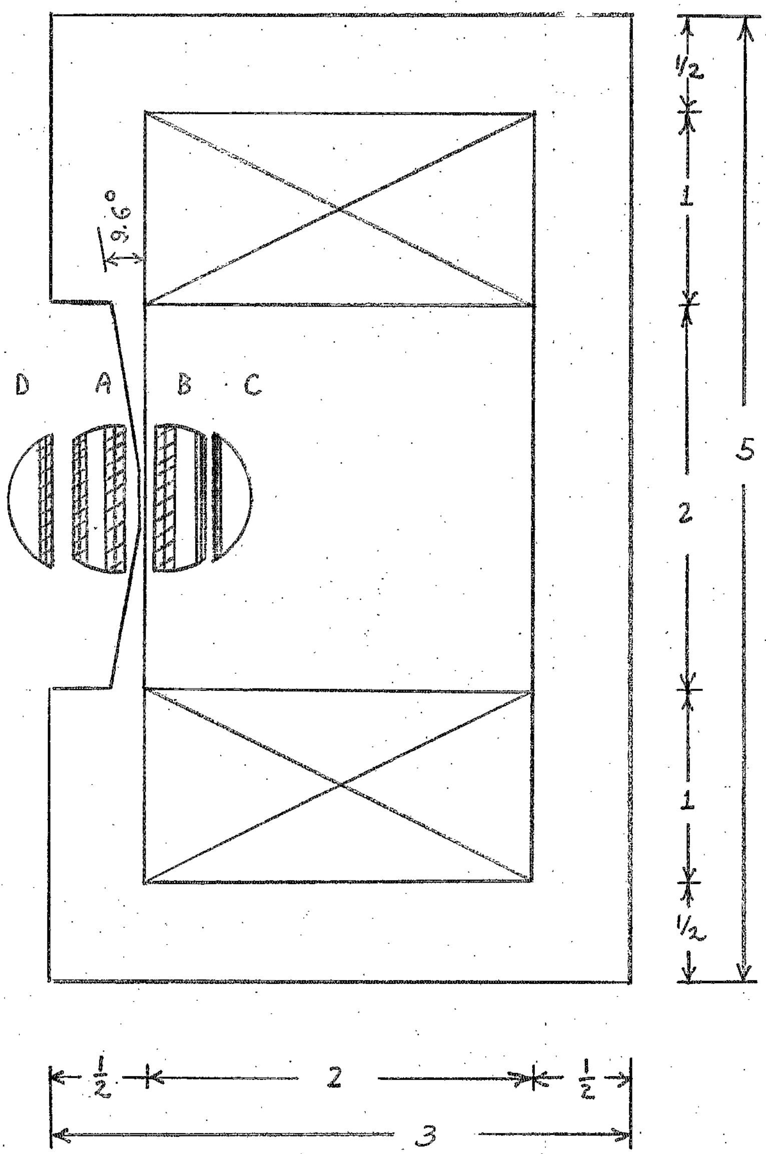


Fig. 3 - Upstream view of Lambertson magnet $L_1$, showing the four horizontally split beam components. The striped areas of the beam components indicate the effect of beam divergence on the septum shadows. This magnet bends the B and C beams up.

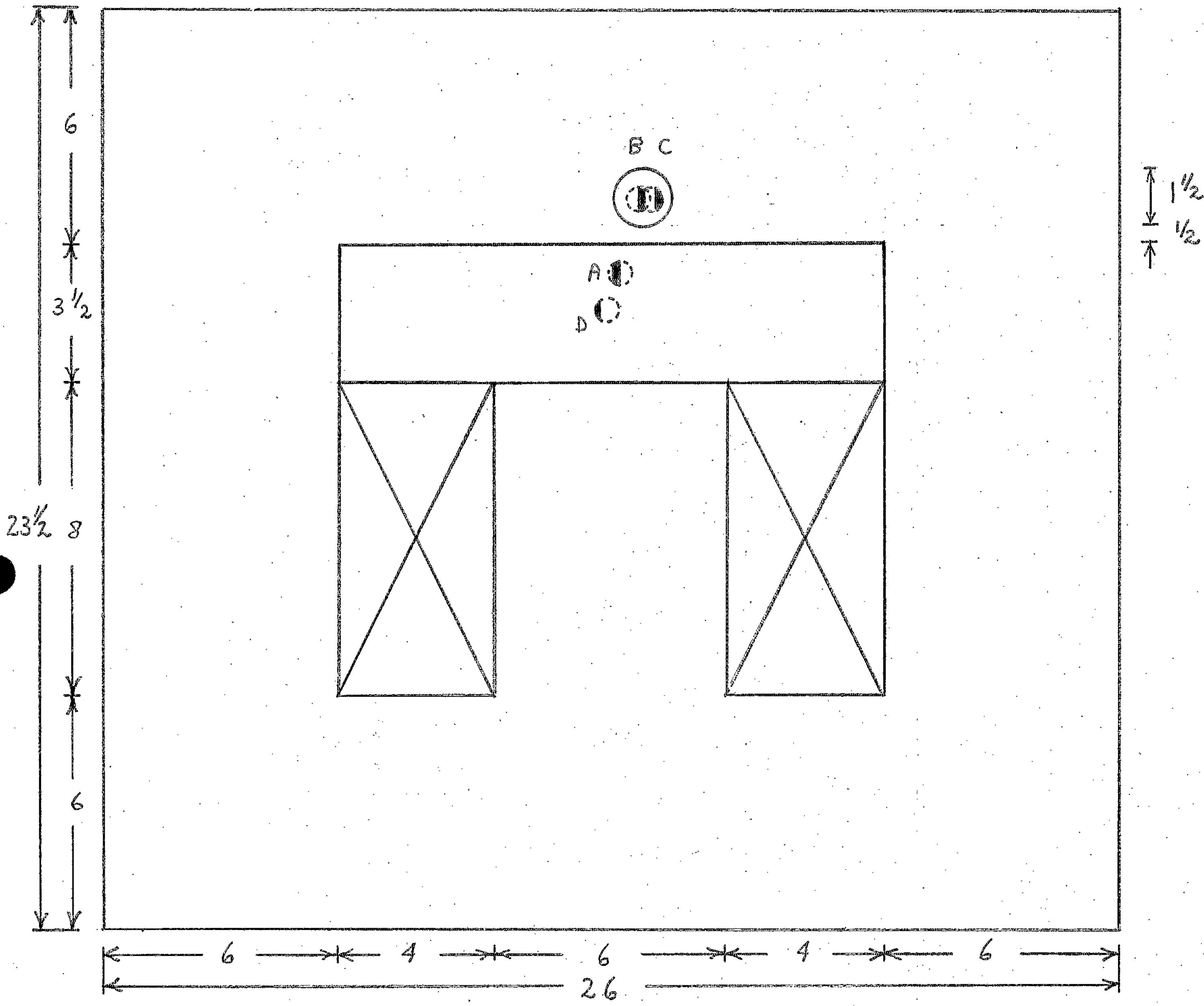


Fig. 4 - Upstream view of Lambertson magnet $L_3$, showing the four beam components that enter it. This magnet bends the D and A beams to the left.