

# Lawrence Berkeley National Laboratory

## Recent Work

### Title

TFTR THREE CHANNEL DEFLECTION MAGNETS - MAGNETIC MEASUREMENTS

### Permalink

<https://escholarship.org/uc/item/7b4100gj>

### Authors

Dorst, Joseph H.  
Green, Michael I.  
Nelson, Donald H.

### Publication Date

1980

LBID-169c.1  
38



# Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA, BERKELEY

## Engineering & Technical Services Division

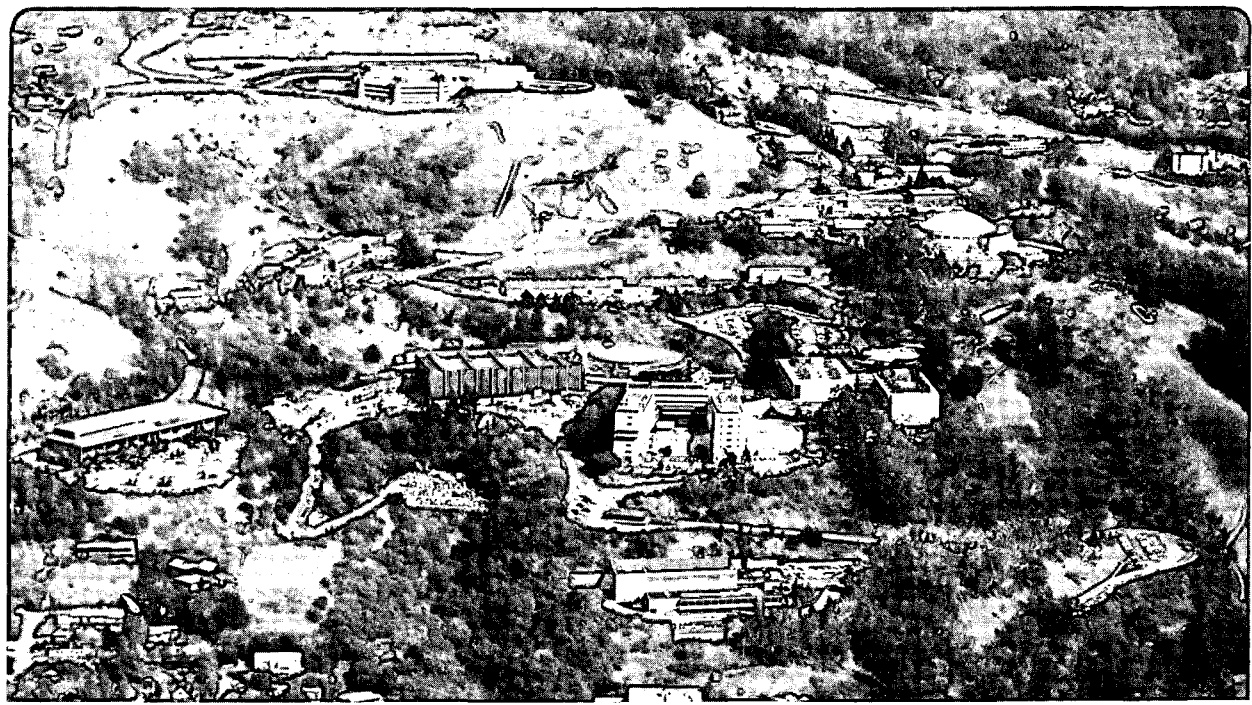
RECEIVED  
LAWRENCE  
BERKELEY LABORATORY

MAK 24 1980

LIBRARY AND  
DOCUMENTS SECTION

**For Reference**

Not to be taken from this room



LBID-169c.1

## **DISCLAIMER**

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

SUBJECT

TFTR THREE CHANNEL DEFLECTION MAGNETS -  
MAGNETIC MEASUREMENTS

NAME

DATE January 8, 1980

Authors: Joseph H. Dorst, Michael I. Green, and Donald H. Nelson

Introduction & Test Plan

Engineering Note MT 273-A (LBID-087-1) summarizes extensive measurements conducted for the first TFTR Three Channel Deflection Magnet (Magnet No.  $\emptyset$ ). A tentative test plan for measuring four additional magnets was distributed in our December 11, 1979 memo to Ken Lou. Subsequent discussion with Ken Lou resulted in an increase in the number of measurements as listed below:

1. Measure  $B_y(0,0,0)^*$  for magnet currents of 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 (Amperes).
2. Check the polarity of  $B_y$ .
3. Determine coil resistance by measuring potential drop across each coil pair for the coil current levels in 1 above.

Measurements were to be made for each channel for a total of 12 sets of data with an overall accuracy of  $\pm 1\%$ . There were no "field-profile" measurements, because fabrication tolerances were adequate to assure adequate similarity to Magnet No.  $\emptyset$ . There are no Hall probes installed on Magnets 1 through 4.

Results

We have attempted to display the data so that each of the sections of Magnets 1 through 4 can be compared with the Center Section of Magnet No.  $\emptyset$ . Figure 1 is a plot of  $B_y(0,0,0)$  vs.  $I$ . The curve plotted in Fig. 1 represents the average of 11 sections of Magnets 1 - 4 (The Left-Hand Section of Magnet No. 3 is not included in this average because it was measured at different values of magnet-current than the remaining sections of Magnets 1 - 4). The points plotted in Fig. 1 represent measurements of the reference magnet (Magnet No.  $\emptyset$  - Center Section).

In order to display small variations between data-sets, the remaining plots are of the quantity  $(B - 3.15 * I)$  vs.  $I$ . Figure 2 shows a point-plot of all the data presented in this note superimposed on a curve representing the Center Section of Magnet  $\emptyset$ . The dashed lines represent a deviation of  $\pm 1\%$  of  $B_y(0,0,0)$  from the curve representing the Center Section of Magnet  $\emptyset$ . Each magnet data is also plotted separately (with the same reference curve) as shown by the figures listed in Table I.

\* The coordinate system is described in Reference 1 (Page 8)

SUBJECT

TFTR THREE CHANNEL DEFLECTION MAGNETS -  
MAGNETIC MEASUREMENTS

NAME

DATE January 8, 1980

Authors: Joseph H. Dorst, Michael I. Green, and Donald H. Nelson

Figure	Magnet	Channel		
		LHS	CEN	RHS
3	0	X	0	
4	1	X	0	+
5	2	X	0	+
6	3	X	0	+
7	4	X	0	+

Table I

Note: There were no measurements of Magnet No. 0 RHS (Right-Hand Section).

Data Analysis and graphs were prepared with the aid of the Tektronix Computer Model No. 4051 and Tektronix Hard-Copy Unit Model No. 4631.

Table II is a guide to the data included in this report. Table III shows the data selected for the center section of Magnet 0.

For completeness we include a plot of B/I vs. I (Fig. 8) in which all the points are plotted along with a curve representing the 11 section average shown in Fig. 1.

Test Equipment

Figure 9 shows the test equipment used for the measurements of Magnets 1 - 4. The Hall-Probe was located at (0,0,0) by means of the fixture shown in Figure 10. Figure 11 shows the power & interlock circuitry used for these tests.

Discussion

The slope of the air-gap-line\* is 3.198 (Gauss/A) for a gap of 16.51 cm and 21 turns per pole. We chose a value of 3.15 to calculate  $B = B(I) = 3.15 * I$ . For the graphical comparisons in Figures 2 through 7. The value of 3.15 gives adequate resolution of differences with a monotonic curve. (The factor of 3.132 mentioned in MT 273 was simply the best straight line fit for data points up to 700 A.)

The measured coil resistances for all sections of Magnets 1 through 4 are  $0.020\Omega \pm 0.01\Omega$  over the range of current  $0 \leq I \leq 900A$ .

$$* \frac{B}{I} [G/A] = \frac{n}{g} \times 1.257 \frac{0e}{At/cm} = 3.198 [G/A]$$

$$n = \text{No. turns} = 42$$

$$g = \text{Gap Dimension} = 16.51 \text{ cm}$$

**ENGINEERING NOTE**BOOK NO.  
616FILE NO.  
LBID-169  
MT 286PAGE  
3 of 16

SUBJECT

TFTR THREE CHANNEL DEFLECTION MAGNETS -  
MAGNETIC MEASUREMENTS

NAME

DATE

January 8, 1980

Authors: Joseph H. Dorst, Michael I. Green, and Donald H. Nelson

It should be noted that, during the measurements of Magnet  $\emptyset$ , 1) no measurements were made in the Right-Hand Section and 2) the Center Section was energized while the Left-Hand Section was measured and the Left-Hand Section was energized while the Center Section was being measured (see note Fig. 3). During the measurements of Magnets 1 - 4 only the section being measured was energized.

Acknowledgements

We wish to thank George Hampton for readying the power-supply, Don Morris for providing a 3-channel interlock system, and Ed Cyr for connecting the power and water and collecting the data.

Distribution: E. Cyr  
G. Hampton  
E. Hartwig/L..Wagner/W. Deuser  
J. Haughian  
D. Hopkins  
K. Lou  
D. Morris  
B. Prichard (Princeton)  
K. Wright (Princeton)  
R. Yourd  
Magnetic Measurements Engineering (4)  
Electronics Engineering Master File (2)

References

1. Green, M.I., LBL Engineering Note MT 273-A, (LBID 087-1), Magnetic Induction Mapping of TFTR Three Channel Deflection Magnet, June 29, 1979.
2. Nelson, D.H. & Green, M.I., memo to K. Lou, TFTR Magnetic Measurements, December 11, 1979.

TFTR MAGNETS 1-4, AVERAGE OF 11 SECTIONS. SQUARES ARE MAG# 0 CEN  
(GAUSS VS AMPERES)

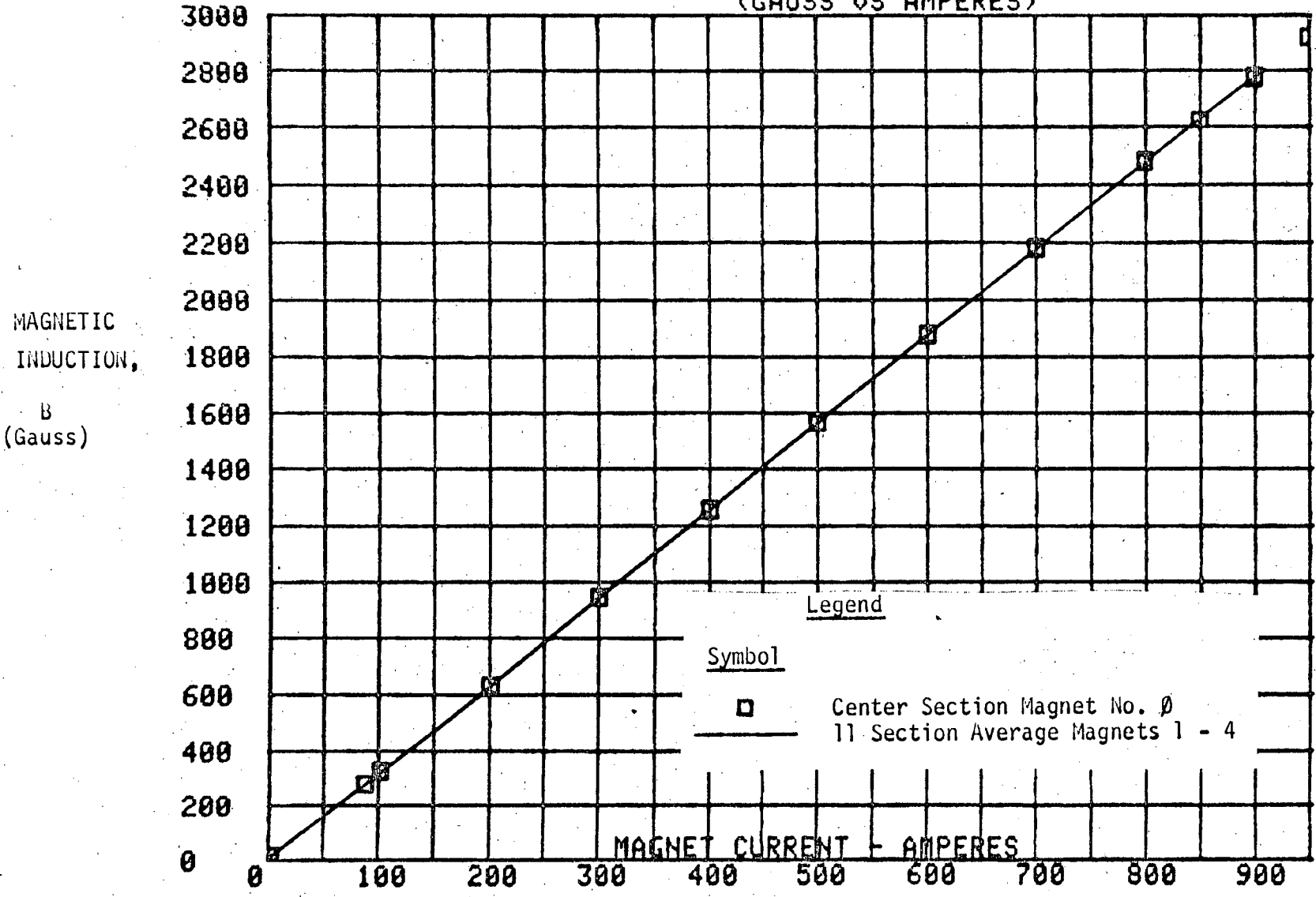


Figure 1

TFTR COMPARISONS

LINE IS MAG# 0      POINTS ARE ALL RUNS  
 DELTA B = B - I \* 3.15      (GAUSS)      October 1978 & January 1980

DELTA B,  
 B - 3.15 \* I  
 (Gauss)

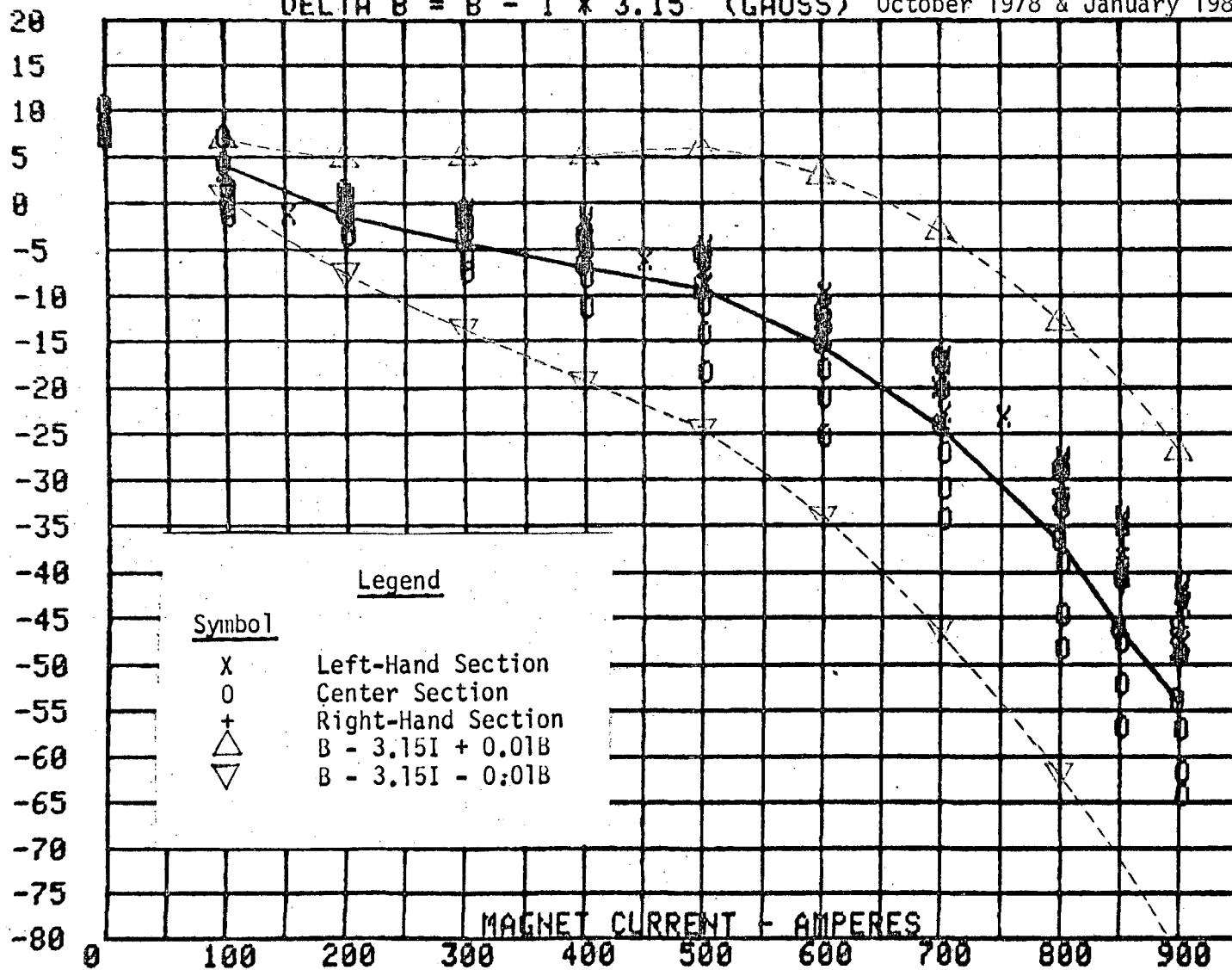


Figure 2



MAG# 0 CEN PTS ARE MAG# 0  
 $\Delta B = B - I * 3.15$  (GAUSS)

October 1978

$\Delta B,$   
 $B - 3.15 * I$   
 (Gauss)

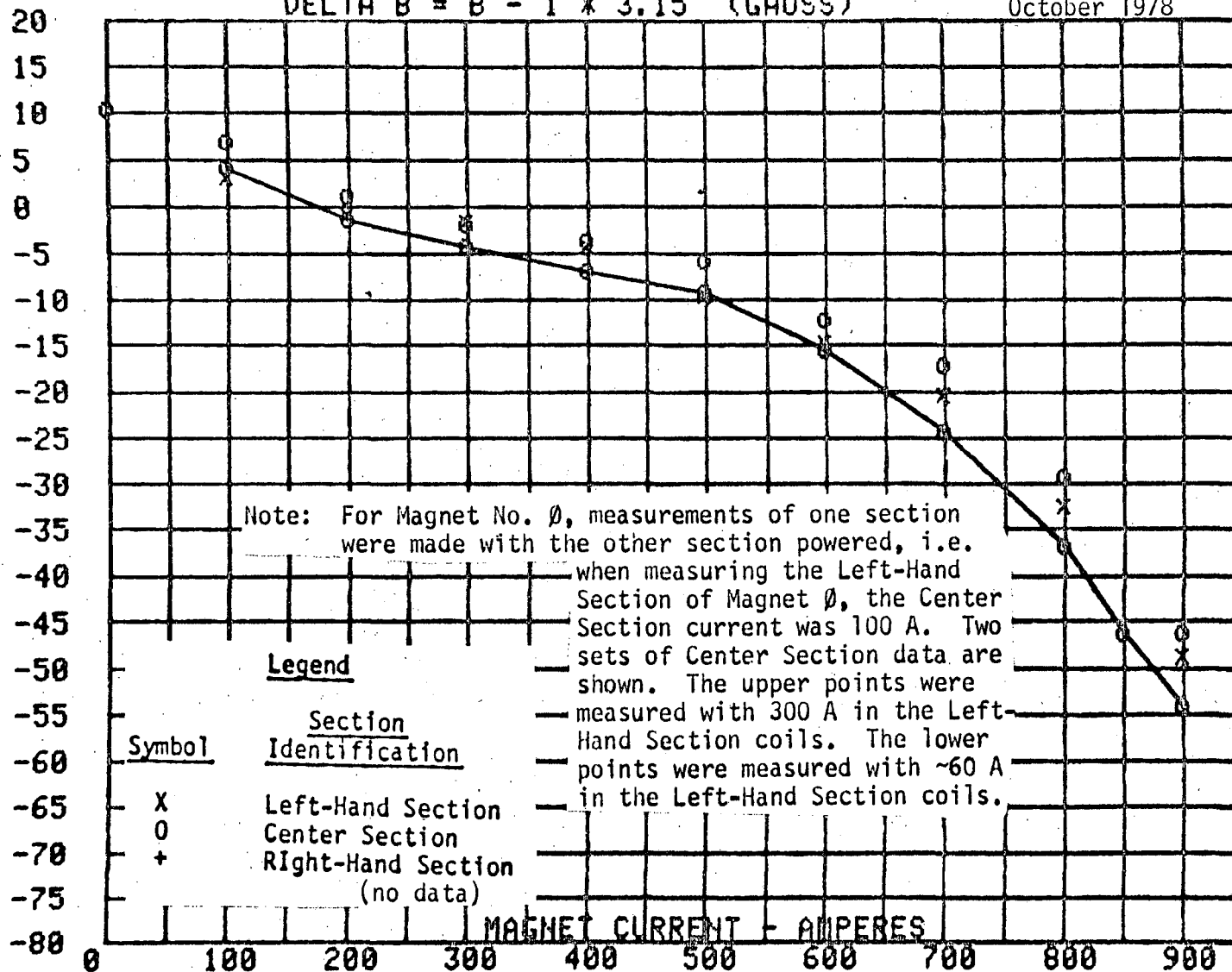


Figure 3

MAG# 0 CEN PTS ARE MAG #1  
 $\Delta B = B - I * 3.15$  (GAUSS)

January 1980

$\Delta B,$   
 $B - 3.15 * I$   
 (Gauss)

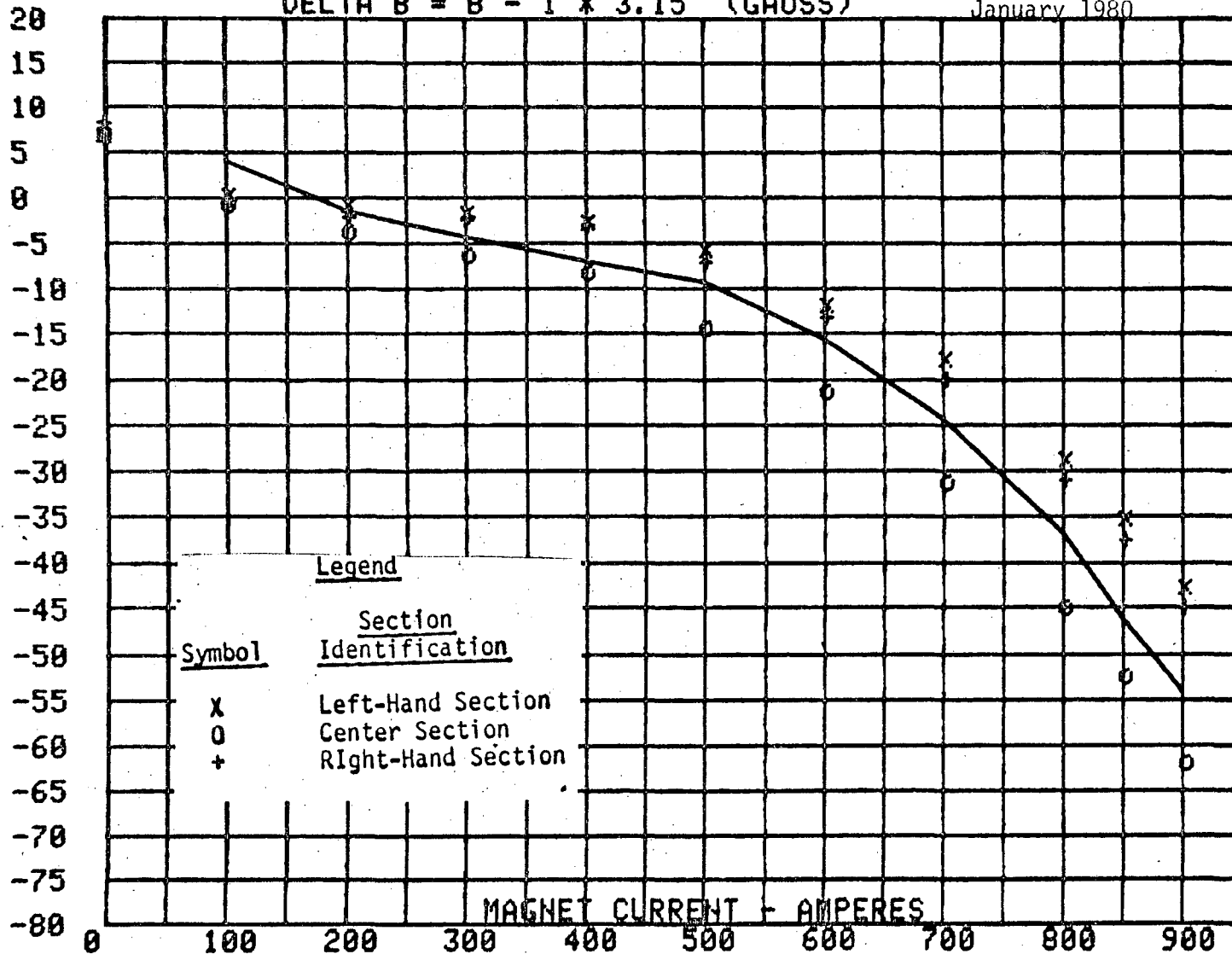


Figure 4

MAG# 0 CEN PTS ARE MAG # 2  
 DELTA B = B - I \* 3.15 (GAUSS)

January 1980

DELTA B,  
 B - 3.15 \* I  
 (Gausses)

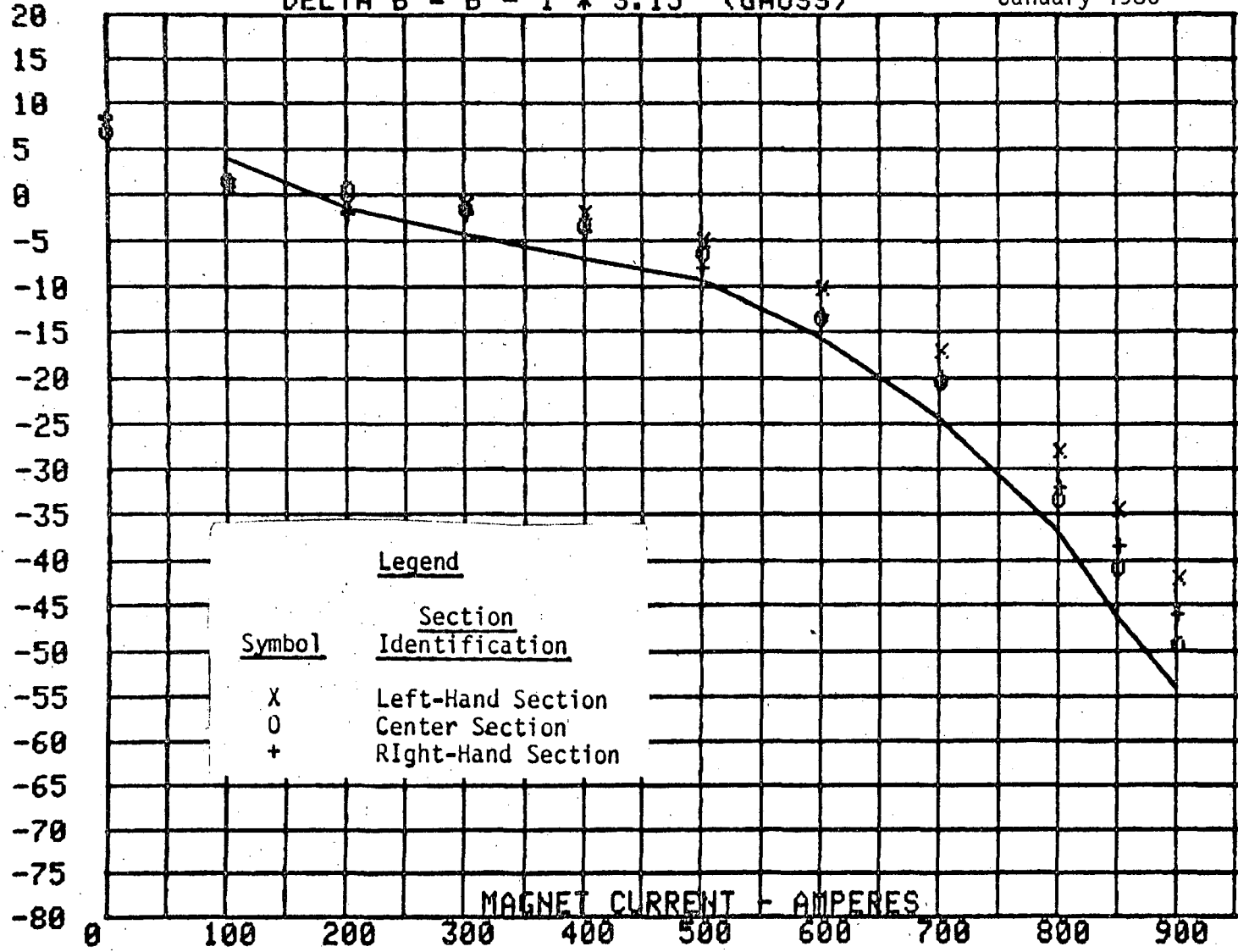


Figure 5

MAG# 0 CEN PTS ARE MAG# 3  
 $\Delta B = B - I * 3.15$  (GAUSS)

January 1980

$\Delta B,$   
 $B - 3.15 * I$   
 (Gauss)

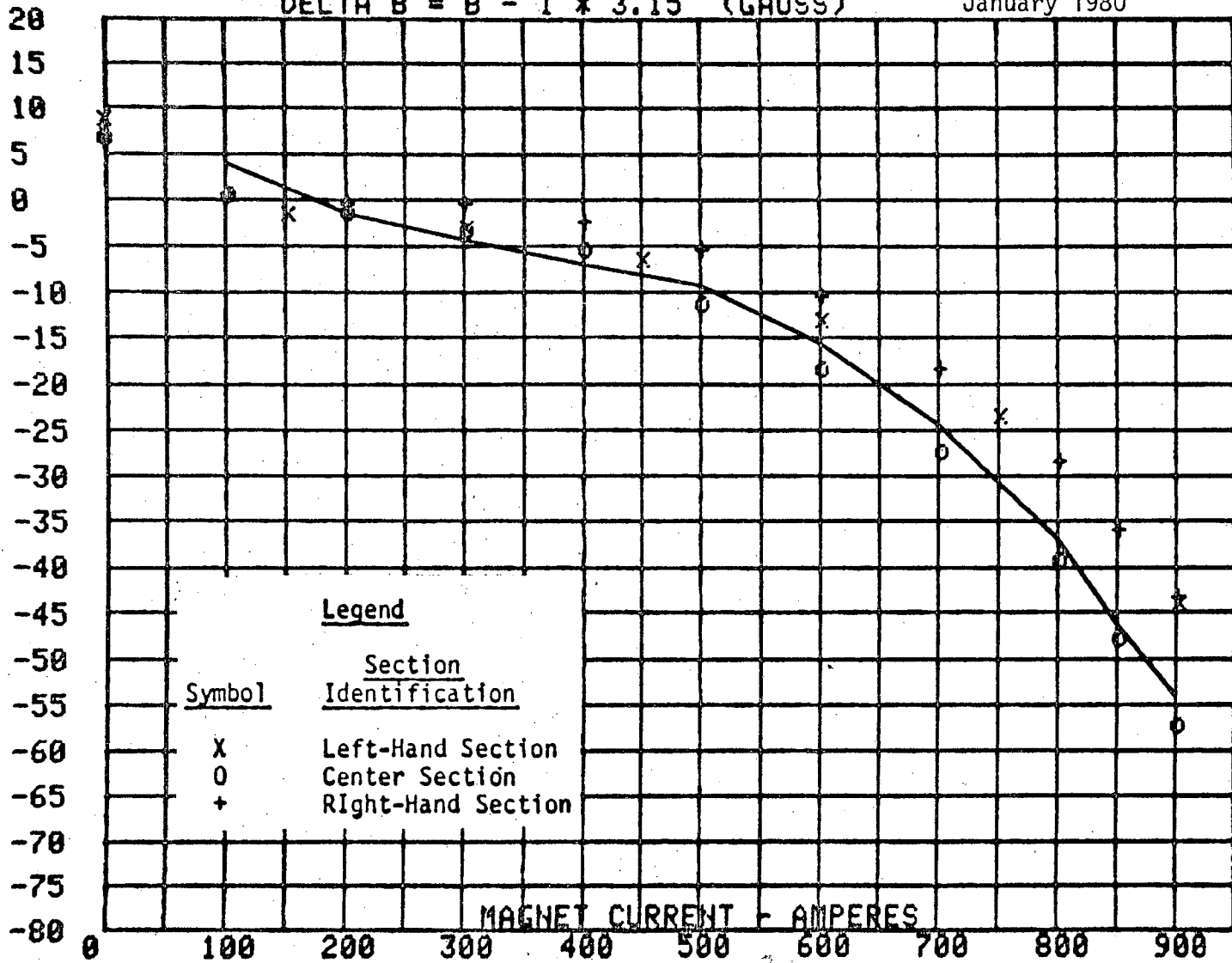


Figure 6

MAG# 0 CEN PTS ARE MAG# 4  
 DELTA B = B - I \* 3.15 (GAUSS)

January 1980

DELTA B,  
 B - 3.15 \* I  
 (Gauss)

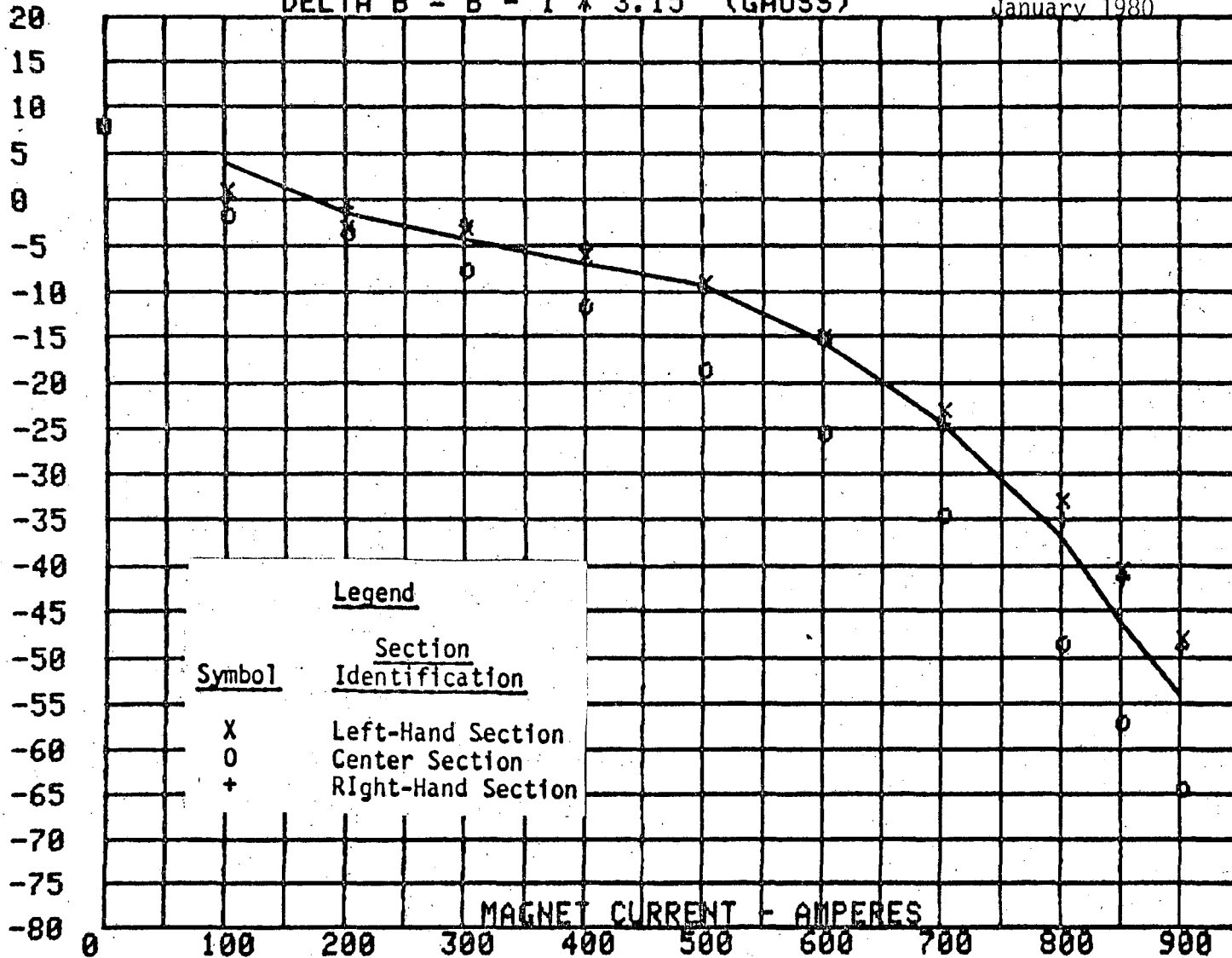


Figure 7

TFTR COMPARISONS

LINE IS AVERAGE OF 11 POINTS ARE ALL RUNS

STRENGTH - B/I - GAUSS/AMPERE October 1978 & January 1980

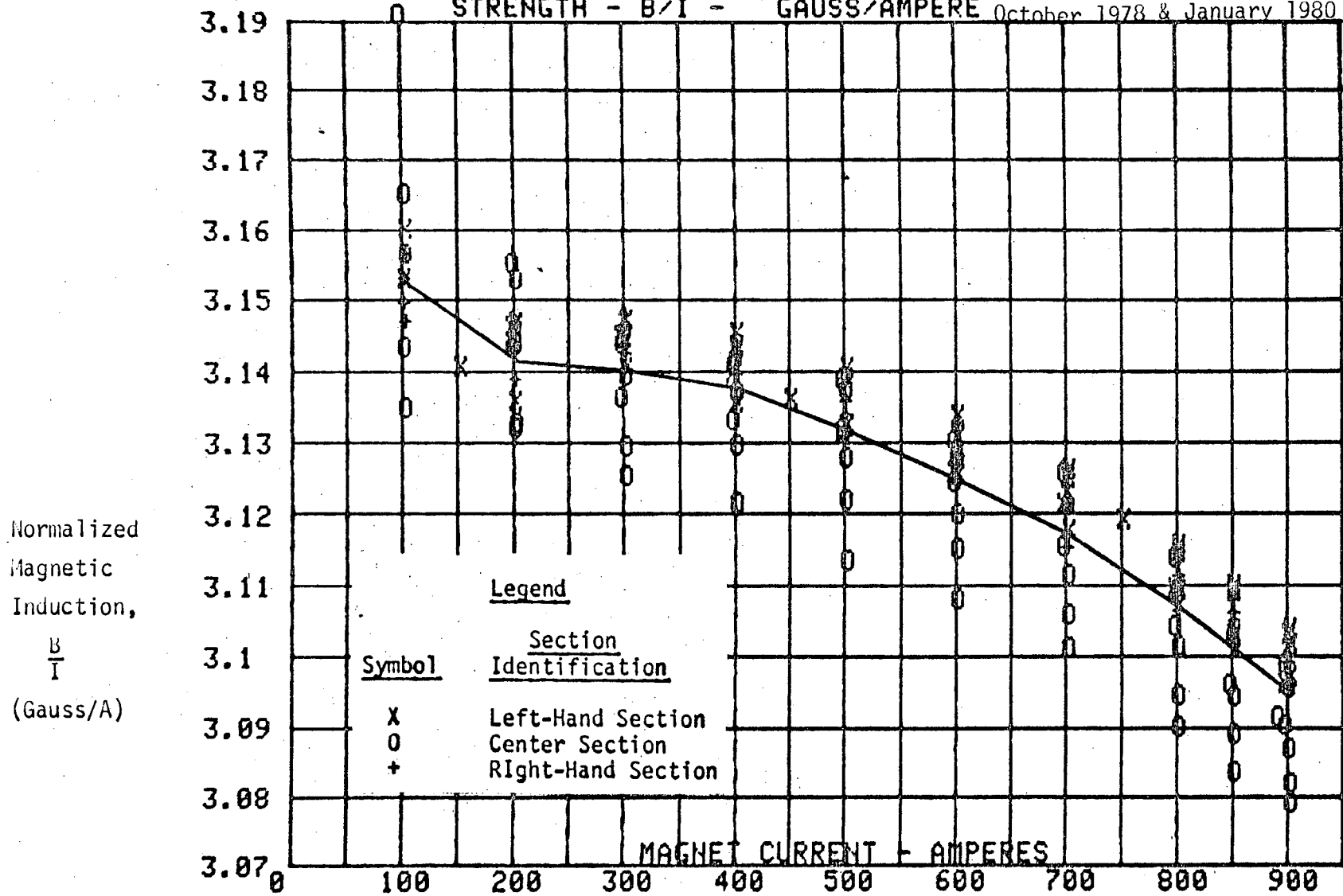


Figure 8

SUBJECT TFTR THREE CHANNEL DEFLECTION MAGNETS - MAGNETIC MEASUREMENTS			<h1 style="margin: 0;">S K E T C H</h1>			Page: 12 of 16		
DRAWN BY Donald H. Nelson			LAWRENCE RADIATION LABORATORY UNIVERSITY OF CALIFORNIA			JOB ORDER INFORMATION	SERIAL NO.	NO. RECD.
DATE 1/8/80	BUILDING NO.	ROOM NO.	APPROVED BY		DATE	DATE ISSUED	DATE RECD.	
						DELIVER TO		

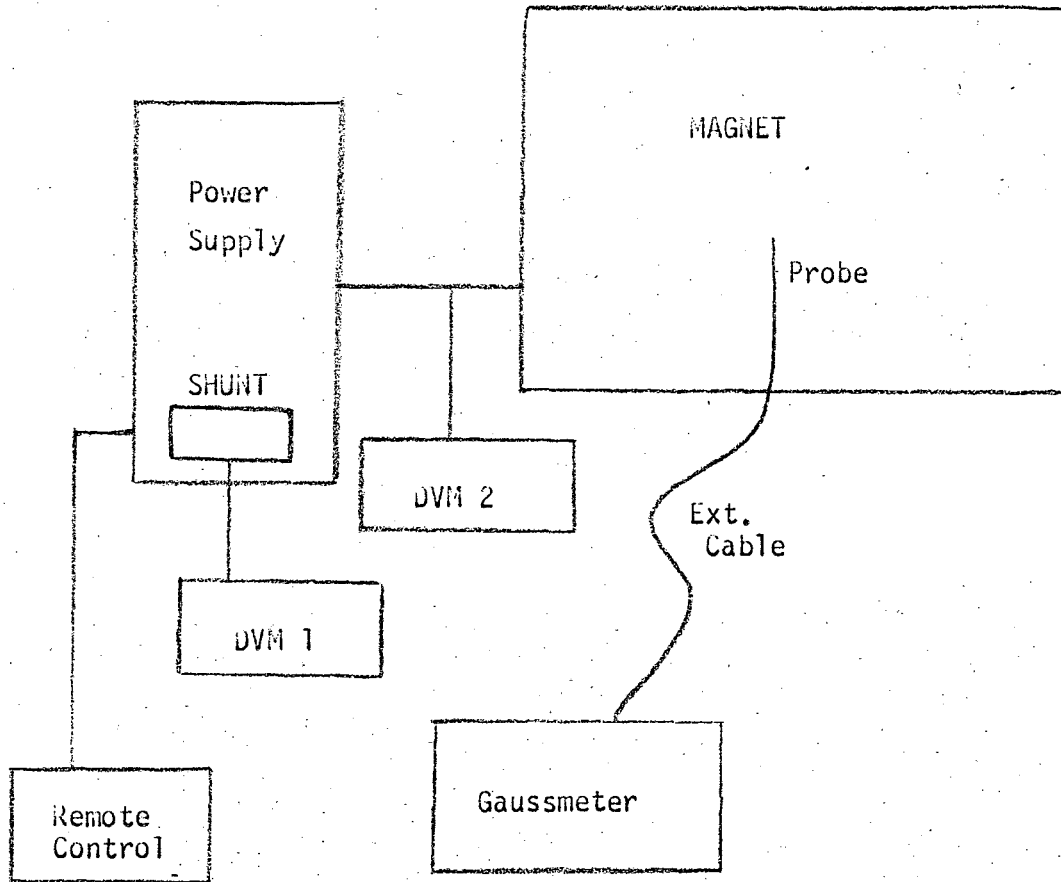


Figure 9 Test Equipment

Magnet	128KW SCR DCP	Drwg. No. 2L 5955
Power-Supply		AEC No. 147291
Shunt	In Power Supply	20A/mV
DVM 1	Keithley Mod. 177	S/N 10450
Remote Control	Lawrence Berkeley Lab	Drwg. No. 2L 5443
Probe	F.W. Bell Mod. HTJ-0608	S/N 119454
		Cal 0.7890
Ext. Cable	F.W. Bell Mod. X0Q4-0025	S/N 99258
Gaussmeter	F.W. Bell Mod. 8860	E.R.D.A. No. 504143
DVM 2	Data Precision Mod. 258	S/N 4457

SKETCH  
 NUMBER

Notes: 1. Both Faces Parallel  
2. Concentric Lathe tool marks on Faces

REQ.	ITEM	PART NUMBER	DESCRIPTION
1	1		4" DIAMETER ALUMINUM ROD
1	2		1/2"-20 Threaded Brass ROD 3 3/4" length

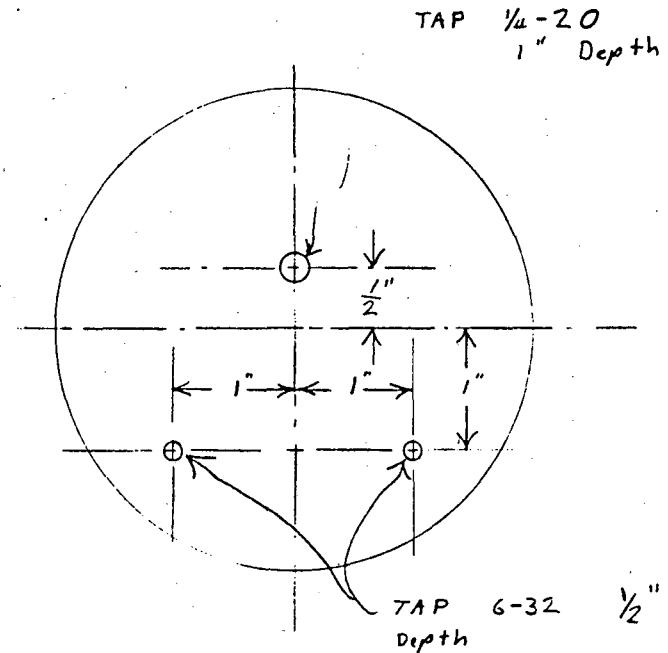
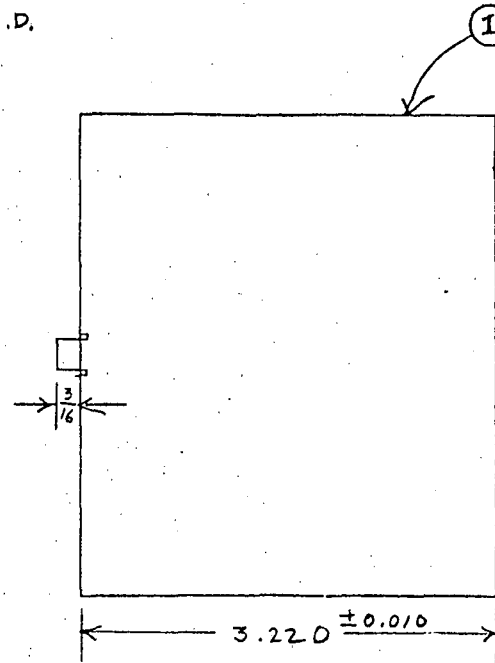
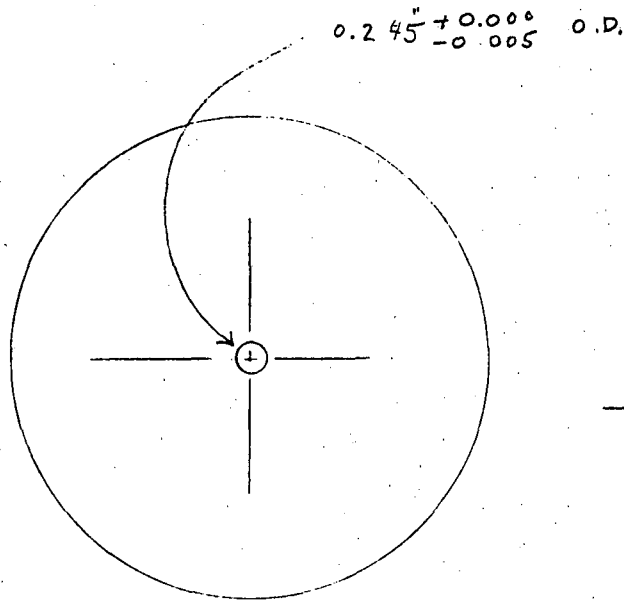


Figure 10 - Probe Mounting Fixture

UNLESS OTHERWISE SPECIFIED				SHOP ORDERS			LAWRENCE BERKELEY LABORATORY UNIVERSITY OF CALIFORNIA - BERKELEY				
1. TOLERANCE	1/32	0.010		ACCT. NO.	SER. NO.		TFTR 3 CH. DEFLECTION MAGNET				
2. SURFACE FINISH	C3	✓		DATE ISS'D.	DATE RECD.	NO. REQD.	HALL PROBE POSITIONER				
2. SAWED, FLAME CUT, SHEARED OR STOCK FINISH		X		DELIVER TO							
4. THREADS CLASS 2.				SURFACE TREATMENT			PAT. CLEAR.	DWG. TYPE	SHOWN ON	SCALE: FULL	
5. CHAMFER ENDS OF ALL SCREW THREADS 30°.				IDENTIFIC. METHOD				D		DO NOT SCALE PRINTS	
6. 1 1/2 PITCH RELIEF WITH ROUND NOSE TOOL ON ALL MACHINE CUT THREADS.				OWN. BY	DATE		MICROFILMED	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO.	
7. BREAK EDGES 1/64 MAX. ON MACHINED WORK.				BY				2014-62		16 V 102	
8. REMOVE BURRS, LOOSE SCALE AND WELD SPATTER.				CHK. BY						2	
9. REFERENCE-USASI OR ASA STDS. SECT. 4-14 & B44.1										REV	
REV.	DWN.	CHK.	DATE	CHANGES							



SUBJECT

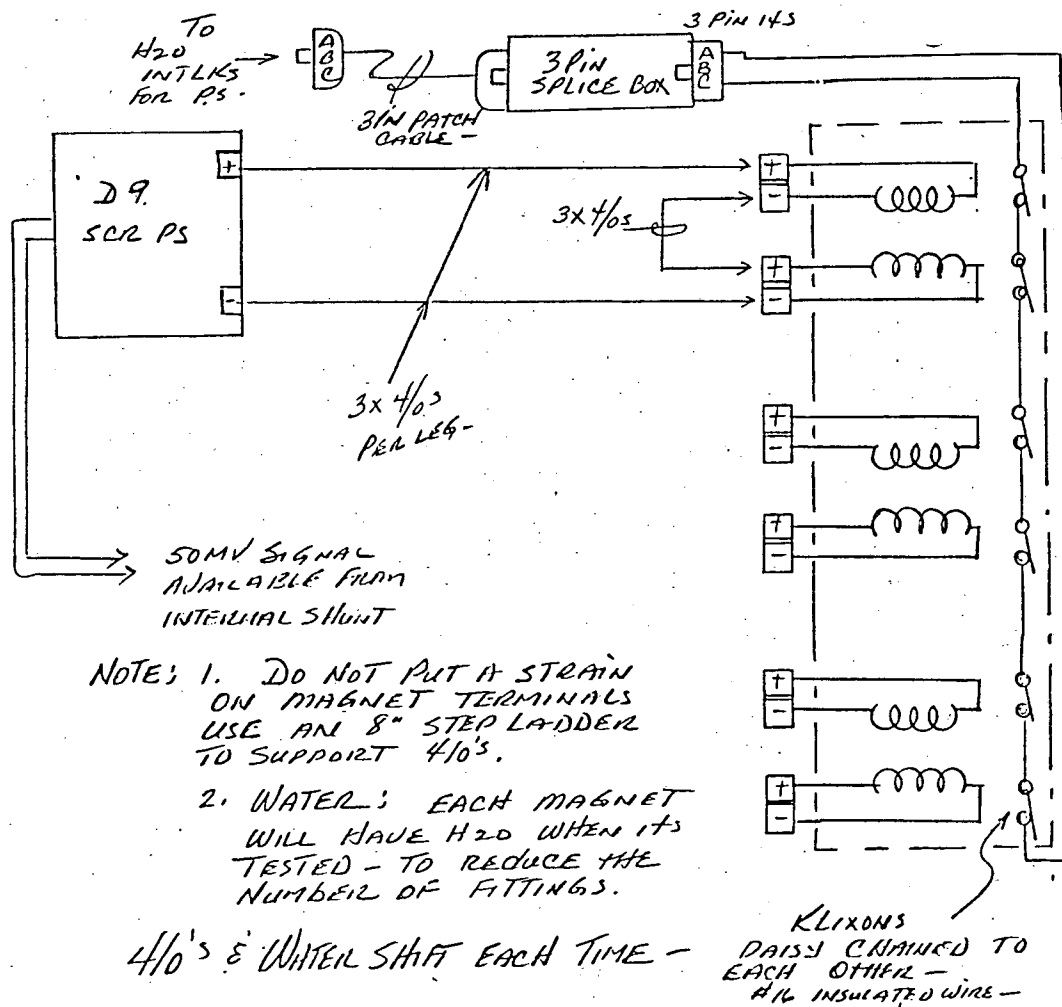
TFTR THREE CHANNEL DEFLECTION MAGNETS -  
MAGNETIC MEASUREMENTS

NAME

DATE

January 8, 1980

Authors: Joseph H. Dorst, Michael I. Green, and Donald H. Nelson

Figure 11  
Power Interlock Circuitry

Drawn by: Don Morris

12-18-79



SER.# 2-13 MAG# 0 CEN PTS ARE MAG # 0 8 '78/10/11 0.1 T/KG

DATA PT	CURRENT (AMP)	B(0,0,0) (GAUSS)	B-3.15*I (GAUSS)	B/I (GAUSS/AMP)
1	86.0	271.8	0.9	3.160
2	100.0	319.1	4.1	3.191
3	200.0	628.6	-1.4	3.143
4	300.0	940.8	-4.2	3.136
5	400.0	1253.1	-6.9	3.133
6	500.0	1565.8	-9.2	3.132
7	600.0	1874.5	-15.5	3.124
8	700.0	2180.6	-24.4	3.115
9	800.0	2483.1	-36.9	3.104
10	850.0	2631.2	-46.3	3.096
11	900.0	2780.8	-54.2	3.090
12	950.0	2927.9	-64.6	3.082
13	500.0	1582.4	7.4	3.165

Table III Data Selected to Represent  
the Center Section of Magnet Ø  
(Reference Magnet)

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.

TECHNICAL INFORMATION DEPARTMENT  
LAWRENCE BERKELEY LABORATORY  
UNIVERSITY OF CALIFORNIA  
BERKELEY, CALIFORNIA 94720