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SLOW EXTERNAL BEAM LAYOUT AND OPTICS AT THE AGS

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AGS DIVISION TECHNICAL NOTE

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1. General

The Slow External Beam (SEB) at the AGS has been operational for many years and has been going through many generations of evolution. This report intends to describe the external beam as it exists at present. The extraction system of the SEB is reported elsewhere[1] and this report only deals with the elements outside of the AGS ring. The beam is split into three target stations A, B and C by means of magnetic septums. The nomenclature of the beam components are described in EP&S Technical Note 81.

2. Description of SEB

The slow extracted beam ejected by F10 ejector magnet goes through F11, F12 and F13 magnetic field and coming out at F13 straight section with the properties given in various papers.[2] Assuming the elliptical phase space contours, the phase ellipse parameters we used at F13 straight section are:

$$\alpha_x = -2.87 \qquad \alpha_y = .987$$
$$\beta_x = 1087.\ \text{in.} \qquad \beta_y = 146.\ \text{in.}$$
$$\varepsilon_x = .015\ \text{in.-mrad} \qquad \varepsilon_y = .0367\ \text{in.-mrad}$$

The Secondary Emission Chamber (SEC) placed approximately 10 ft downstream of F13 monitors the intensity and serves as the input to the extraction servo. The small steering dipole (CD014) is to adjust the direction of the beam parallel to the .0243 in. thick magnetic septum (AD019) which splits beam between A and BC target stations. The split ratio is controlled by the F10 ejector current and CD014 which determines the position and the direction of the beam at AD019. The quadrupole triplet (CQ1, CQ2AB, CQ3) changes the optical properties of the beams such that go through various small apertures throughout the SEB system downstream. The .5 in. thick septum (AD1) is placed to separate the beam to A further away from BC. The beam to A station goes through bending magnets AD2-8 and AQ4AB, AQ5AB and AQ6 to make total bend of 12° and focus to A target. The small steering dipoles CD074, CD079 and CD114 to give the position and angle of the beam on 2nd .0216 in. thick magnetic septum (BD120), which separates the beam to B station and C station. The BD120 can be remotely moved and change skew angle to complement the function of CD074, CD079 and CD114. The beam goes through the vertically focusing quadrupole (CQ4) in order to enhance the split and change the beam to go through vertical aperture of .5 in. thick septums (BD1 and 2). The BD1 and 2 separates the beam to B from beam to C. The beam to B goes through dipoles (BD3, BD4, BD5, BD6) and quadrupoles BQ5, BQ6, BQ7&8, BQ9 to focus to the B target station. Total bend to the B station is 6.62 degrees. Rest of the beam goes through CQ5, CQ6, CQ7, CQ8 to focus at C target station. Each of the lines to target station also has at least two pitching components to adjust the height and angle of the beam. A small steering dipole which is controlled by servo system on the horizontal beam position at the target in order to keep the beam on the target. Since the beam momentum changes a good fraction of a percent during the spill, the bending magnets AD1-8 and BD3-7 are ramped by the electronic function generators.

3. Optics and Beam Envelopes

Using the computer program the ellipse parameters mentioned above were transported down through the beam lines. The beam sizes observed at various flags confirms the assumed parameters were approximately right. The detailed measurement was not carried out so far. Figure 2 shows the horizontal and vertical phase ellipse at A-C splitting thin septum (AD019) and horizontal phase ellipse at AD1 ($\frac{1}{2}$ in. thick septum) with 1.5 mR kick from AD019. Because of the historical reasons AD019 septum is not placed in a most favorable optical condition. The most favorable condition would be the beam to be horizontally large and minimum divergence. The theoretical minum loss at this septum is due to the septum thickness and apparent septum thickness due to phase space rotation within the length of the magnet and about 8%. The split loss can be varying depending upon the ratio of the beam to A and BC. Figure 3 shows the horizontal and vertical phase ellipse at BC splitting septum BD120 and horizontal phase ellipse at BD1 with a .6 mR kick from BD120. The loss due to the septum thickness and phase space rotation is somewhat smaller, about 6%. Figures 4, 5 and 6 plot the horizontal and vertical beam envelopes assuming full beam goes through the system for C, B and A lines, respectively. The plots are for typical running conditions and it varies slightly according to the requirement at target stations. B and A lines are plotted from the splitting point. The distances shown are the distance from middle of the F13 straight section in inches.

The operational problems like minimizing the loss and changing the splitting ratios are going to be written up elsewhere.

Acknowledgments

The slow external beam had gone through many years of improvement by Drs. L. Blumberg, A. Maschke and most recently, by H. Brown. Messrs. E. Jablonski, A. Soukas and H. Hsieh contributed their talent and ingenuity to the improvement.

References

1. M.Q. Barton, BNL Accel. Dept. Int. Report AADD-86, 1965.
   M.Q. Barton and J. Faure, BNL Accel. Dept. Int. Report AADD-131, 1967.

2. See for example, L. Blumberg et al., BNL Accel. Dept. Int. Report AGS Div. 69-12, 1969.

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Dept. Admin.

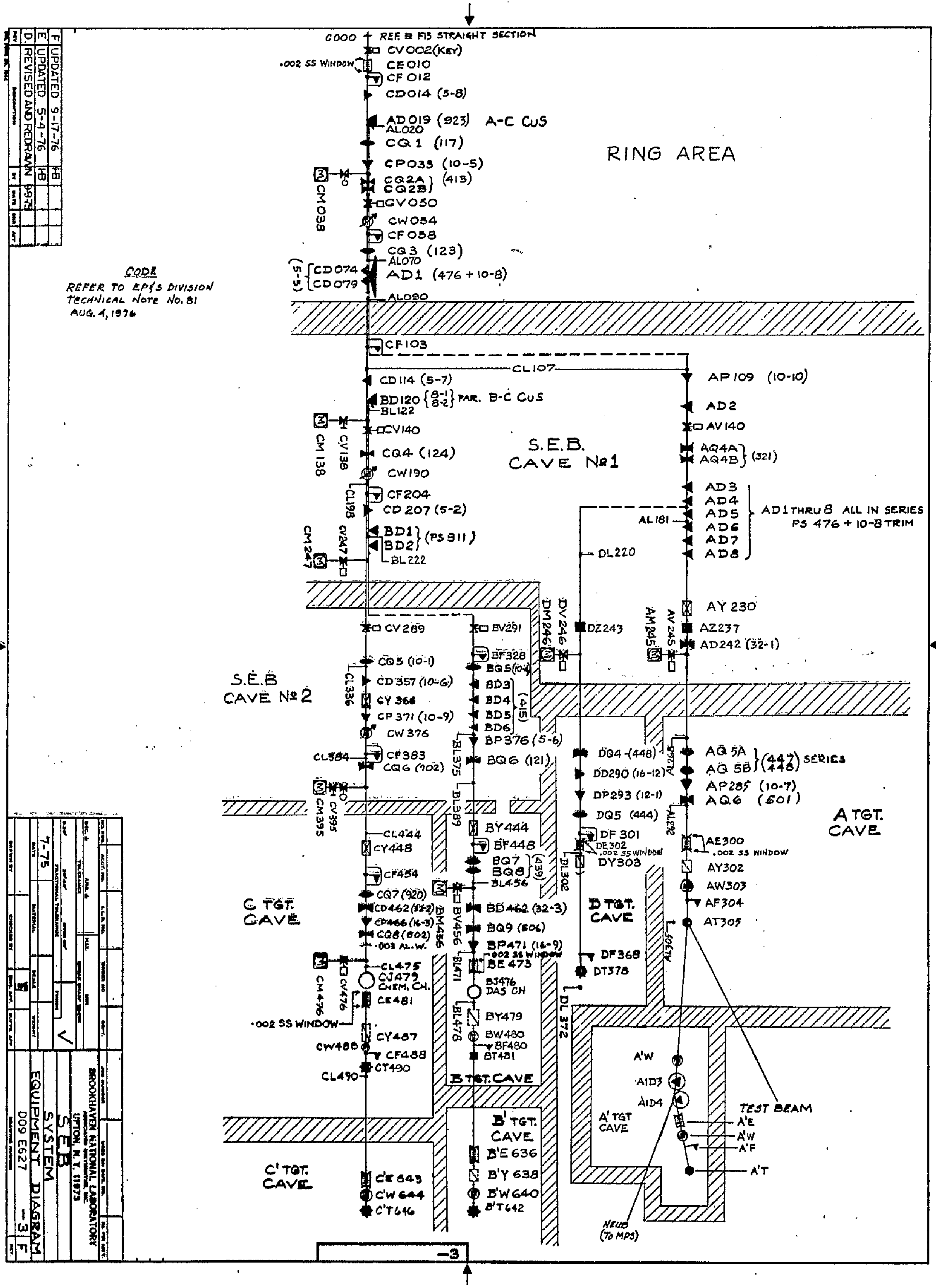
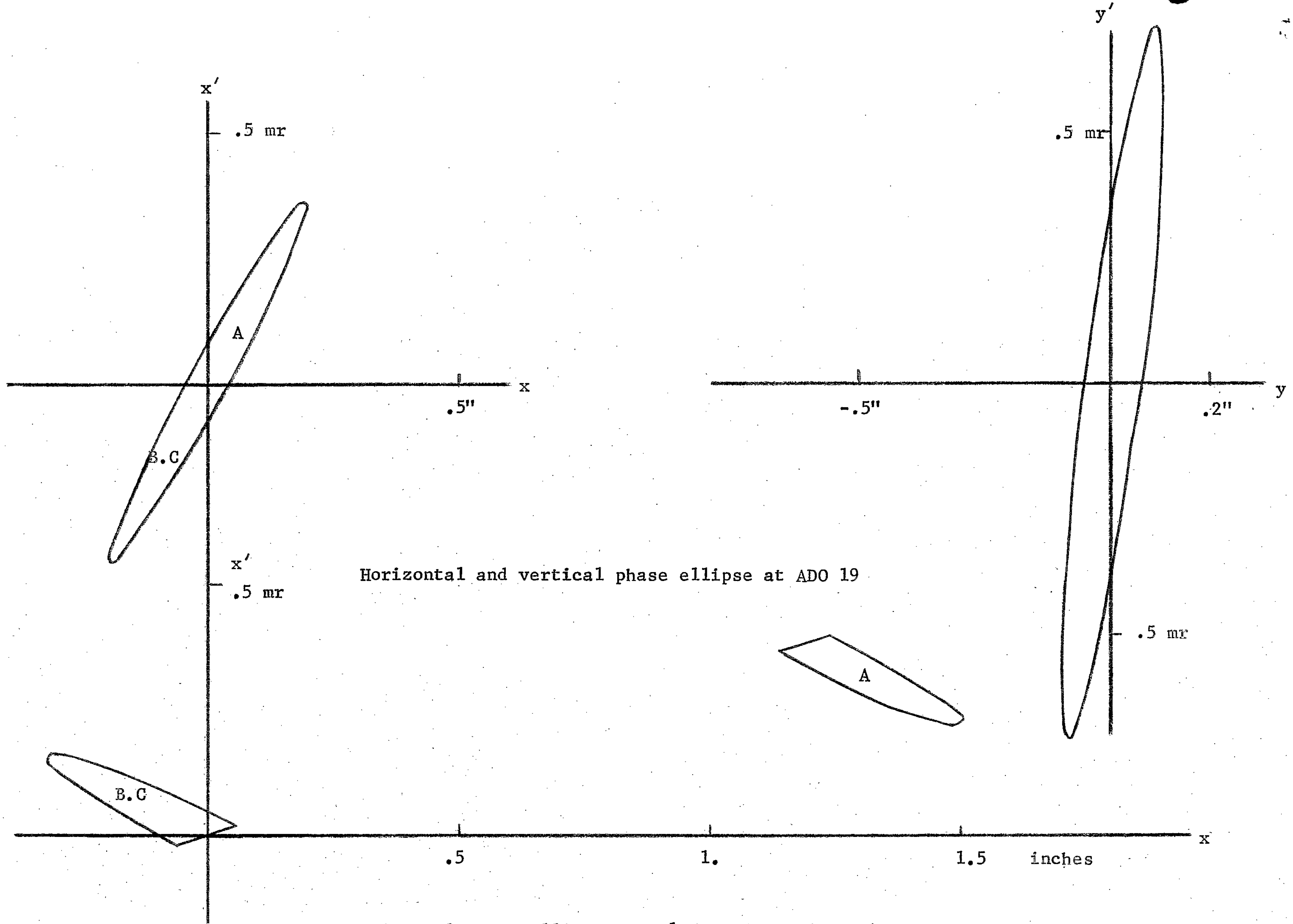
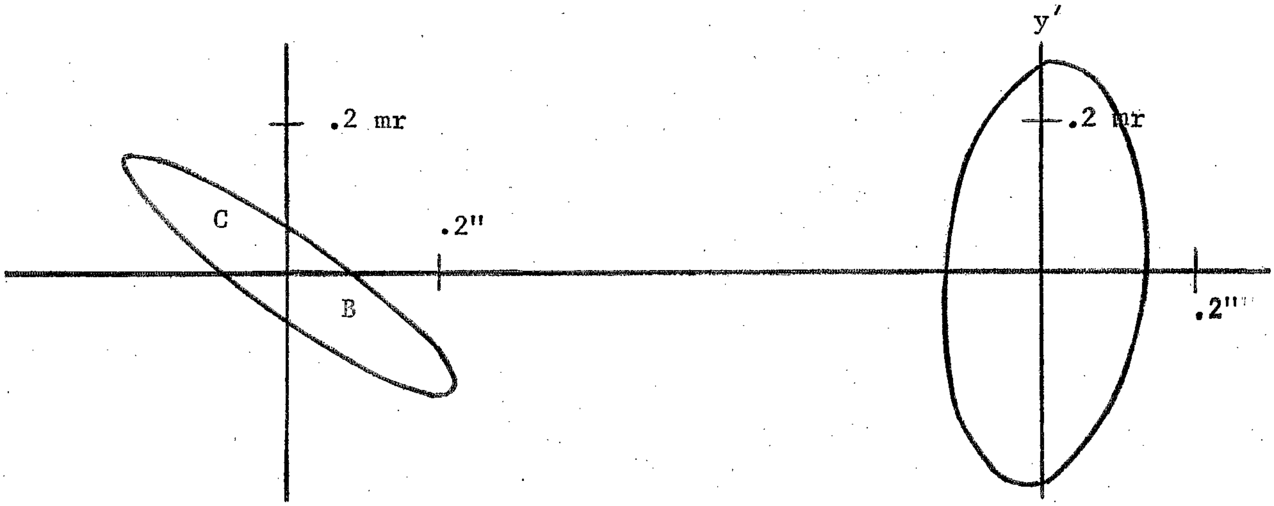

RING AREA
S.E.B. CAVE №1
S.E.B CAVE №2
CODE
REFER TO EP&S DIVISION TECHNICAL NOTE No. 81 AUG. 4, 1976
A TGT. CAVE
B TGT. CAVE
B' TGT. CAVE
C TGT. CAVE
C' TGT. CAVE
D TGT. CAVE
A' TGT CAVE
TEST BEAM
BROOKHAVEN NATIONAL LABORATORY
UPTON, N.Y. 11973
SEB SYSTEM EQUIPMENT DIAGRAM
D09 E627 -3 F
F UPDATED 9-17-76
E UPDATED 5-4-76
D. REVISED AND REDRAWN

Fig. 1



Horizontal and vertical phase ellipse at ADO 19

Fig. 2 **Horizontal Phase Ellipse at AD1** (ADO 19 at 1.5 mr)



Horizontal and Vertical Phase Ellipse AD BD120

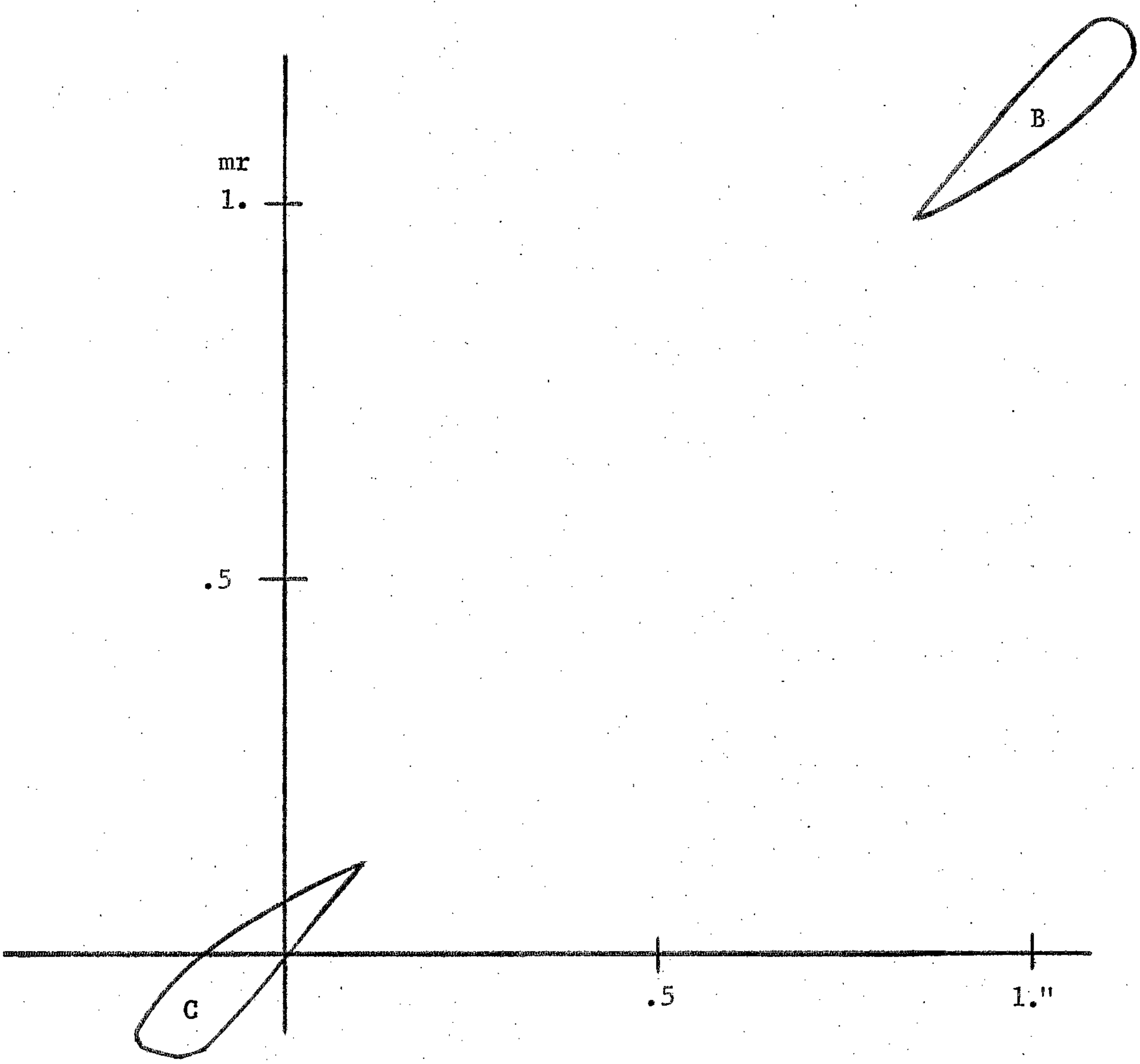
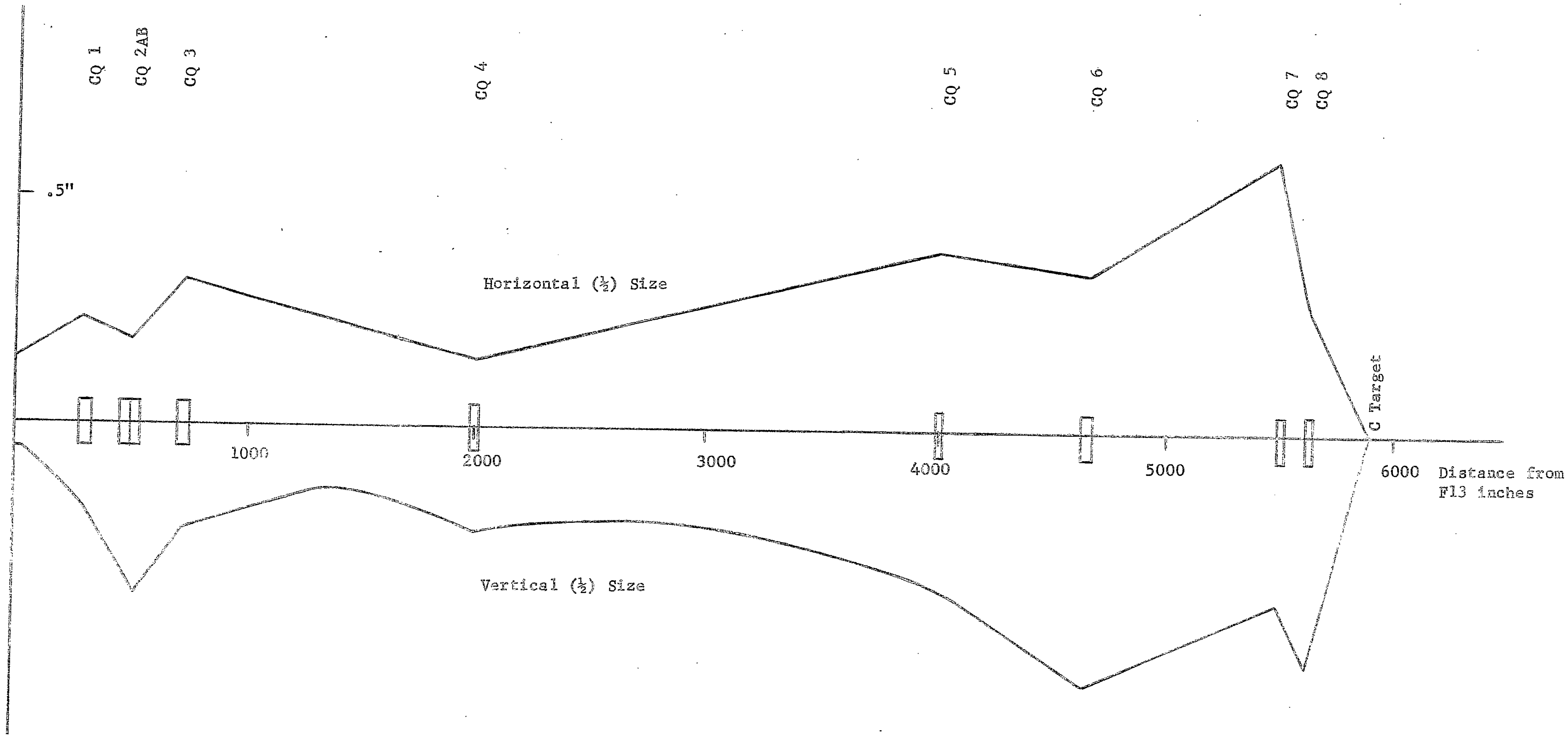


Fig. 3 Horizontal Phase Ellipse AD BD1 (BD120 at .6 mr)


CQ 1
CQ 2AB
CQ 3
CQ 4
CQ 5
CQ 6
CQ 7
CQ 8
.5"
Horizontal (½) Size
C Target
1000
2000
3000
4000
5000
6000
Distance from F13 inches
Vertical (½) Size

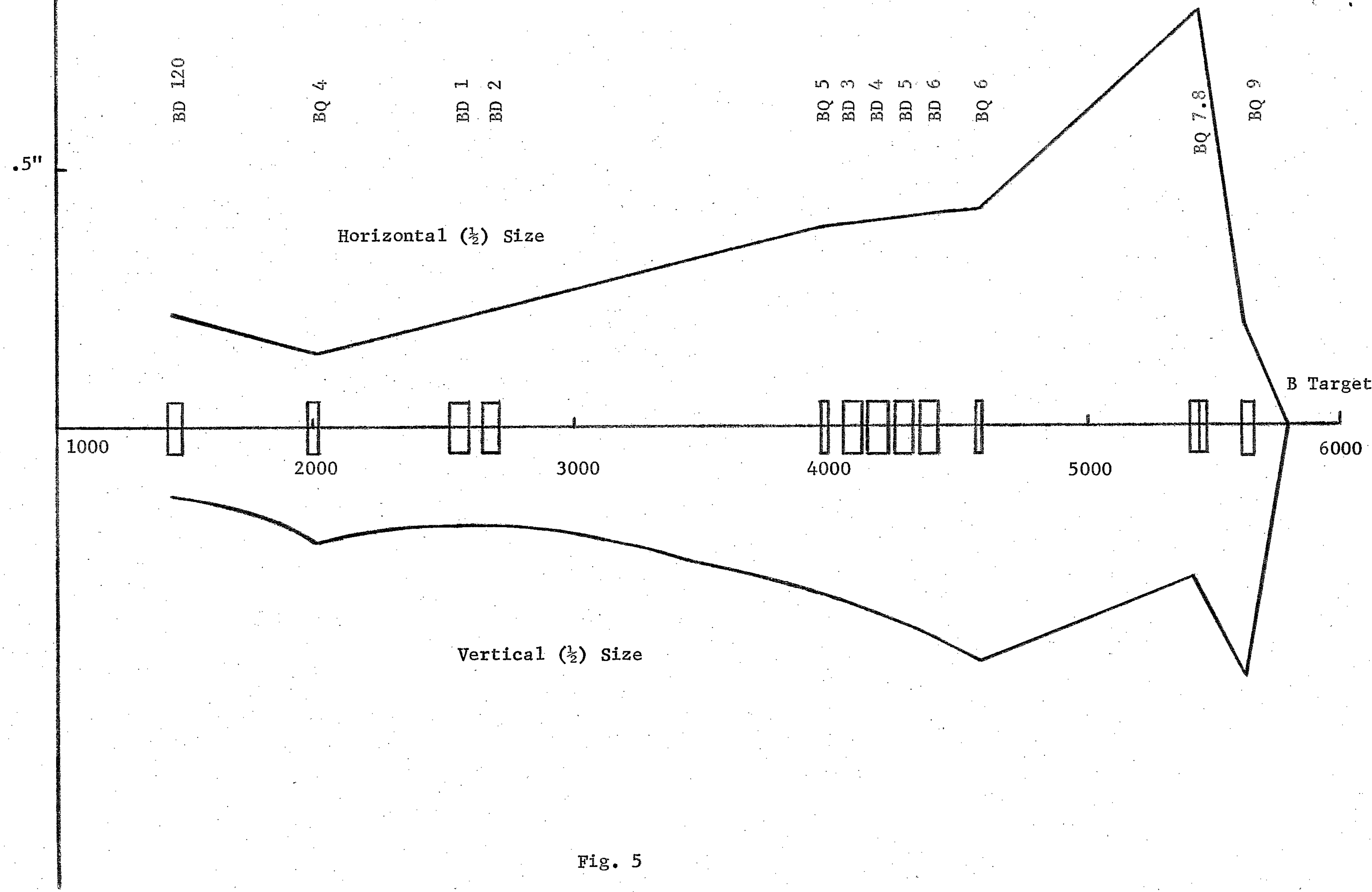
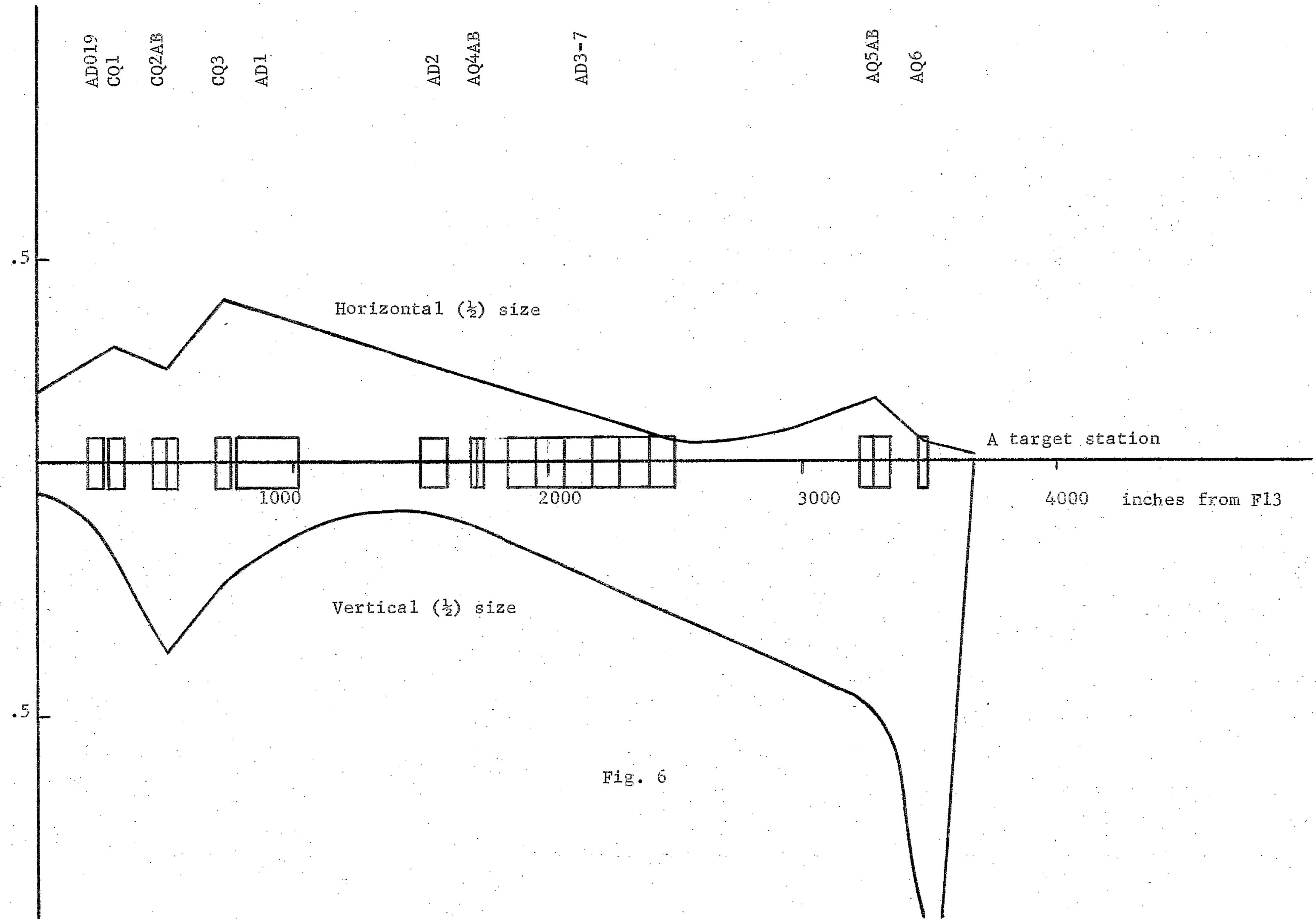

BD 120
BQ 4
BD 1
BD 2
BQ 5
BD 3
BD 4
BD 5
BD 6
BQ 6
BQ 7.8
BQ 9
.5"
Horizontal (½) Size
B Target
1000
2000
3000
4000
5000
6000
Vertical (½) Size

Fig. 5



AD019
CQ1
CQ2AB
CQ3
AD1
AD2
AQ4AB
AD3-7
AQ5AB
AQ6
.5
Horizontal (½) size
A target station
1000
2000
3000
4000
inches from F13
Vertical (½) size
.5

Fig. 6