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# Calibration of the HEBT Steering Dipoles (ND431, ND437) and Pitchers (NP435, NP440)

L. Ahrens

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Collider Accelerator Department  
**Brookhaven National Laboratory**

**U.S. Department of Energy**

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AGS Studies ReportDate(s) May 6, 1985 Time(s) 1800-2400Experimenter(s) L. Ahrens, and C. GardnerReported by C. GardnerSubject Calibration of the HEBT steering dipoles (ND431, ND437) and pitchers (NP435, NP440)Observations and Conclusion

The purpose of this study was to obtain calibrations of the four final dipole magnets in the High Energy Beam Transport (HEBT) line to the AGS. These four magnets consist of two dipoles, ND430 and ND437, which are used to adjust the horizontal steering, and two pitchers, NP435 and NP440, which adjust the vertical steering of the H<sup>-</sup> beam into the AGS.

The basic method of the calibration is illustrated schematically in figure 1. With the two quadrupoles, NQ433 and NQ444, and the AGS magnets turned OFF the dipoles and pitchers were swept through a series of values and the resulting positions of the beam at the A20 SEM were recorded. If we let  $\Delta X$  be the change in the horizontal position at the A20 SEM due to changes of  $\Delta_{431}$  and  $\Delta_{437}$  in the command settings of ND431 and ND437 respectively, then

$$\Delta X = (L_1 + D_1) C_{431} \Delta_{431} + D_1 C_{437} \Delta_{437} \quad (1)$$

where  $L_1$  and  $D_1$  are as defined in figure 1 and  $C_{431}$ ,  $C_{437}$  are the desired calibration factors for the two dipoles. Similarly, if we let

$\Delta Z$  be the change in the vertical position at the A20 SEM due to changes of  $\Delta_{435}$  and  $\Delta_{440}$  in the command settings of NP435 and NP440 respectively, then

$$\Delta Z = (L_2 + D_2) C_{435} \Delta_{435} + D_2 C_{440} \Delta_{440} \quad (2)$$

where  $L_2, D_2$  are as defined in figure 1 and  $C_{435}, C_{440}$  are the calibration factors for the two pitchers.

Each of the four magnets ND431, ND437, NP435, NP440 were swept in turn through a series of values with the other magnets fixed. Figures 2-5 are plots of the resulting position at the A20 SEM for each of the sweeps. The plots show that the position at the A20 SEM varies linearly with the magnet setting as expected. If we let  $M_{431}, M_{437}, M_{435}, M_{440}$  be the slopes of the lines which are fit to the data in figures 2-5 respectively, then the calibration factors defined in (1) and (2) are

$$C_{431} = M_{431}/(L_1 + D_1) = \frac{.001285}{433.5} = 2.96(16) \times 10^{-6} \text{ radians/command}$$

$$C_{437} = M_{437}/D_1 = \frac{.001036}{359.5} = 2.88(14) \times 10^{-6} \text{ radians/command} \quad (3)$$

$$C_{435} = M_{435}/(L_2 + D_2) = \frac{.001187}{382.7} = 3.10(08) \times 10^{-6} \text{ radians/command}$$

$$C_{440} = M_{440}/D_2 = \frac{.000620}{327.0} = 1.90(08) \times 10^{-6} \text{ radians/command}$$

(Note: The numbers in parentheses are the errors in the last digits of the quoted number.)

Figures 6 and 7 show typical A20 SEM plots from which the horizontal and vertical positions of the beam were determined. Note that with the quads NQ433, NQ444 and the AGS magnets OFF the beam width is broad in the horizontal plane at the A20 SEM and narrow in the vertical plane.

The calibration factors given in equation (3) may be expressed in terms of radians/amp using the 27 March 1985 current vs command calibration done by E. Elliott and J. Addressi for the four magnets. Using  $C'$  to denote the calibration factors in terms of radians/amp we find

$$C'_{431} = C_{431} / (1.715 \times 10^{-3} \text{ amps/command}) = 1.728(93) \times 10^{-3} \text{ radians/amp}$$

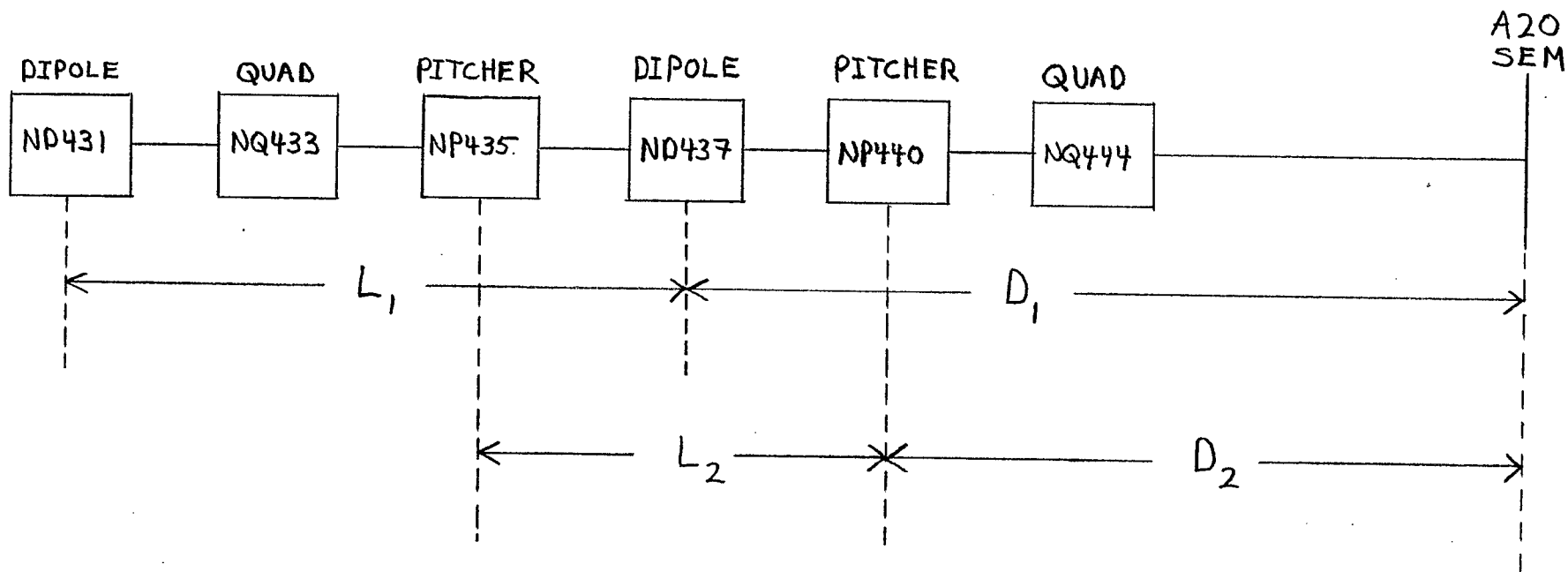
$$C'_{437} = C_{437} / (1.678 \times 10^{-3} \text{ amps/command}) = 1.717(83) \times 10^{-3} \text{ radians/amp}$$

$$C'_{435} = C_{435} / (0.686 \times 10^{-3} \text{ amps/command}) = 4.52(12) \times 10^{-3} \text{ radians/amp}$$

$$C'_{440} = C_{440} / (0.502 \times 10^{-3} \text{ amps/command}) = 3.78(16) \times 10^{-3} \text{ radians/amp}$$

It would be useful and interesting to compare our results with a calibration of the four magnets in terms of field vs current; however, to our knowledge, no such calibration exists. It would be appreciated if anyone knowing of such a calibration would get in touch with us.

Figure 1. Experimental Setup.



$$L_1 = 74.061'' , \quad D_1 = 359.48''$$

$$L_2 = 55.632'' , \quad D_2 = 327.027''$$

Quads NQ433, NQ444, and the AGS magnets were OFF.

ND431 SWEEP; NQ433,444 OFF; AGS OFF; ND437=2040  
SLOPE= 0.001285 +/- 0.000069  
INTERCEPT= 4.795128 +/- 0.125735

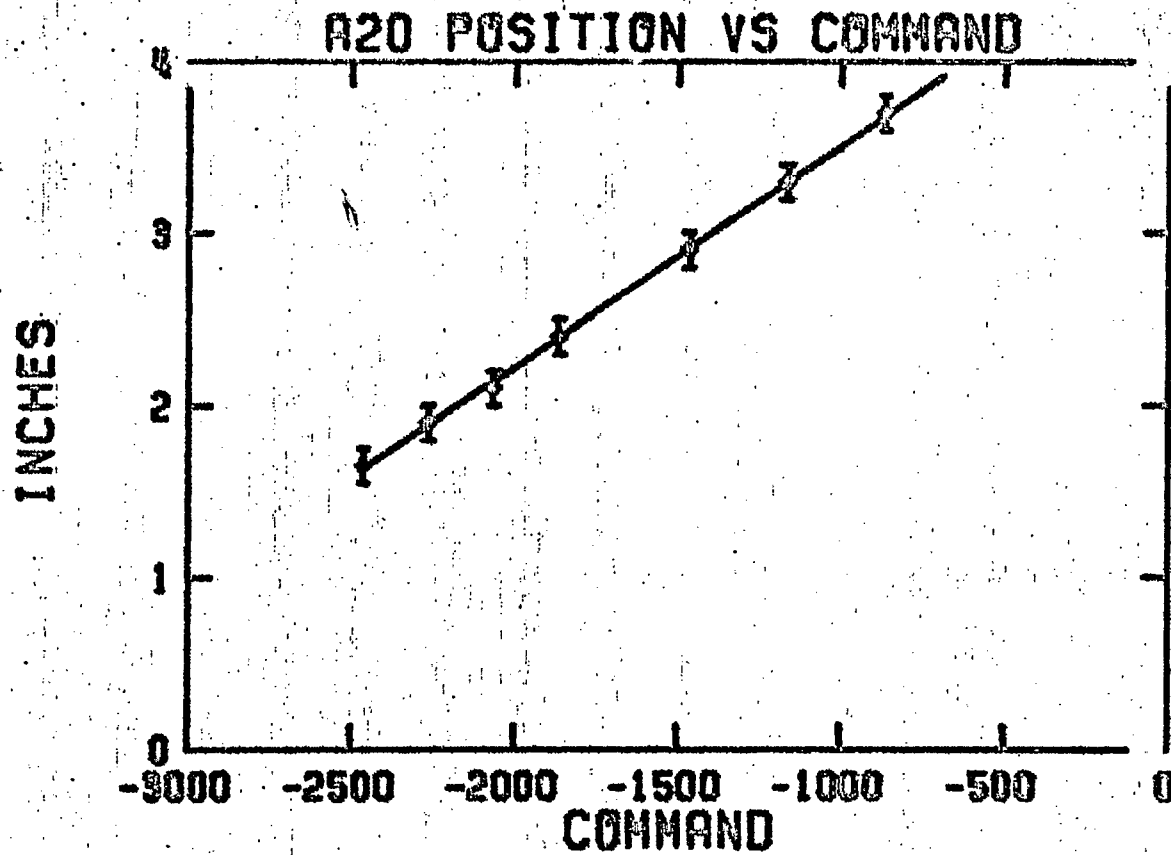


Figure 2.

ND437 SWEEP; NQ433,444 OFF, AGS OFF; ND431=-2064  
SLOPE= 0.001036 +/- 0.000049  
INTERCEPT= 0.092500 +/- 0.120981

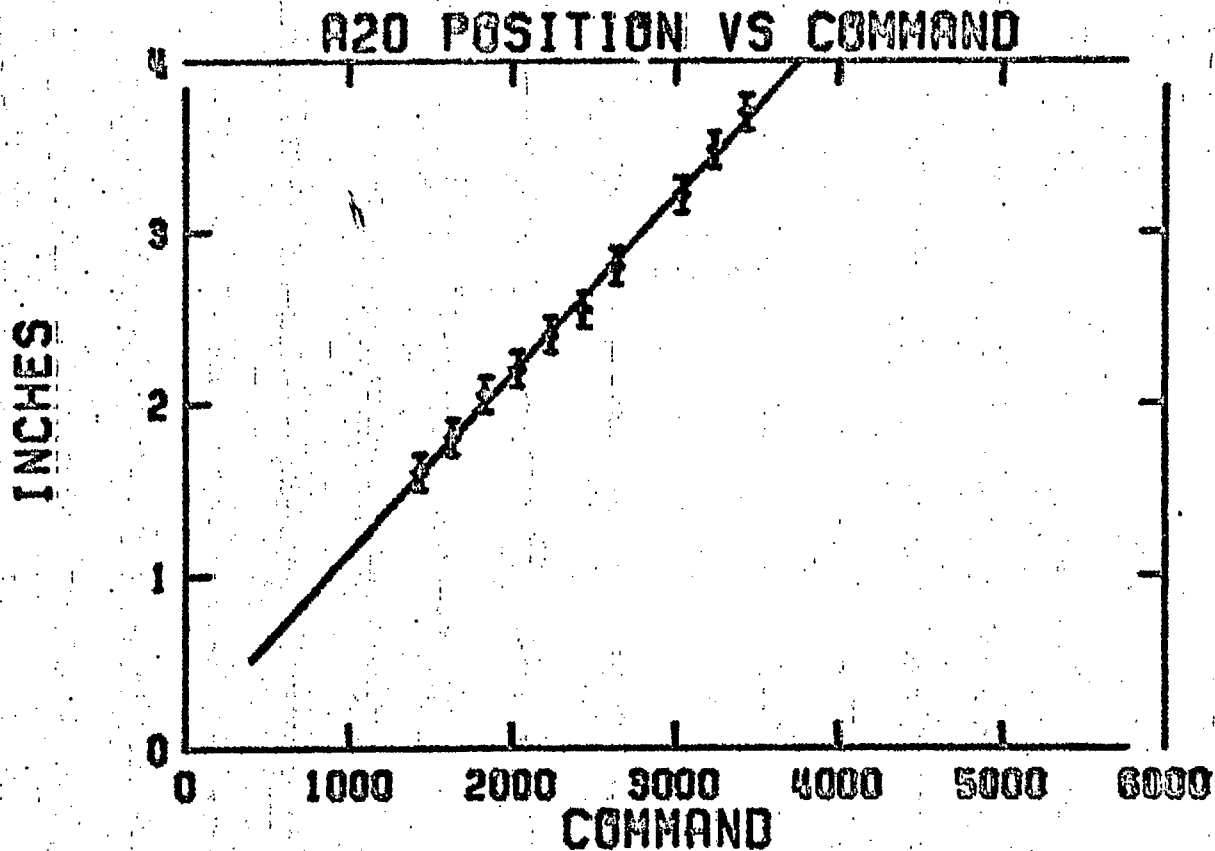


Figure 3.



NP435 SWEEP; NQ433,444 OFF; AGS OFF; NP440=943

SLOPE= 0.001187 +/- 0.000029

INTERCEPT= 0.513304 +/- 0.018226

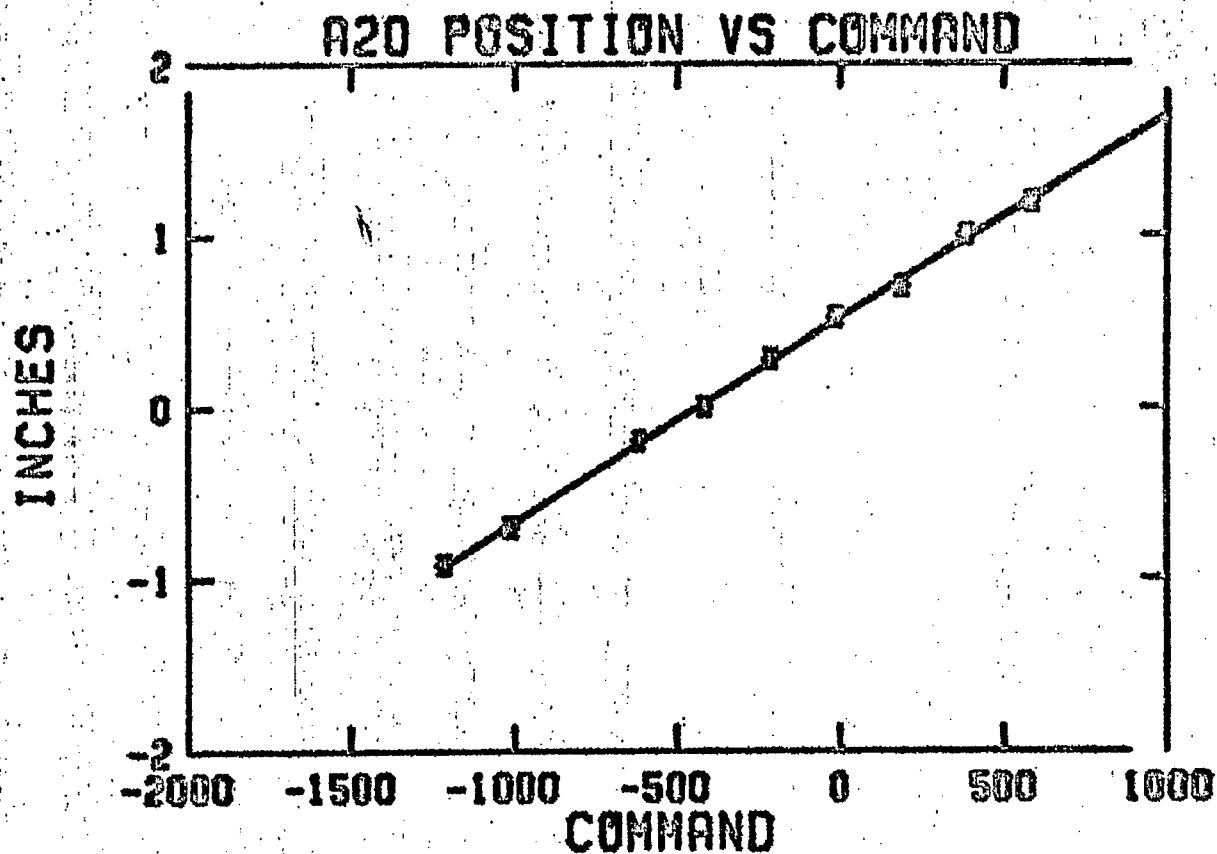


Figure 4.

NP440 SWEEP; NQ433,444 OFF; AGS OFF; NP435=-412  
SLOPE= 0.000620 +/- 0.000026  
INTERCEPT= -0.530778 +/- 0.034158

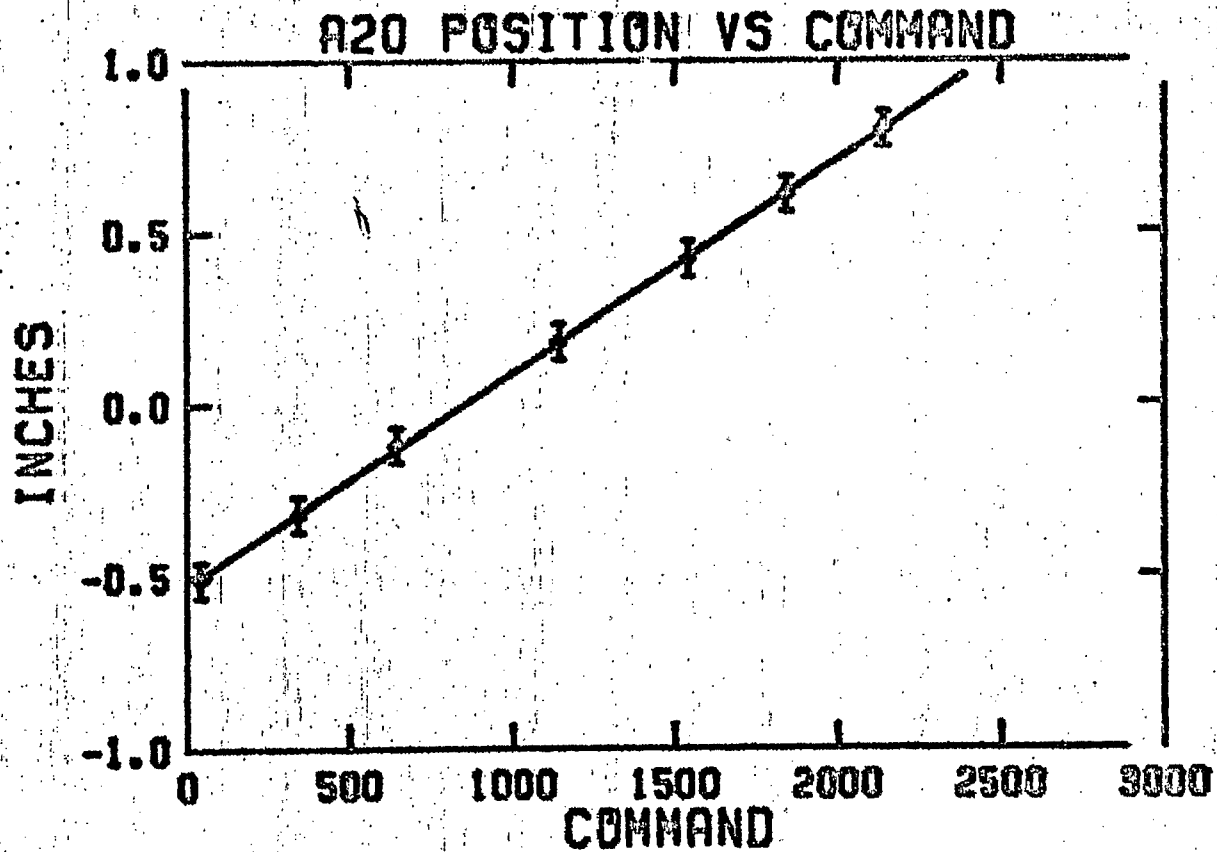


Figure 5.

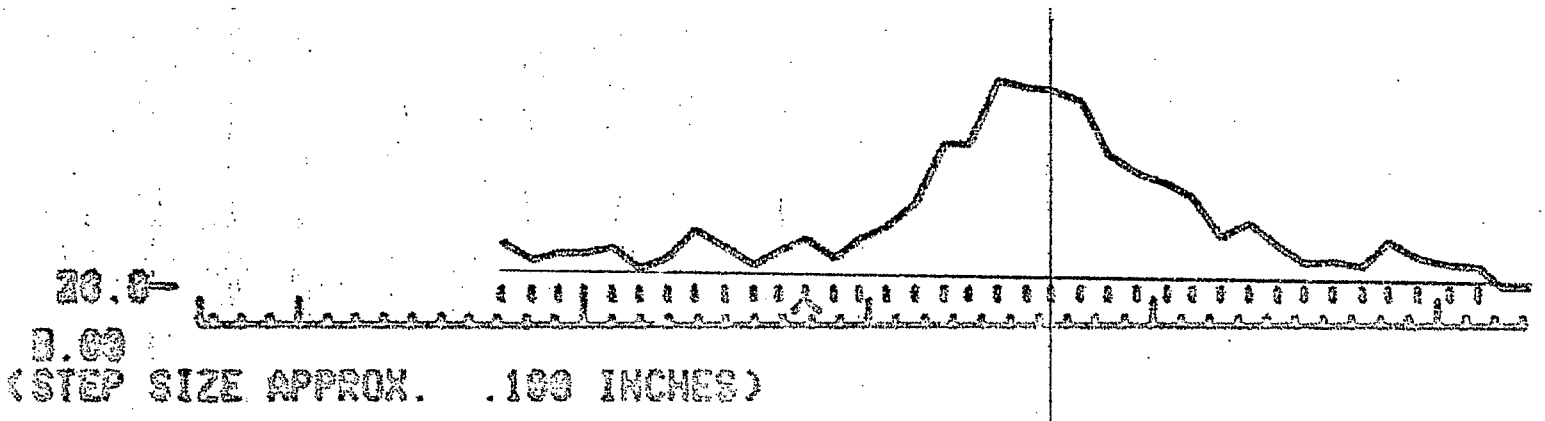


Fig. 6. Horizontal A20 SEM plot.

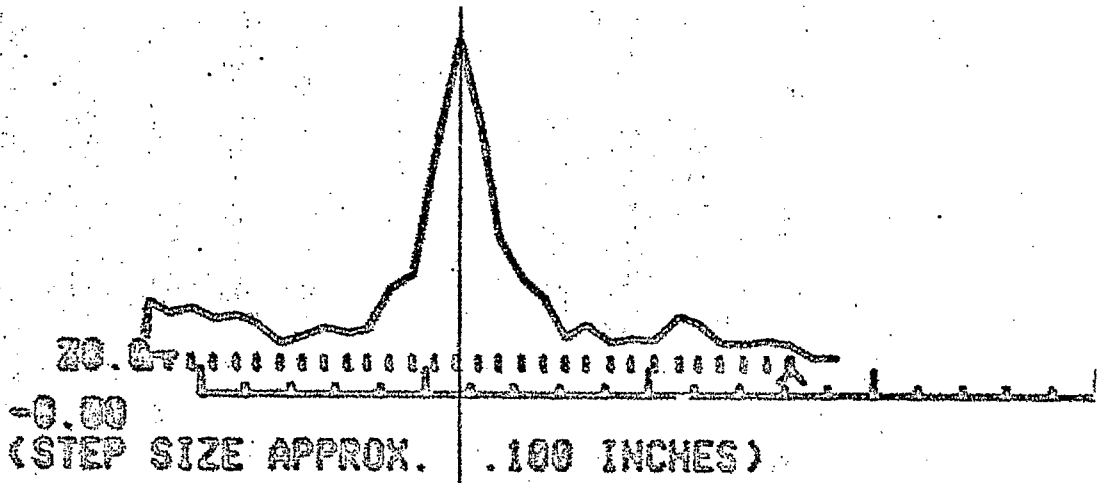


Fig. 7. Vertical A20 SEM plot.