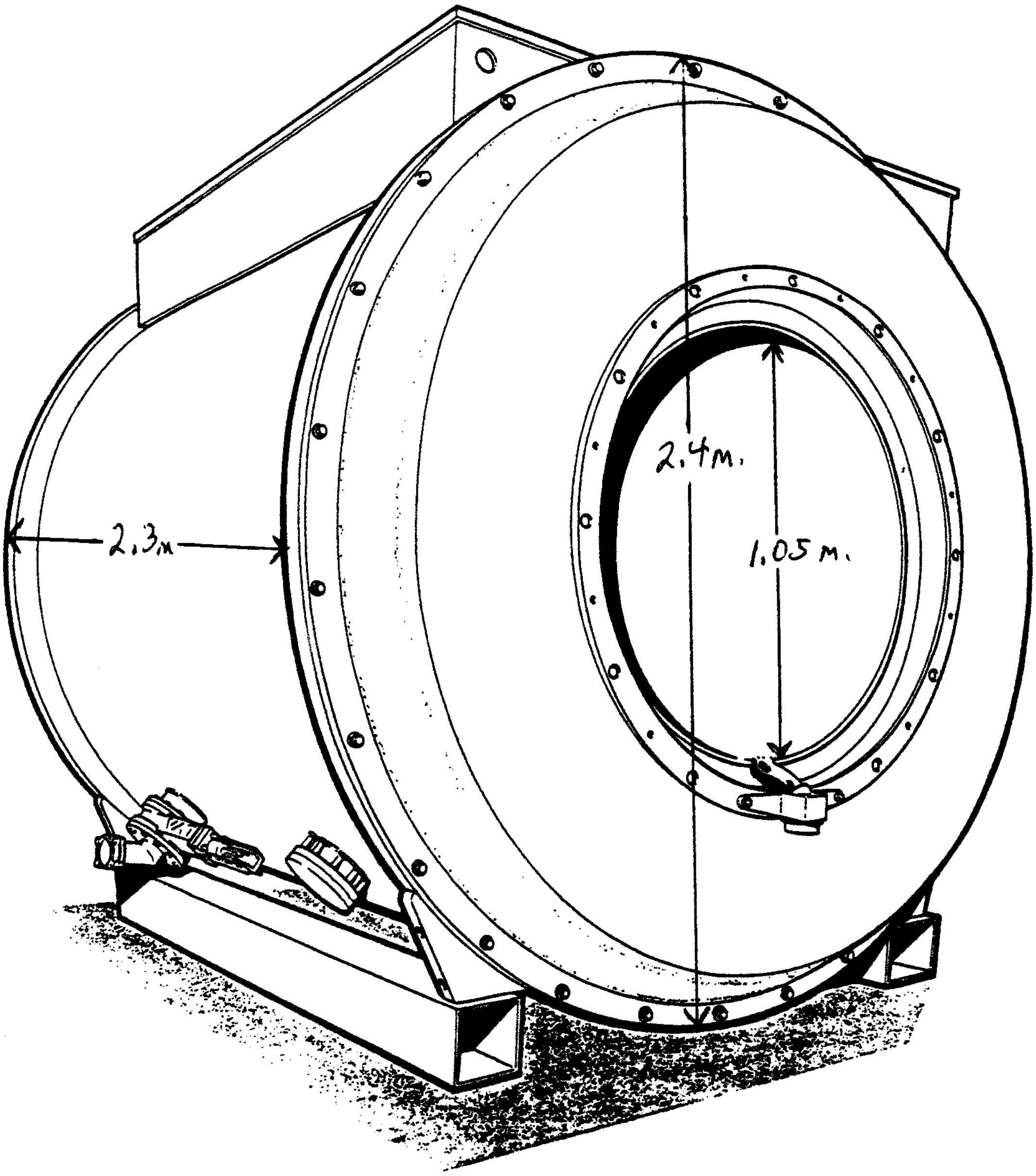
FIELD MAPPING THE "TWIST" SOLENOID

Mike Barnes, Doug Evans and Dave Morris, TRIUMF

A large bore 2.2 Tesla Superconducting Solenoid must be field mapped for the TWIST experiment at TRIUMF to an accuracy of 1 part in 10,000 over a 36 cm. diameter and a 1.2 meter length. Preliminary measurements were carried out at 10% excitation using a hall probe mounted on the 3-D survey table in the Magnet Measurement Area, without B shielding in place. Additional measurements were carried out at 50 % excitation with the solenoid in it's final position on the beamline with B shielding in place, using a six-way Hall probe array. These results will be presented and compared to 3D predictions. An automated survey system with two rotating arms and 12 Hall probes mounted on them is being built to complete the field mapping. The hardware and software of this system will be discussed.

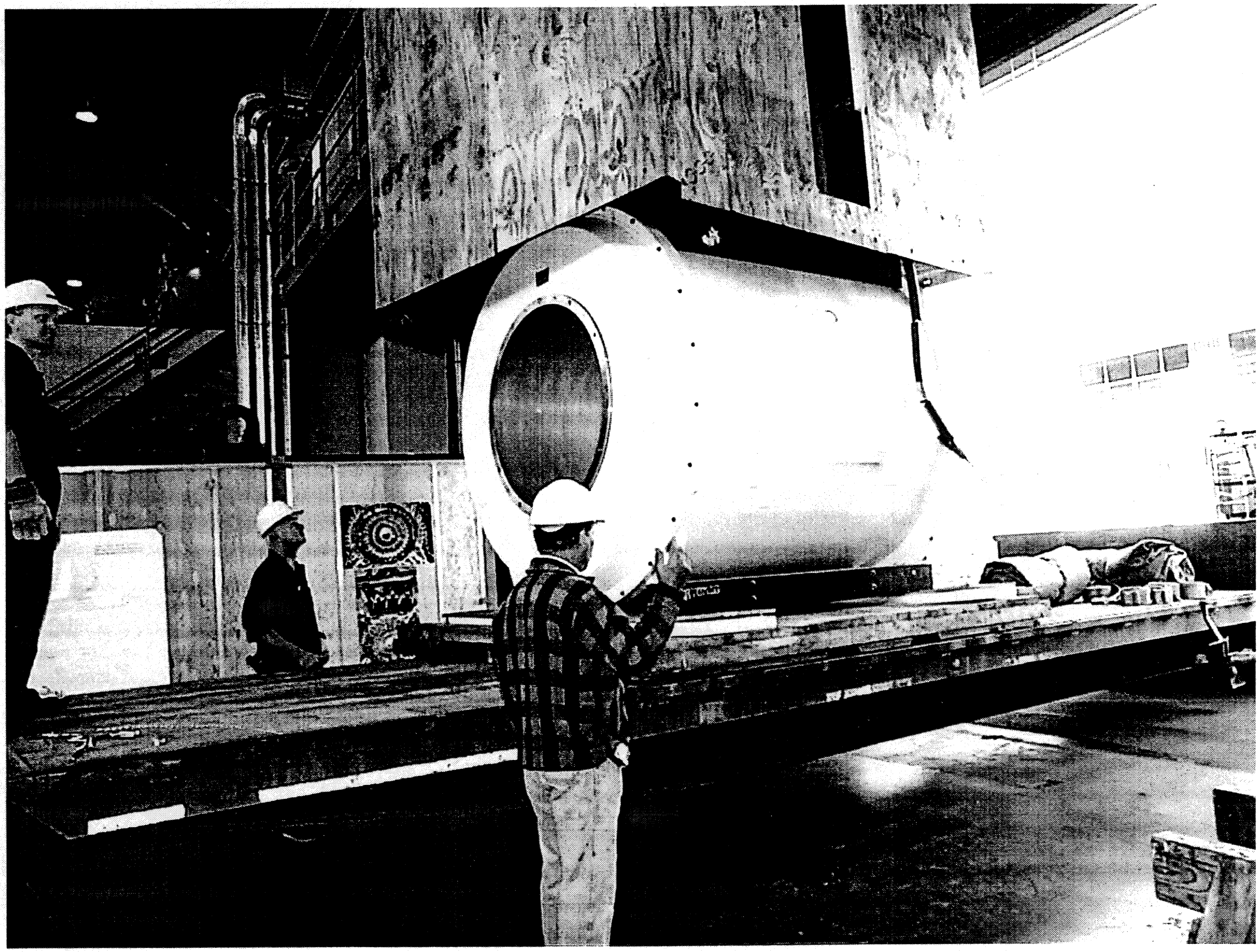
MAGNET SPECIFICATIONS



Weight: 7800 kg.

I(max): 242 amps

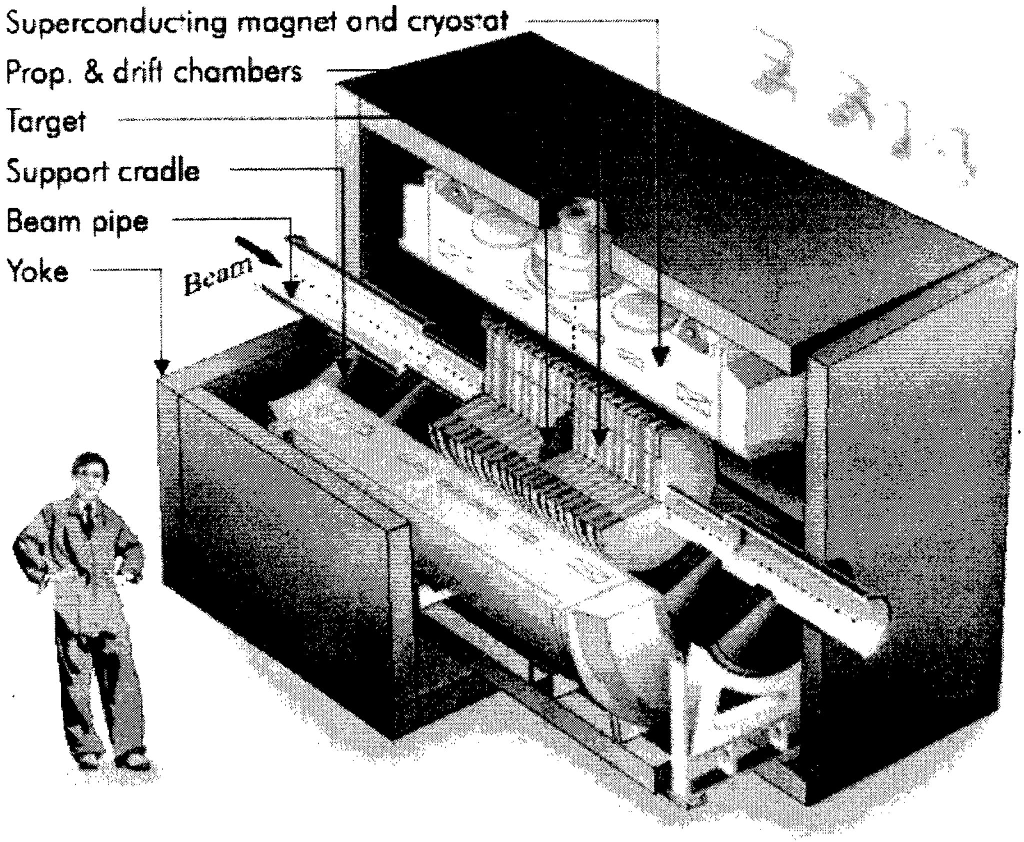
B(max): 2.1 T.



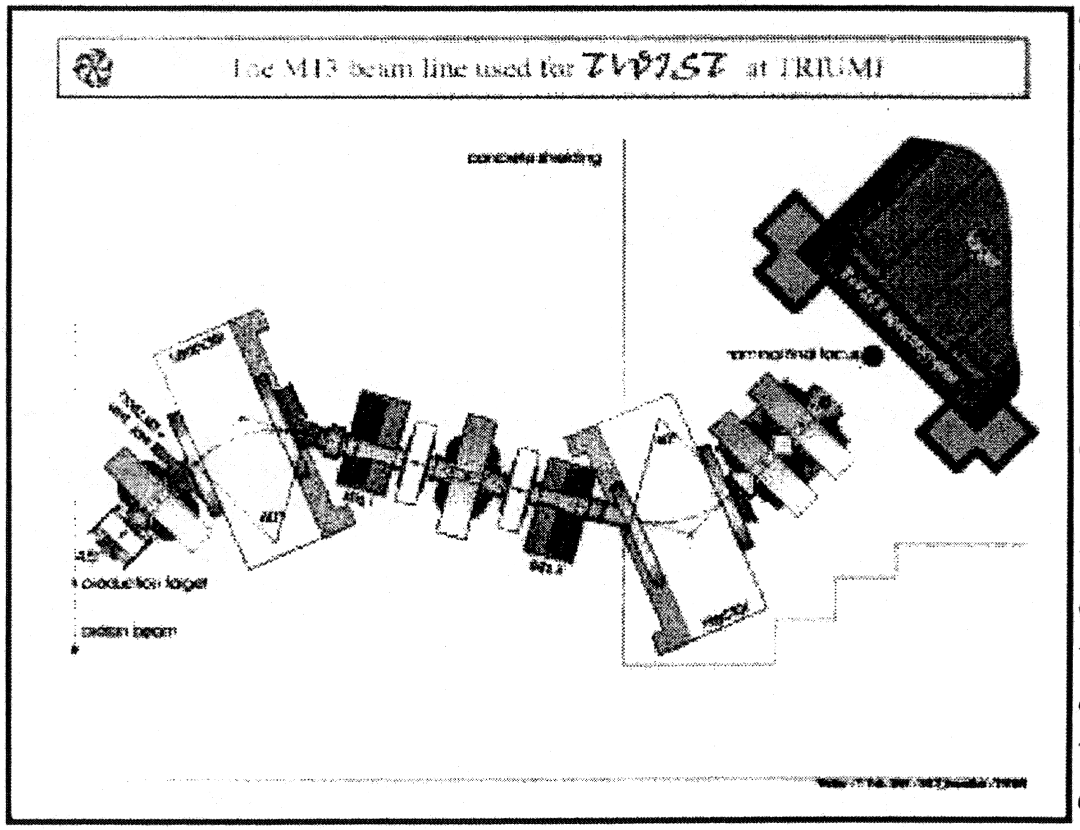
TWIST - The TRIUMF Weak Interaction Symmetry Test

A collaboration of KIAE (Russia), Texas A&M, TRIUMF, University of Alberta, University of British Columbia, University of Montreal, University of Northern British Columbia, University of Regina, University of Saskatchewan, Valparaiso University

TWIST is an experiment which is designed to measure the decay distributions of polarized muons to high precision. Distributions which are differential in energy and angle will be determined to a precision of 1 part in 10,000, allowing a determination of the parameters of the standard model which characterize the muon decay to a precision 3 to 10 times higher than previously achieved. The ultimate interest motivating the experiment is the need to better understand the left-right asymmetry which has been artificially incorporated into the standard model.



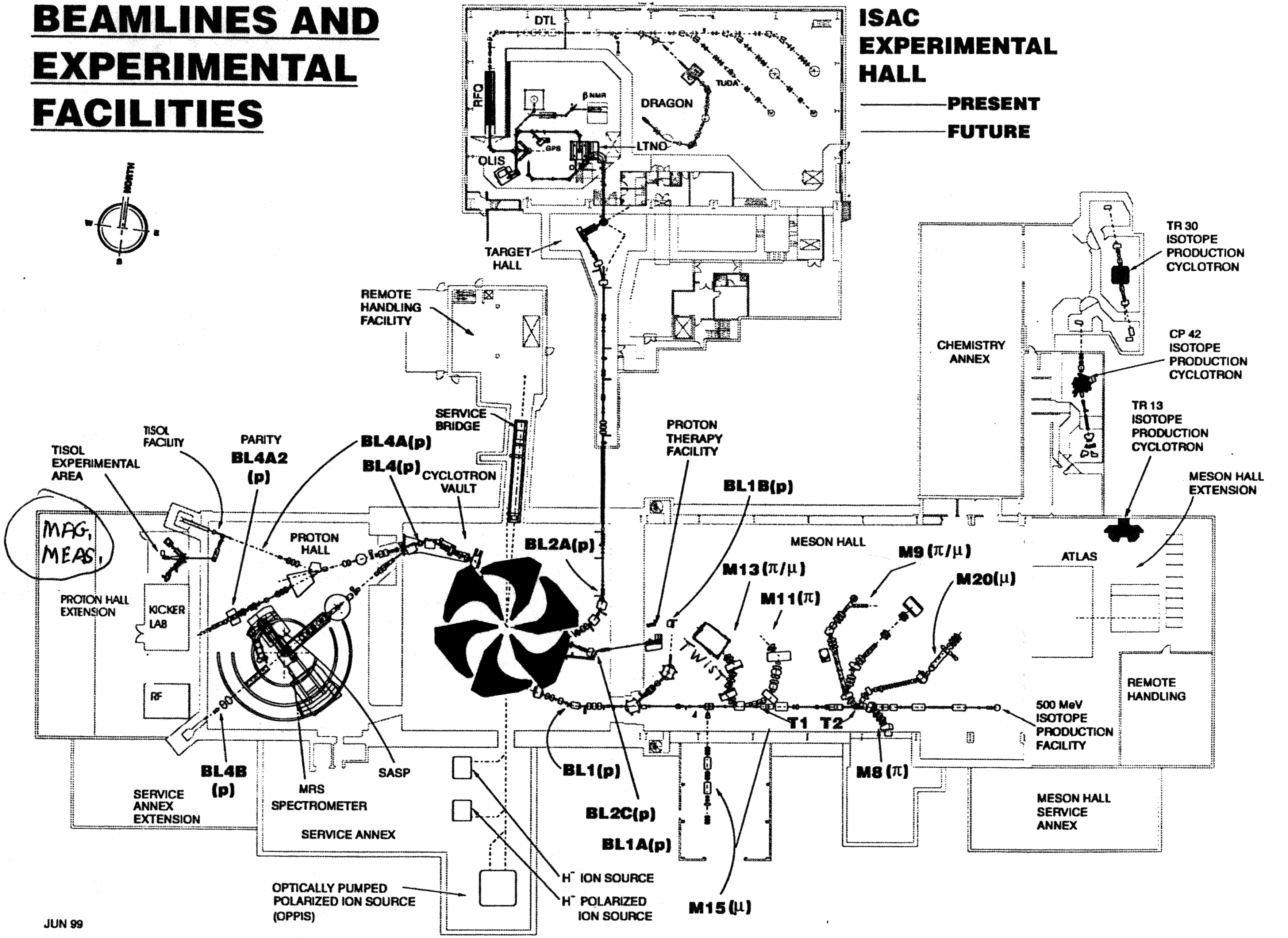
The Experiment



The experiment is being assembled at the TRIUMF cyclotron facility in Vancouver, BC. The "M13" beamline is used to produce a beam of muons with a well-defined orientation of their spins. The beamline is shown at left, with the TWIST magnet and detector shown at the right-hand side of the figure.

The measurements will employ a large bore superconducting solenoid magnet (surplus from a Magnetic Resonance Imaging (MRI) company). Polarized positively charged muons produced at TRIUMF will be directed into the magnetic field where they will be stopped at the centre of a precision detector package.

BEAMLINES AND EXPERIMENTAL FACILITIES



JUN 99

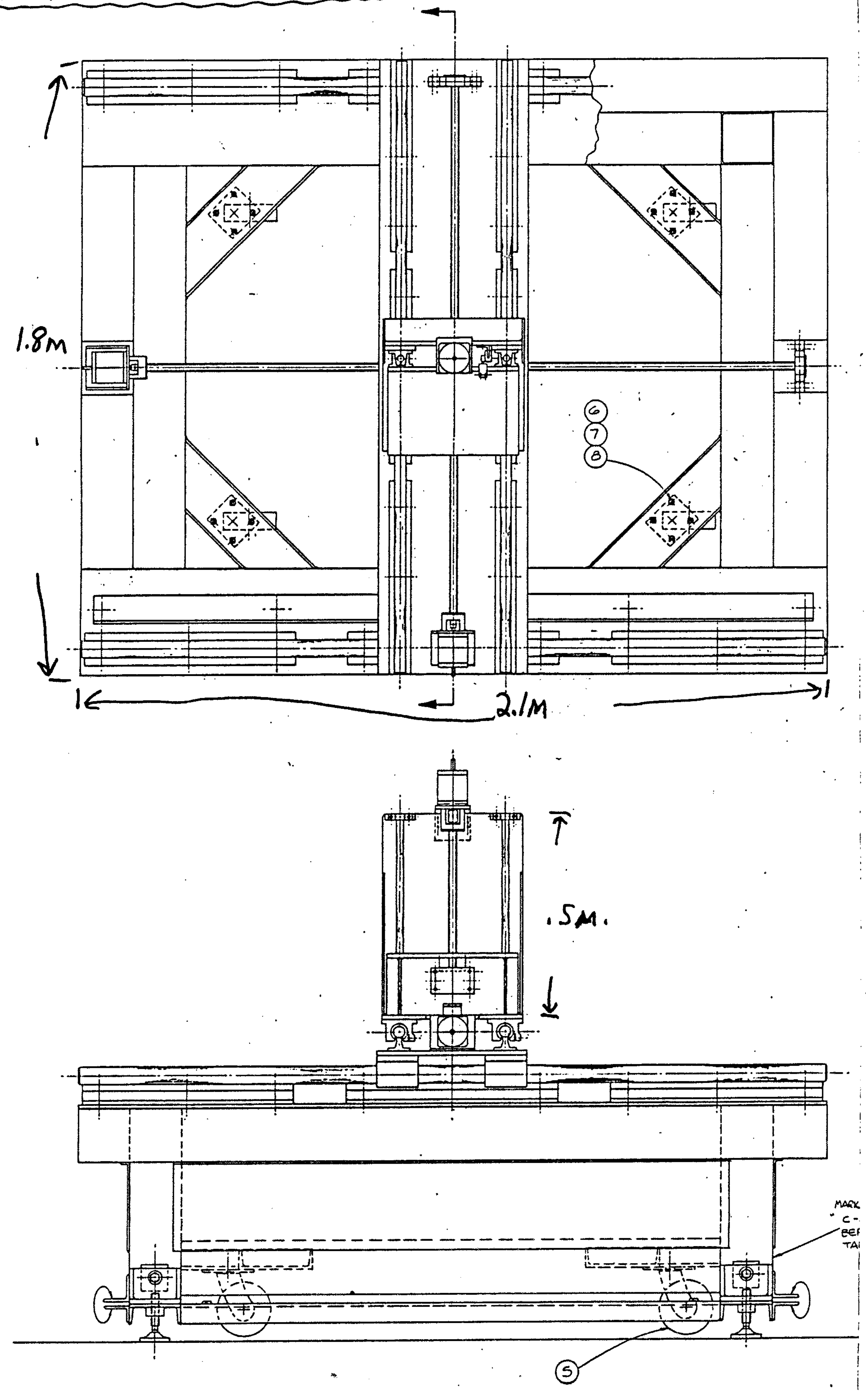
I) MEASUREMENTS AT I=10% (0.2 T.) WITH NO YOKE STEEL

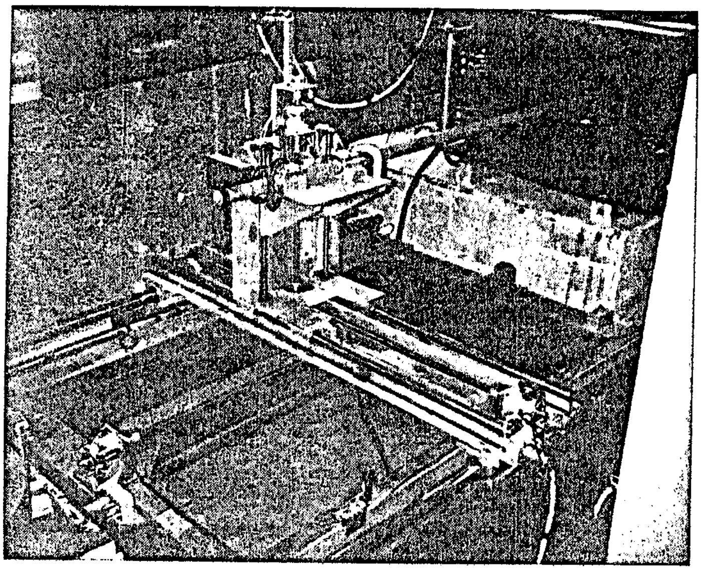
- measurements done in Magnet Measurement area using the 3D positioning table with a hall probe mounted on the boom.

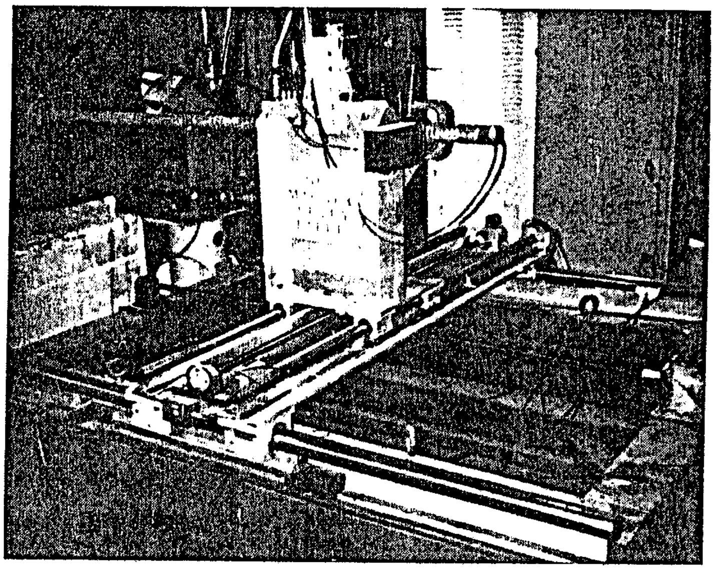
EQUIPMENT:

a) DECstation 5000/240 computer (Unix based)
b) HP 3458A. DVM
c) HP 3488A. Multiplexer
d) Siemens SBV-613 hall probe
e) Boron fiber and Kevlar wrapped probe arm (3 meters long).

3D POSITIONING TABLE

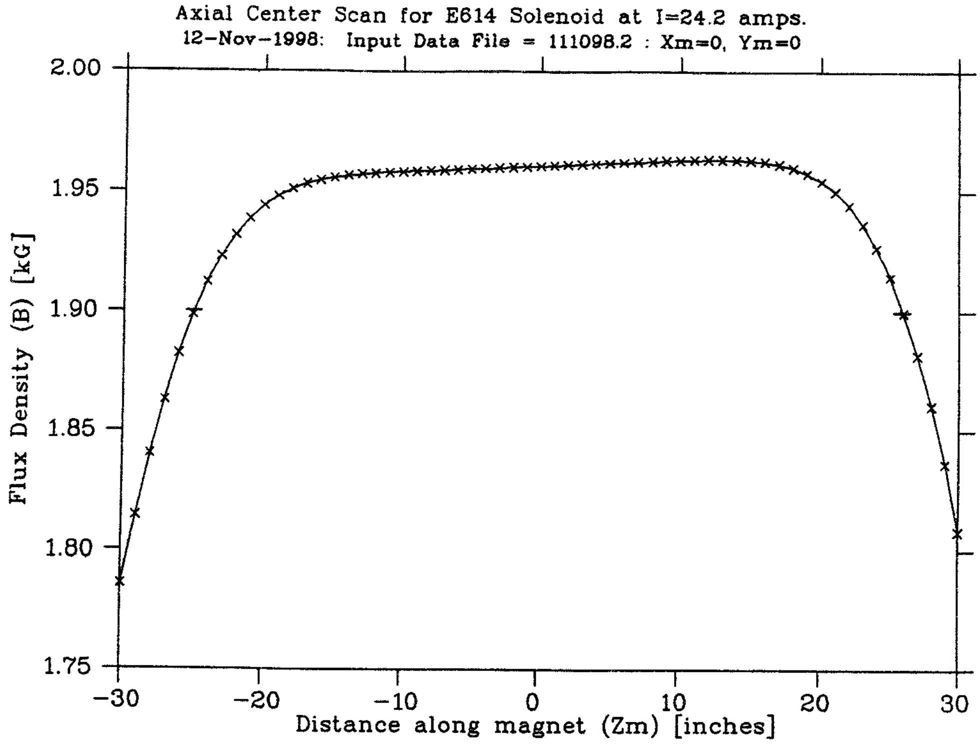


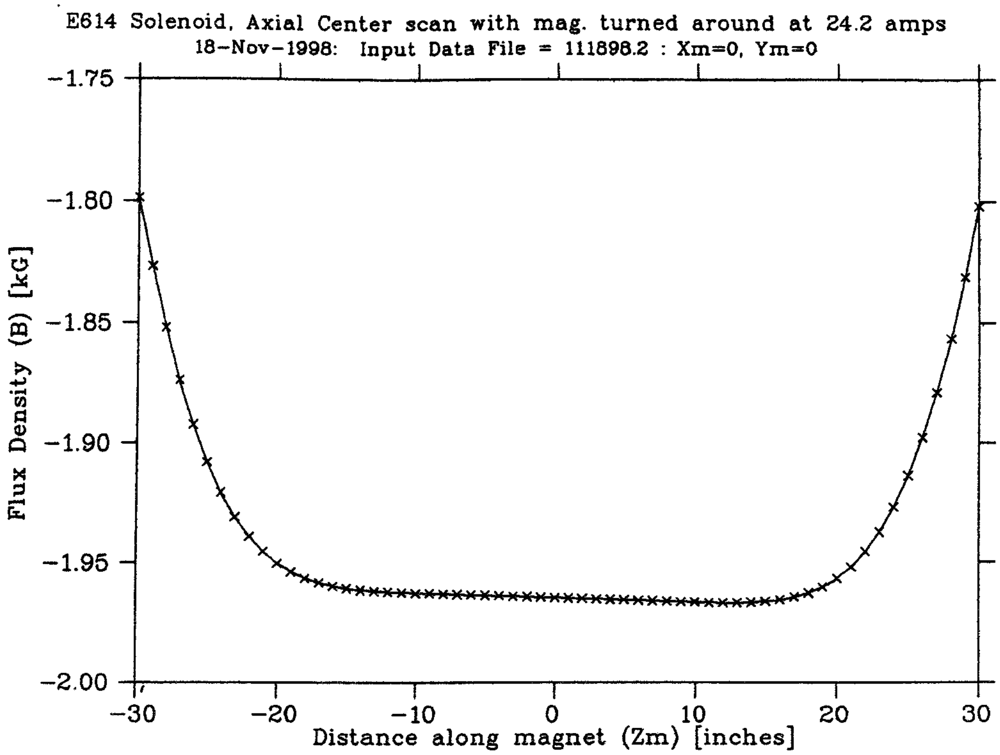




3D MAGNET MEASURMENT SURVEY TABLE

RESULTS:





- B higher at +Z end of grid (survey table end) regardless of magnet orientation.

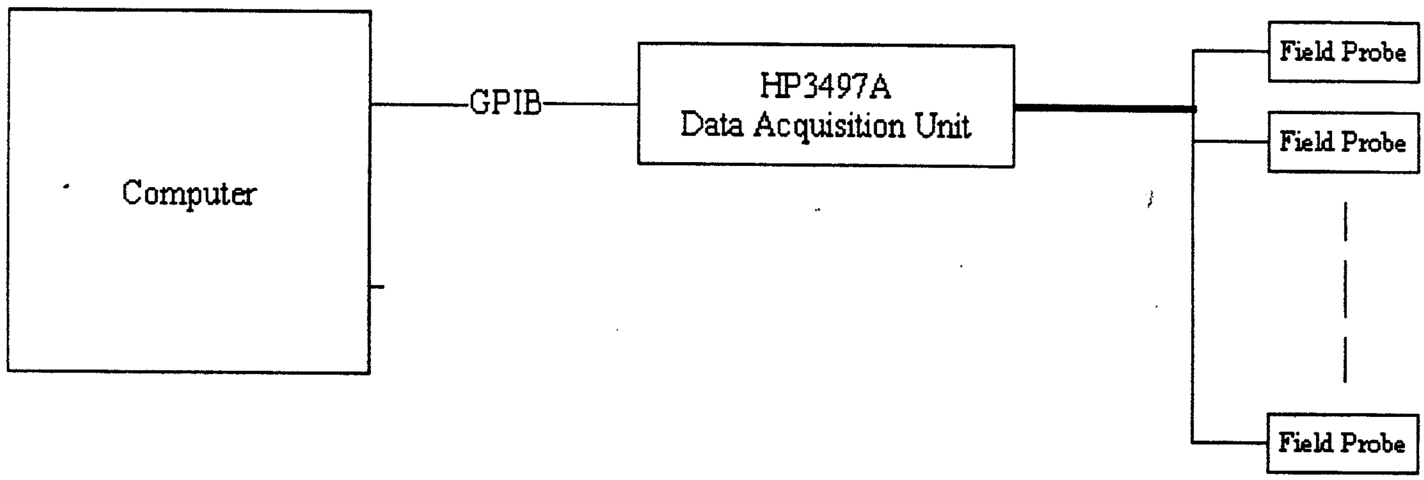
- Steel from survey table affecting B inside solenoid?

II) MEASUREMENTS AT I=47% (1.0 T.) WITH YOKE STEEL

- Magnet moved to M-13 area and measurements done using the 6-way hall probe array.

EQUIPMENT:

a) Pentium PC with GPIB card and Network card
b) HP 3497A Data Acquisition Unit (DVM, 20 channel mux and digital IO).
c) 6 Bell BHT-910 hall probes
d) G-10, 6-way hall probe mapper



JACQ - Java Acquisition System

David Morris - TRIUMF

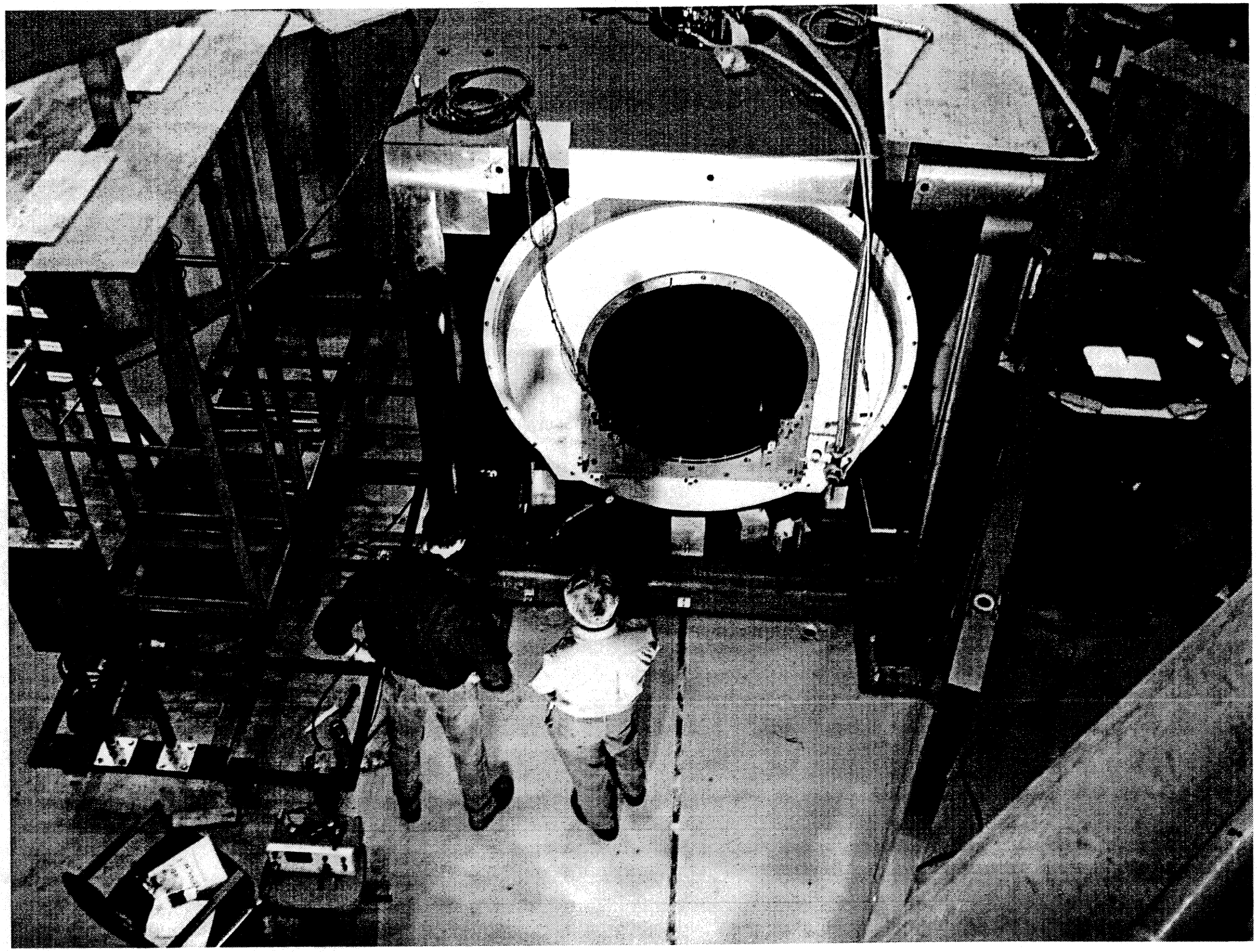
Introduction

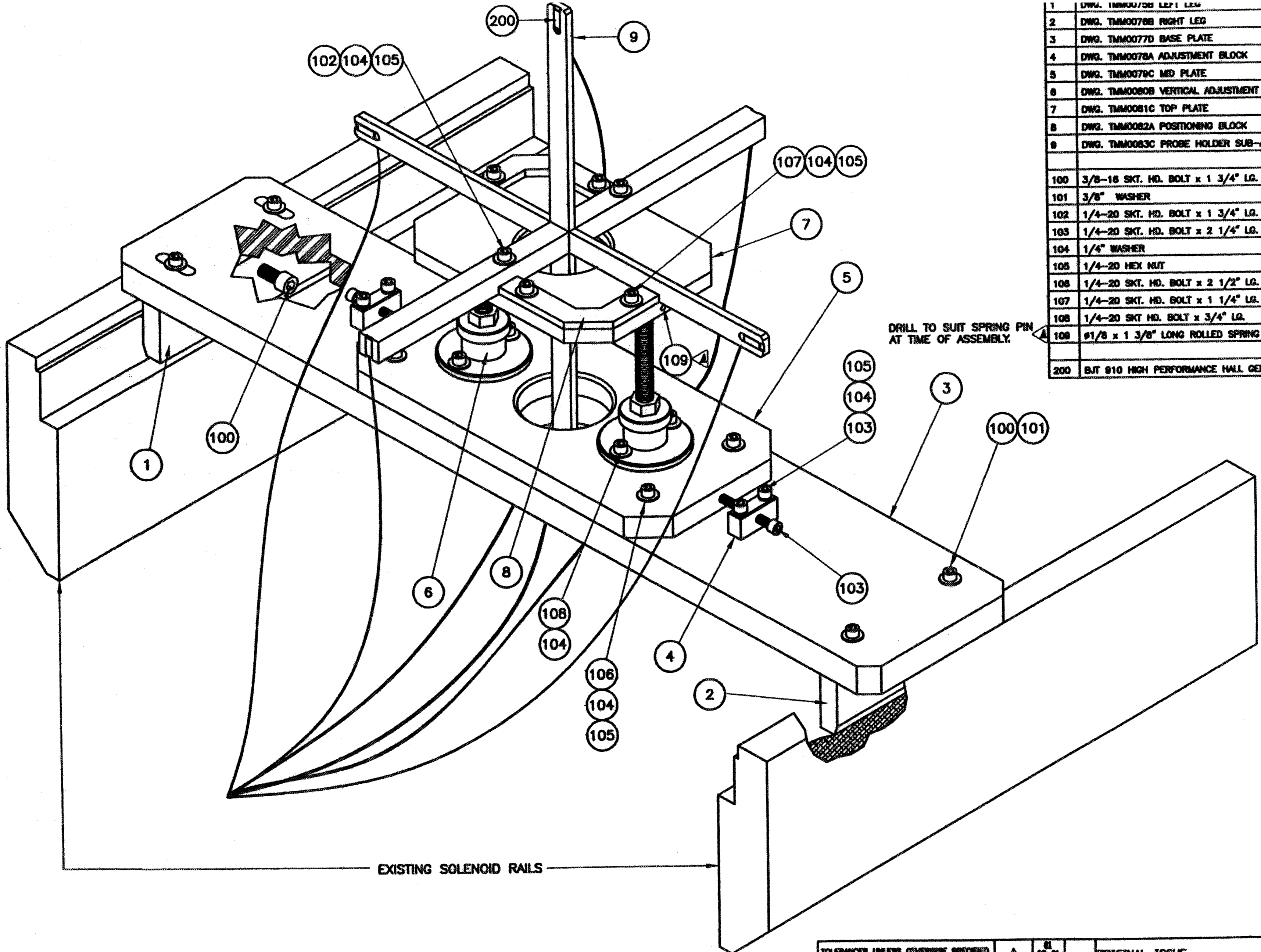
An automated system was needed to collect data during the mapping of the Twist Superconducting Solenoid. Several commercial tools were available that could be adapted to the task, but an interest in investigating the Java language resulted in the use of an in-house program.

The measurement system runs on a Microsoft Windows 98 based PC with a National Instruments PCI-GPIB interface. The control and acquisition equipment includes a Hewlett-Packard 3497A Data Acquisition Unit, and a TRIUMF built motor control system using an Oregon Microsystems PC68 Stepping Motor Controller. The motor controller communicates using a serial port and allows four axes of motion.

The software is written in JAVA using the Sun Microsystems JDK 1.3. The development tools include Sun's Forte for Java CE and Microsoft Visual C++ 6.0. It is object oriented, and was designed using the standard object oriented methodology, employing use cases, class diagrams to define the static class relationships and sequence diagrams to define the dynamic model. An interface layer was written in C to link JAVA to the existing device driver library for GPIB communication.

The acquisition system was originally developed for measuring characteristics of the Super Phenix Charge Booster at ISN in Grenoble, and generalized to allow easy conversion to other uses.





DRILL TO SUIT SPRING PIN AT TIME OF ASSEMBLY.

1	DWG. TMM0075B LEFT LEG	[illegible]	[illegible]
2	DWG. TMM0076B RIGHT LEG	G10	1
3	DWG. TMM0077D BASE PLATE	G10	1
4	DWG. TMM0078A ADJUSTMENT BLOCK	G10	2
5	DWG. TMM0079C MID PLATE	G10	1
6	DWG. TMM0080B VERTICAL ADJUSTMENT SUB-ASS'Y.	MISC.	2
7	DWG. TMM0081C TOP PLATE	G10	1
8	DWG. TMM0082A POSITIONING BLOCK	G10	2
9	DWG. TMM0083C PROBE HOLDER SUB-ASS'Y.	G10	1
100	3/8-16 SKT. HD. BOLT x 1 3/4" LG.	NYLON	5
101	3/8" WASHER	NYLON	4
102	1/4-20 SKT. HD. BOLT x 1 3/4" LG.	NYLON	2
103	1/4-20 SKT. HD. BOLT x 2 1/4" LG.	NYLON	6
104	1/4" WASHER	NYLON	32
105	1/4-20 HEX NUT	NYLON	14
106	1/4-20 SKT. HD. BOLT x 2 1/2" LG.	NYLON	4
107	1/4-20 SKT. HD. BOLT x 1 1/4" LG.	NYLON	6
108	1/4-20 SKT HD. BOLT x 3/4" LG.	NYLON	4
A 109	ø1/8 x 1 3/8" LONG ROLLED SPRING PIN	Cu	2
200	BJT 910 HIGH PERFORMANCE HALL GENERATORS	MISC.	6

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
DECIMALS .XX ±
.XXX ±
ANGULAR ±
SURFACE FINISH μin

A	01 09-01		ORIGINAL ISSUE	D.R.	T.E.
REV	DATE	LOC	REVISION DESCRIPTION	BY	APP'D

TRIUMF 4004 WESBROOK MALL VANCOUVER, BRITISH COLUMBIA CANADA V6T-2A3 CANADA'S NATIONAL MESON FACILITY

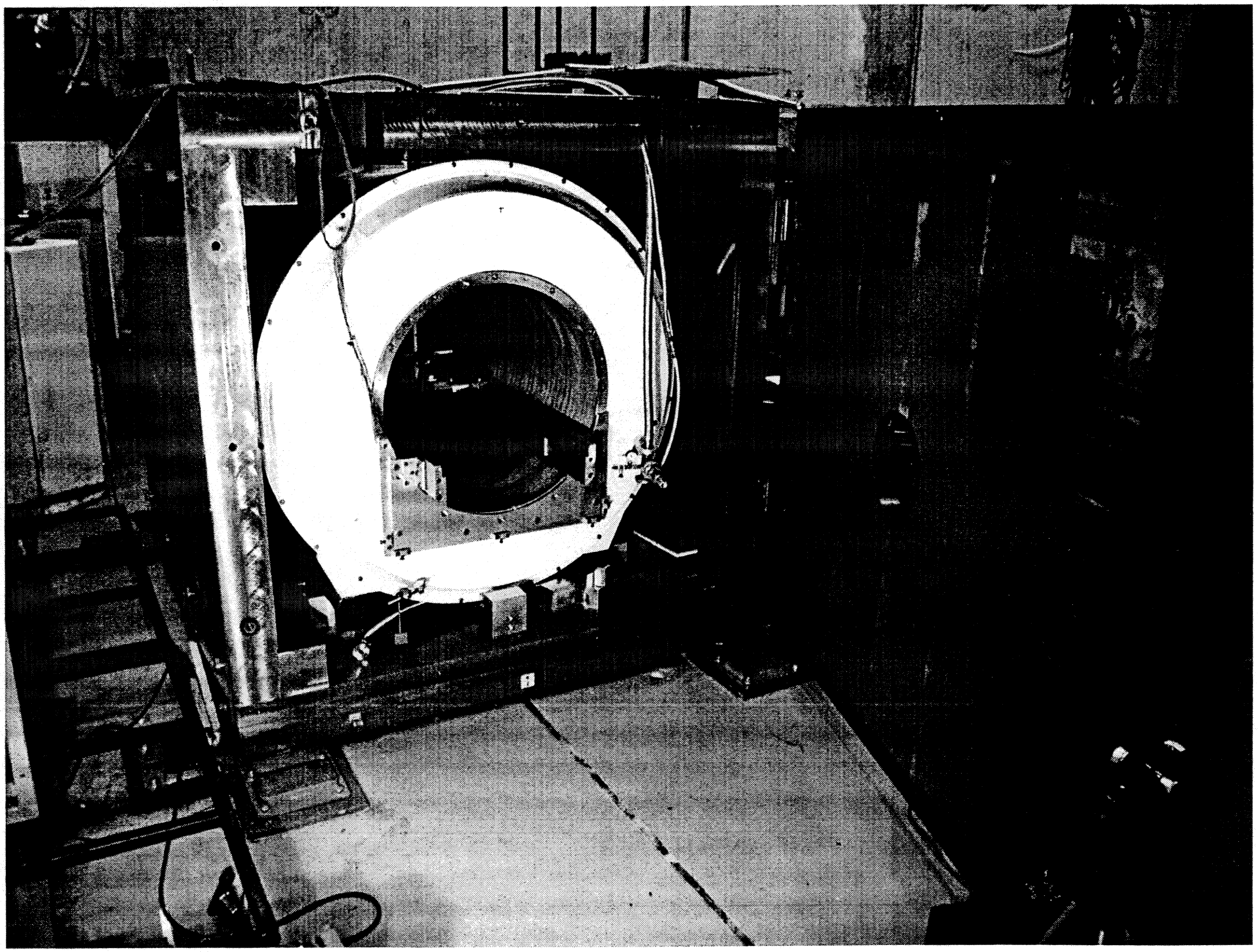
ALL DIMS IN INCHES

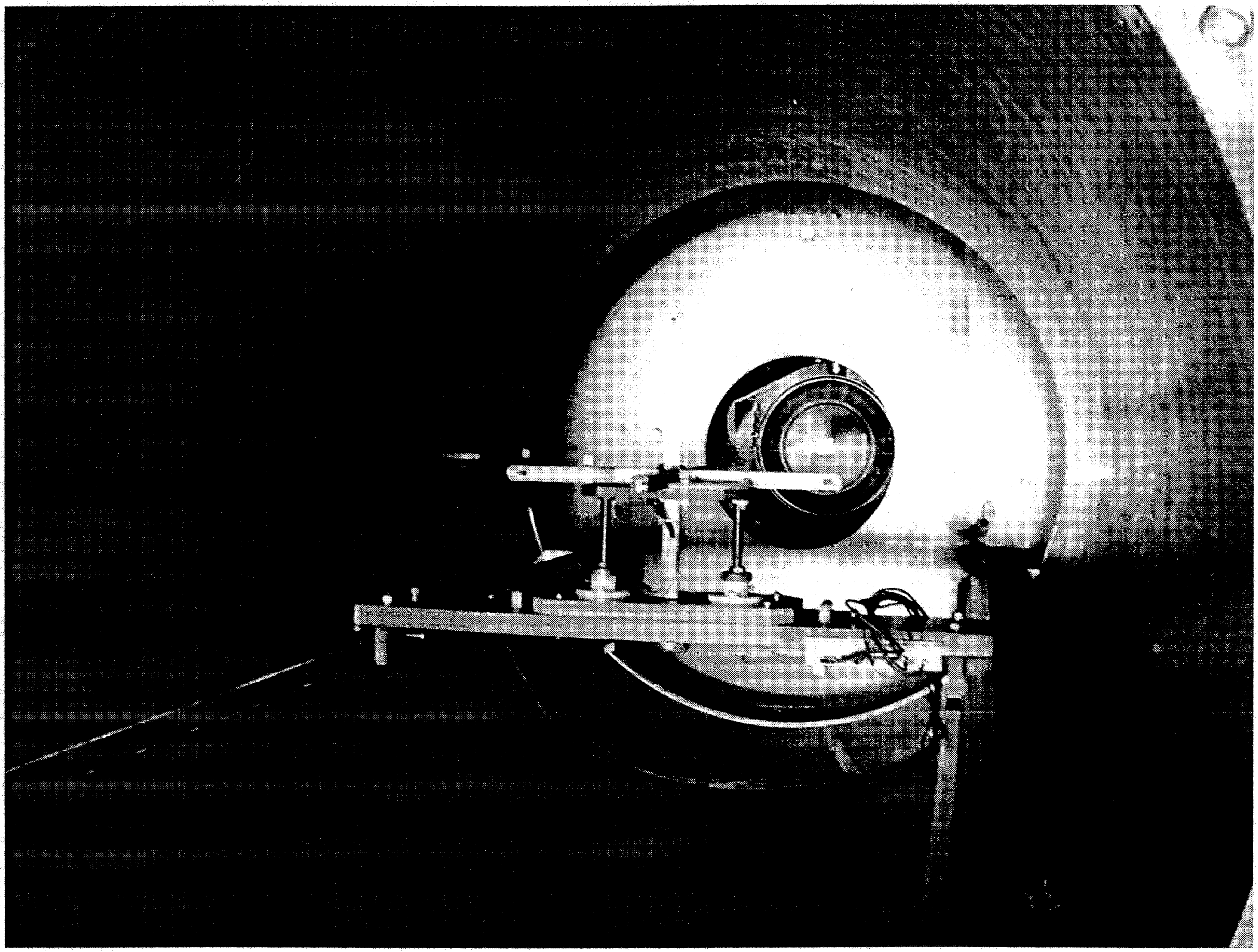
STATIONARY MAPPING PROBE

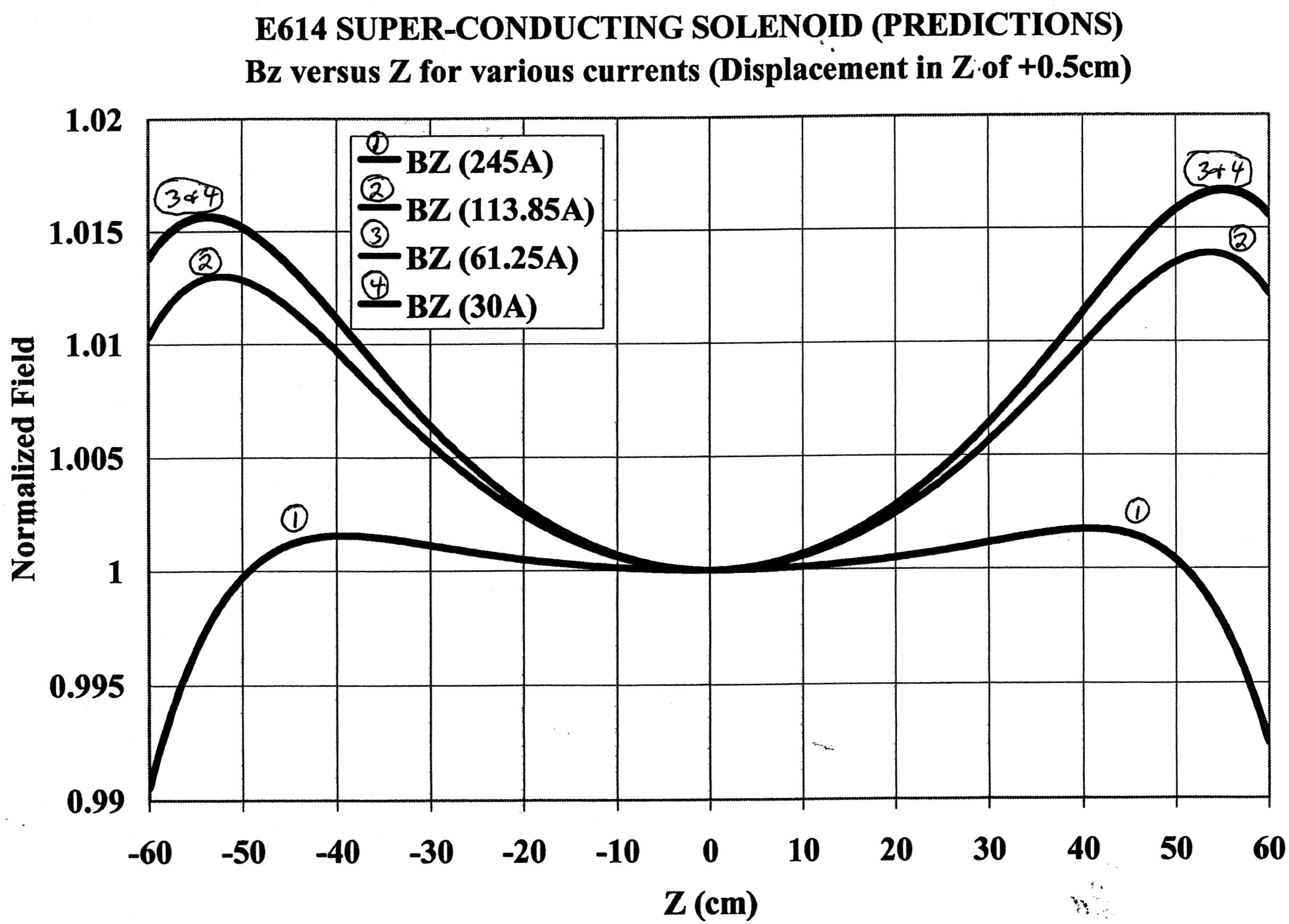
E-614

DESIGNED D.R.
DRAWN D.ROWBOTHAM
CHECKED T.E.
REA # E-430
TRI-DN-3368
DL- TMM0003L
SUB ASSY:
ASSEMBLY:

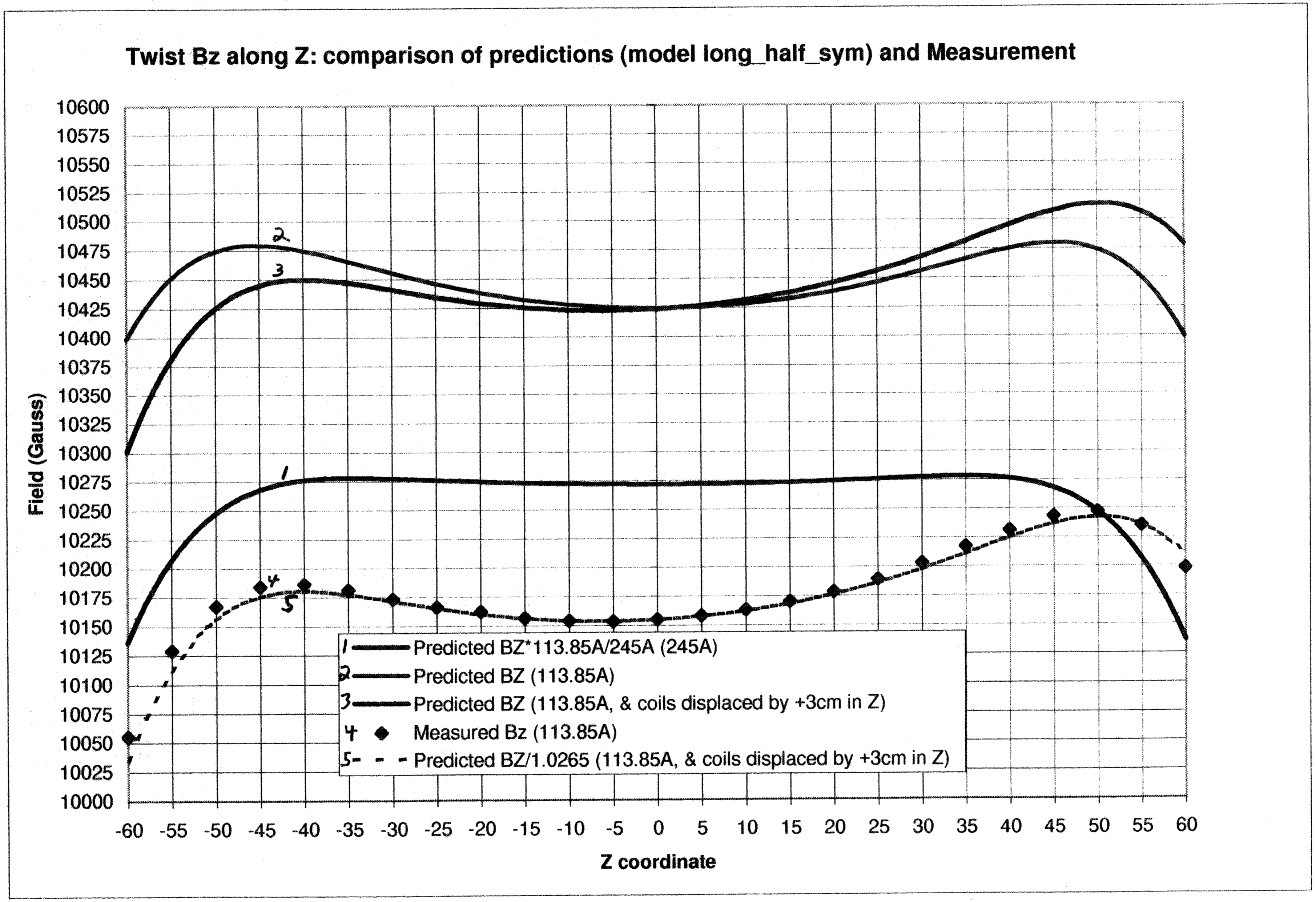
SCALE 1:2
DATE 01-09-01
THIRD-ANGLE PROJECTION
DWG NO. TMM0074C
REV A







E614 SUPER-CONDUCTING SOLENOID (PREDICTIONS)
Bz versus Z for various currents (Displacement in Z of +0.5cm)
Normalized Field
Z (cm)
① BZ (245A)
② BZ (113.85A)
③ BZ (61.25A)
④ BZ (30A)
3+4
②
①
1.02
1.015
1.01
1.005
1
0.995
0.99
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60


Twist Bz along Z: comparison of predictions (model long_half_sym) and Measurement
Field (Gauss)
Z coordinate
1 Predicted BZ*113.85A/245A (245A)
2 Predicted BZ (113.85A)
3 Predicted BZ (113.85A, & coils displaced by +3cm in Z)
4 Measured Bz (113.85A)
5 Predicted BZ/1.0265 (113.85A, & coils displaced by +3cm in Z)

RESULTS:

a) B is 2.5% lower than predicted.

b) B is 0.6% higher at downstream peak than at upstream peak.

c) B is shifted in Z about 3 cm.downstream from physical center of mag.

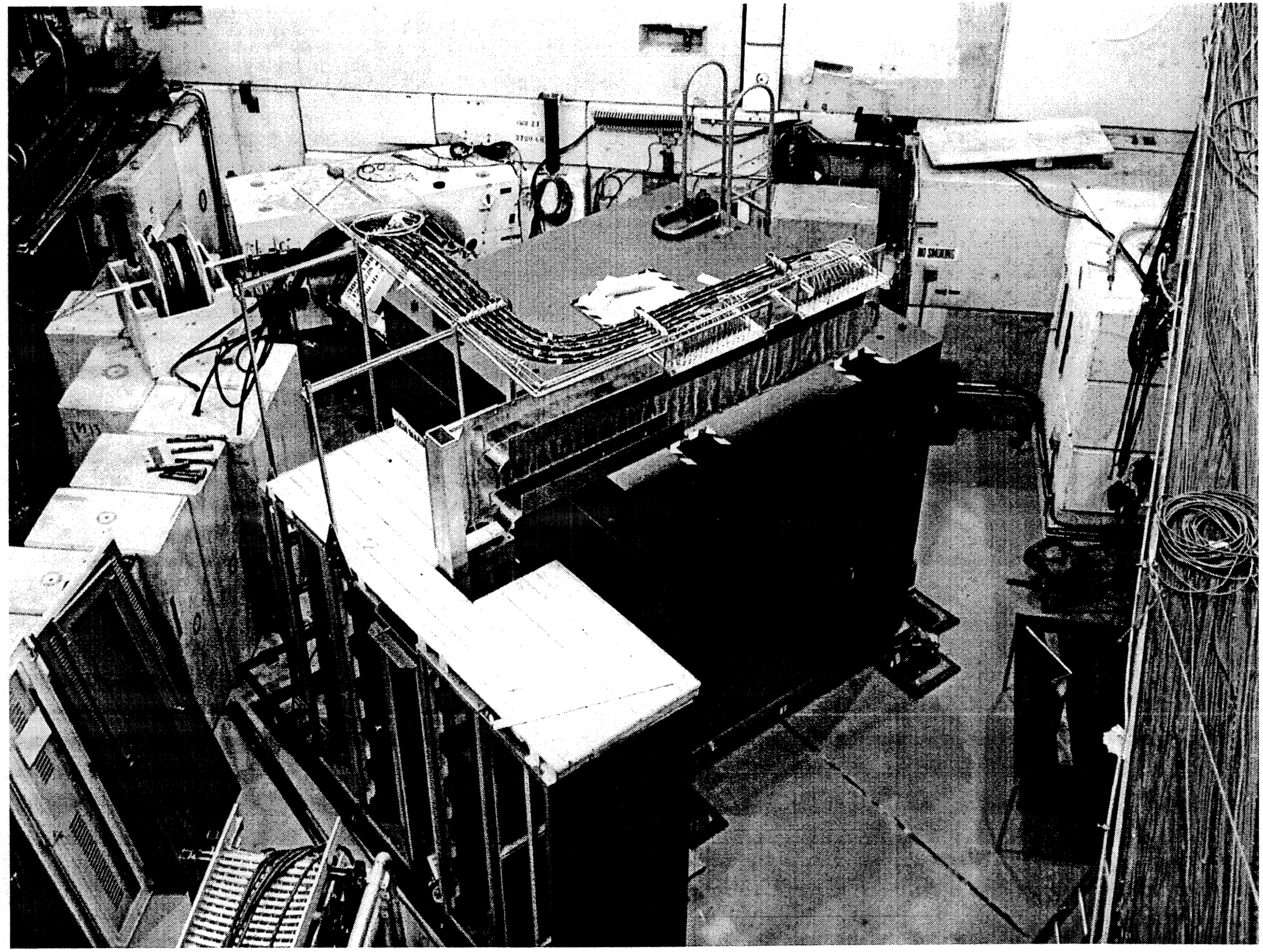
d) The 4 probes at R = 20 cm., spaced 90 deg. apart at the same Z, are uniform to 0.06% for Z = +/-40 cm.

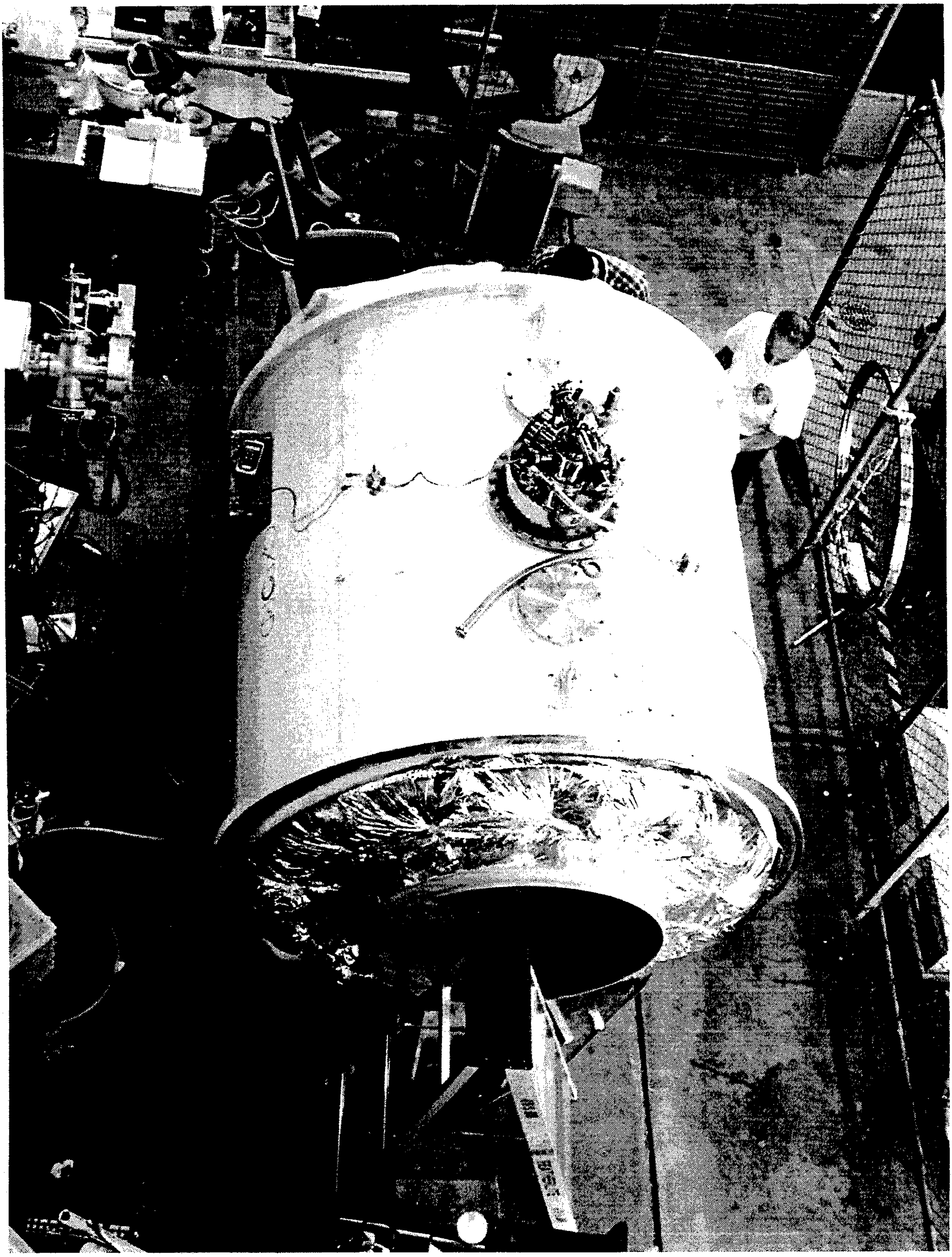
QUESTION:

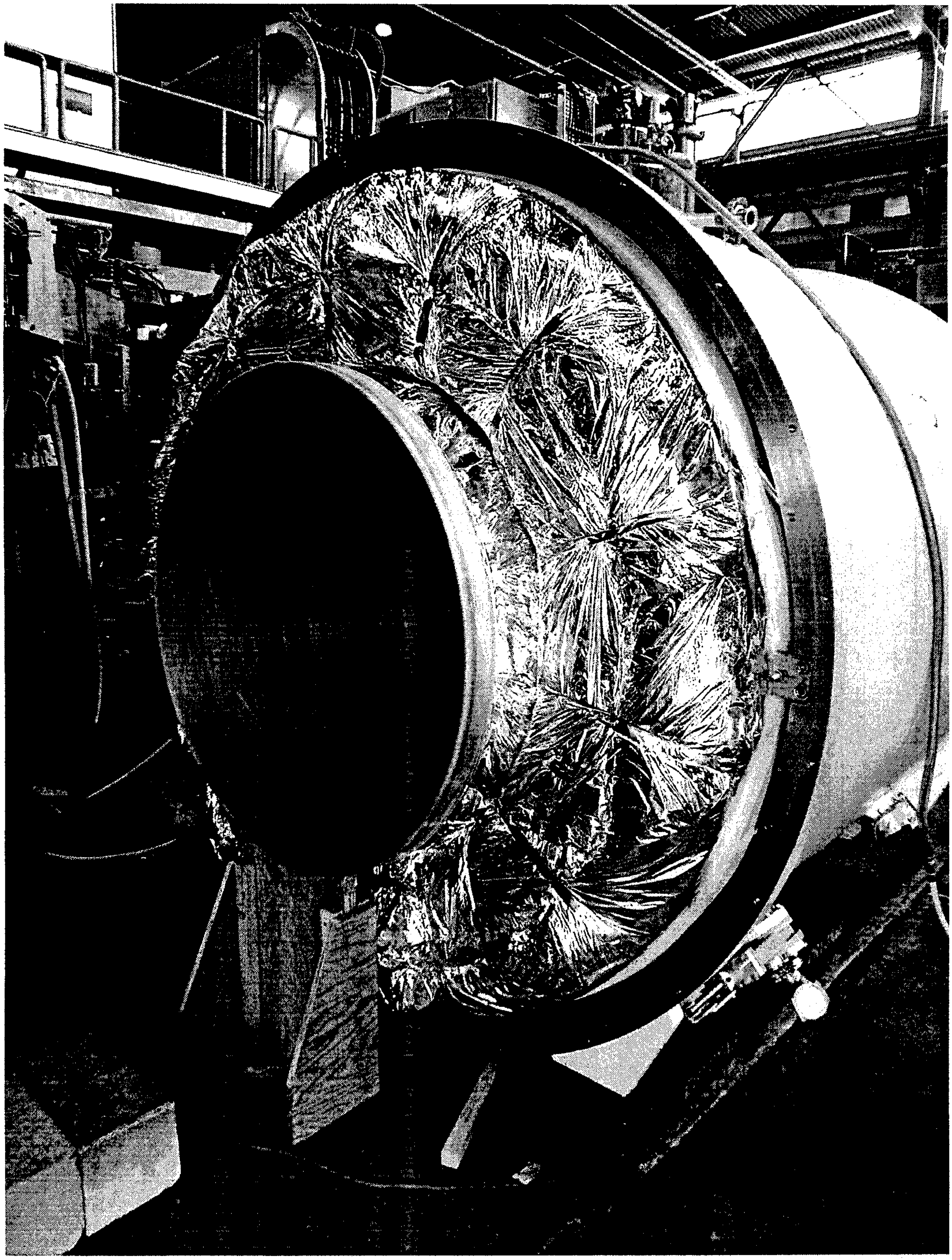
Are coils moving to give Z assymetry and B shift?

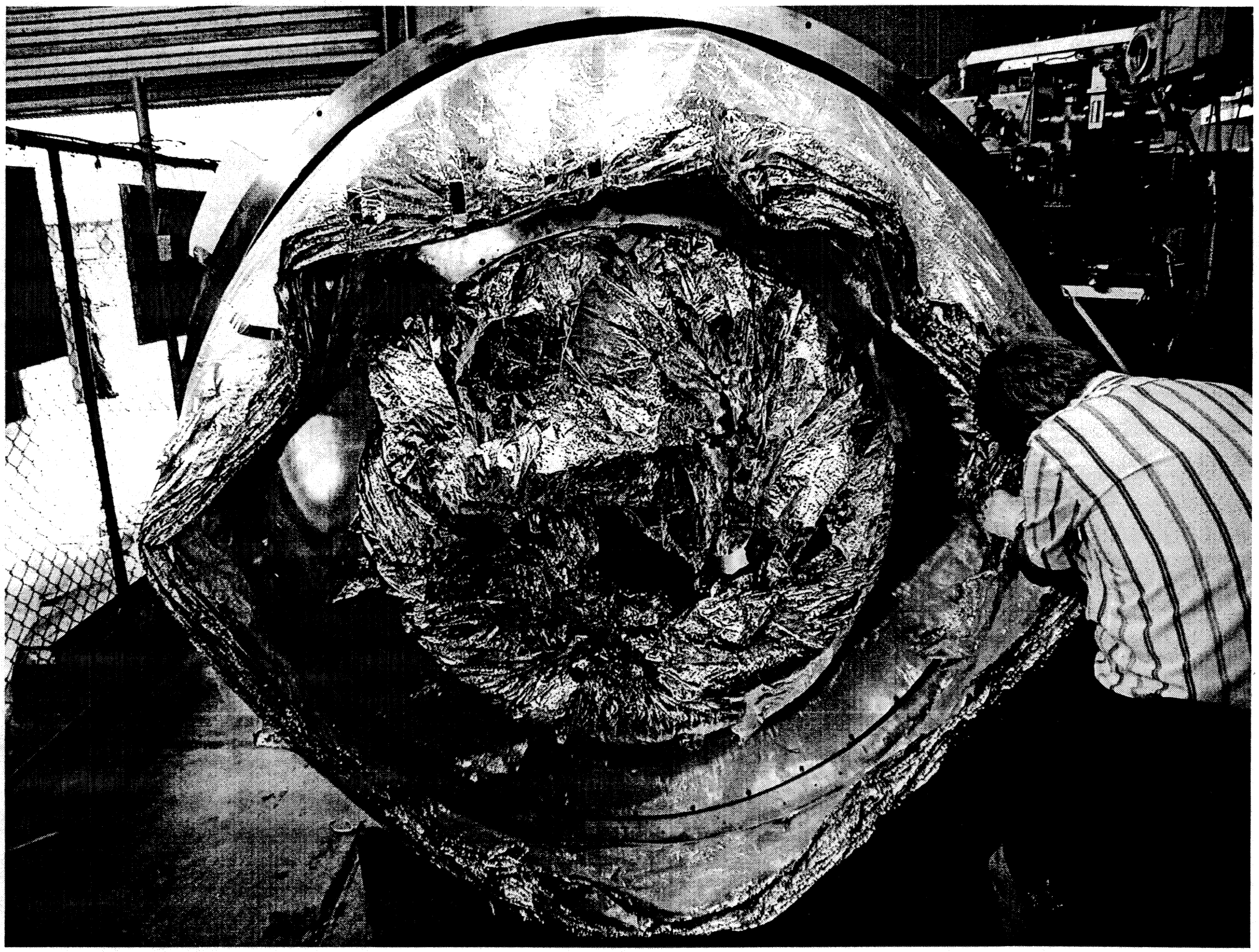
ACTION:

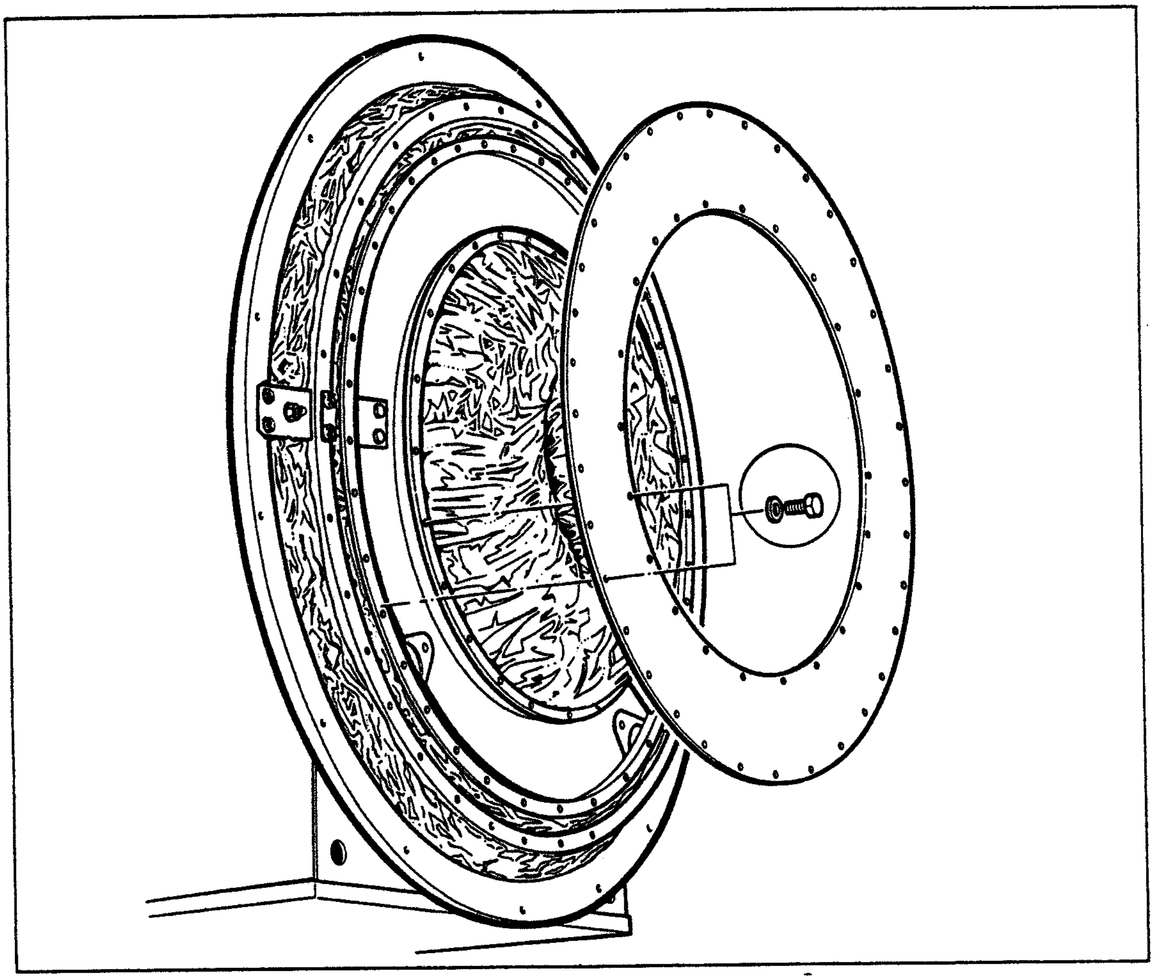
After much discussion we decided to take the magnet apart and look for any mechanical problems which may exist.

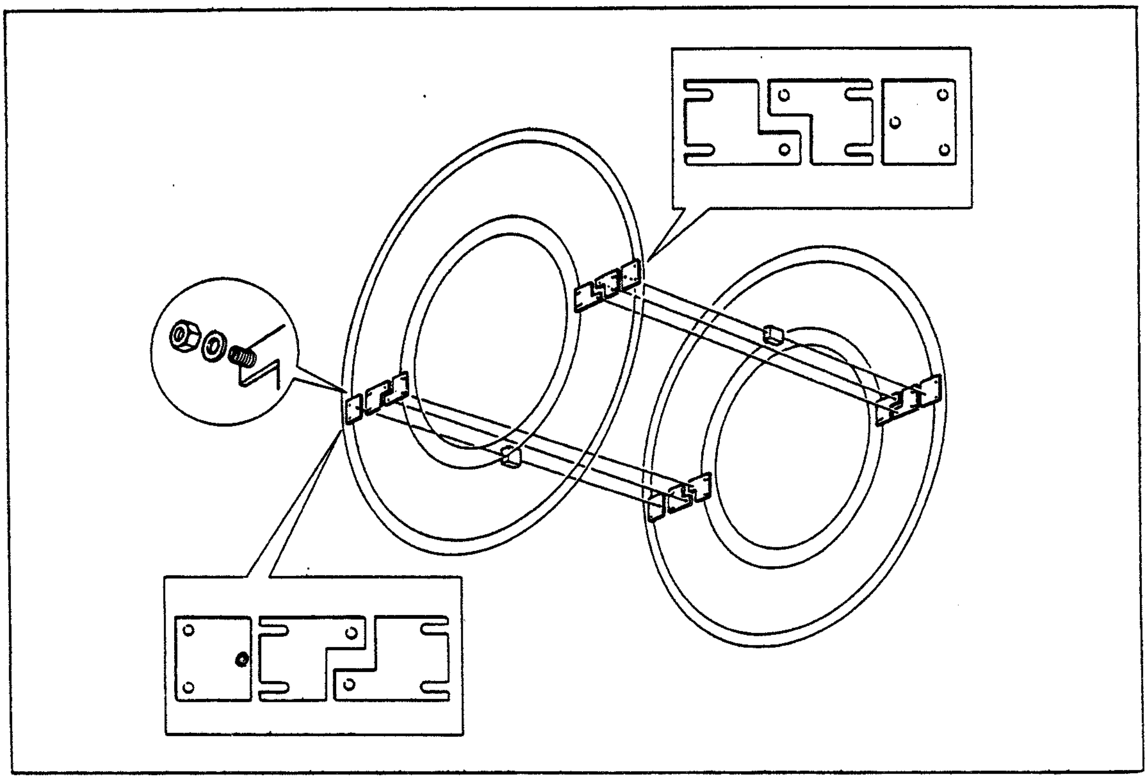










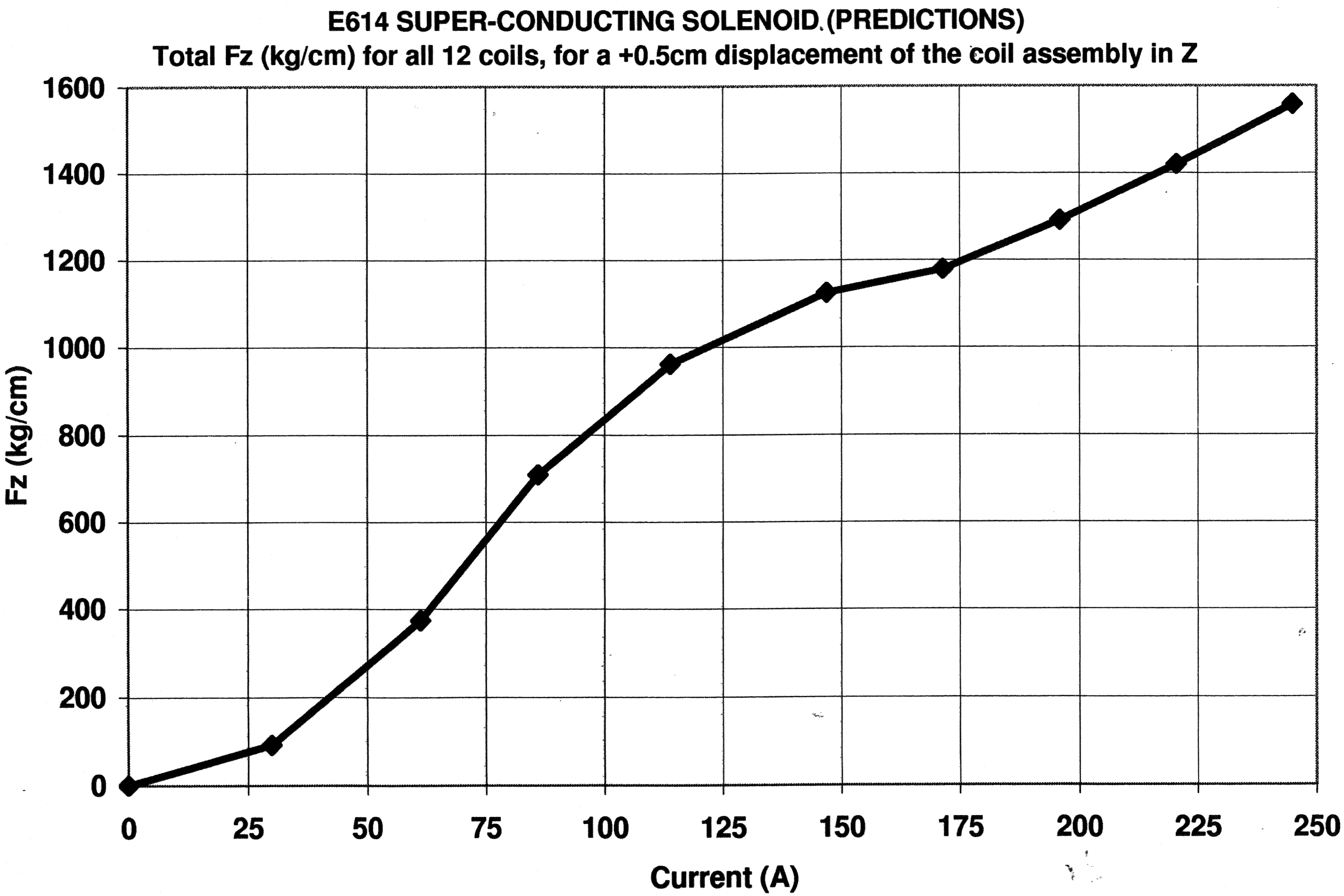


- found one longitudinal rod missing and the others loose. Helium vessel was easy to move inside outer chambers! Obtained new rod.

- installed new rod, along with 4 strain gauge bridge modules to measure the direction and amount of stress at the four outer rod connect points.

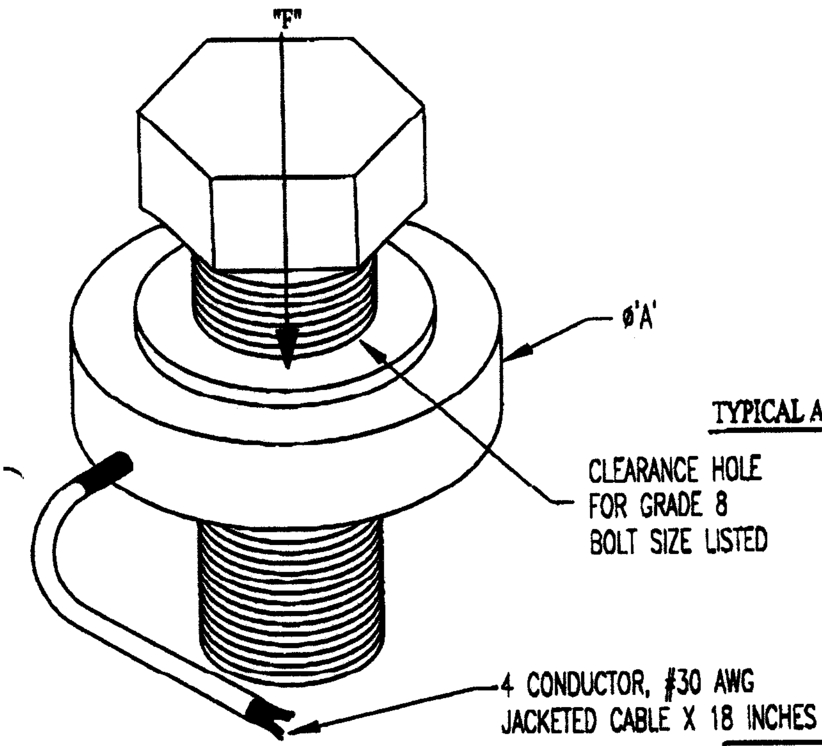
- tightened all rods to spec., centering coils as well as possible.

- move magnet back to M-13 experimental area and install it in the yoke steel in preparation for powering to check stresses on rods.


E614 SUPER-CONDUCTING SOLENOID (PREDICTIONS)
Total Fz (kg/cm) for all 12 coils, for a +0.5cm displacement of the coil assembly in Z
Fz (kg/cm)
0
200
400
600
800
1000
1200
1400
1600
0
25
50
75
100
125
150
175
200
225
250
Current (A)

MUSE MEASUREMENT CORP.

PRECISION FLAT WASHER FORCE SENSOR
M7000 MODEL
STAINLESS STEEL WELDED CONSTRUCTION
BOLT SIZES # 10 THROUGH 1"(OTHER SIZES AVAILABLE)
CAPACITIES: #10 @ 3.4 K, UP TO 1" @ 81K LBS.



TYPICAL APPLICATIONS USE UNDER BOLT / FASTENER TO MONITOR DIE FORCES, EQUALIZE FORCE TO OBTAIN UNIFORMITY. CONVERTS STRUCTURE INTO WEIGHING APPARATUS THROUGH BOLT STRESSES. MONITOR LOAD CHANGES ON DAMS AND BRIDGES.

SPECIFICATION

OUTPUT:	1.0 MV/V
NON-LINEARITY:	0.1% F.S.O.
HYSTERESIS:	0.1% F.S.O.
ZERO BALANCE:	± 1%
COMP. TEMP. RANGE:	0-150°F
SAFE TEMP. RANGE:	0-150°F
TEMP. EFFECT. ON OUTPUT:	.001%/°F
TEMP. EFFECT ON ZERO:	0.01%/°F
TERMINAL RESISTANCE:	1000 OHM
EXCITATION VOLTAGE:	10 VDC
SAFE OVERLOAD:	250 %

MODEL NO.	BOLT SIZE	A	B	OPERATING LOAD (LBS)	MAX.LOAD (LBS)
M7000-#10	#10	1.077	.37	3.4K	5K
-1/4	1/4	1.077	.37	6.5K	9.5K
-5/16	5/16	1.077	.37	8.5K	12.5K
-3/8	3/8	1.077	.37	10.2K	15K
-7/16	7/16	1.598	.50	16.2K	24K
* -1/2	1/2	1.598	.50	21.0K	31K
-9/16	9/16	1.598	.50	26.0K	38.5K
-5/8	5/8	1.598	.50	32.0K	47.5K
-3/4	3/4	2.413	.50	43.0K	64K
-7/8	7/8	2.413	.50	62.0K	92K
-1	1.0	2.413	.50	81.0K	120K

OPTIONS: OPERATING TEMP., CABLE LENGTH, 0-5V, 4-20mA S.S. ARMORED CABLE, TEFLON CABLE, CALIBRATION, MIL-STD 45662, OTHER OPTIONS OR VARIATIONS AVAILABLE.

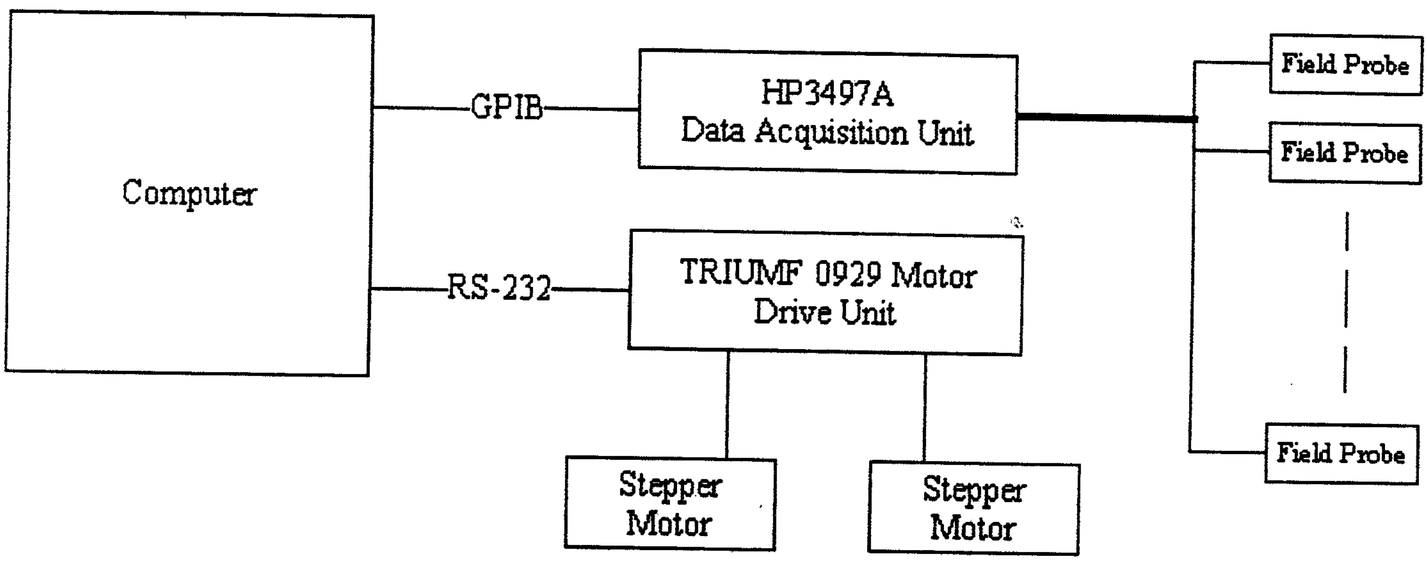
SAFETY CONSIDERATIONS: Always use load cells below the specified load rating. Load applied must be in the primary load axis. Extraneous loads or compound stress must be avoided. De-rate load cell maximum load or supply safety hardware where failure could cause injury or damage. (I.E. safety chains, safety rods etc.) Do not jerk load or apply load at high rate of speed. Inspect routinely for damage excessive wear or corrosion, replace if found. Consult a qualified engineer prior to use.

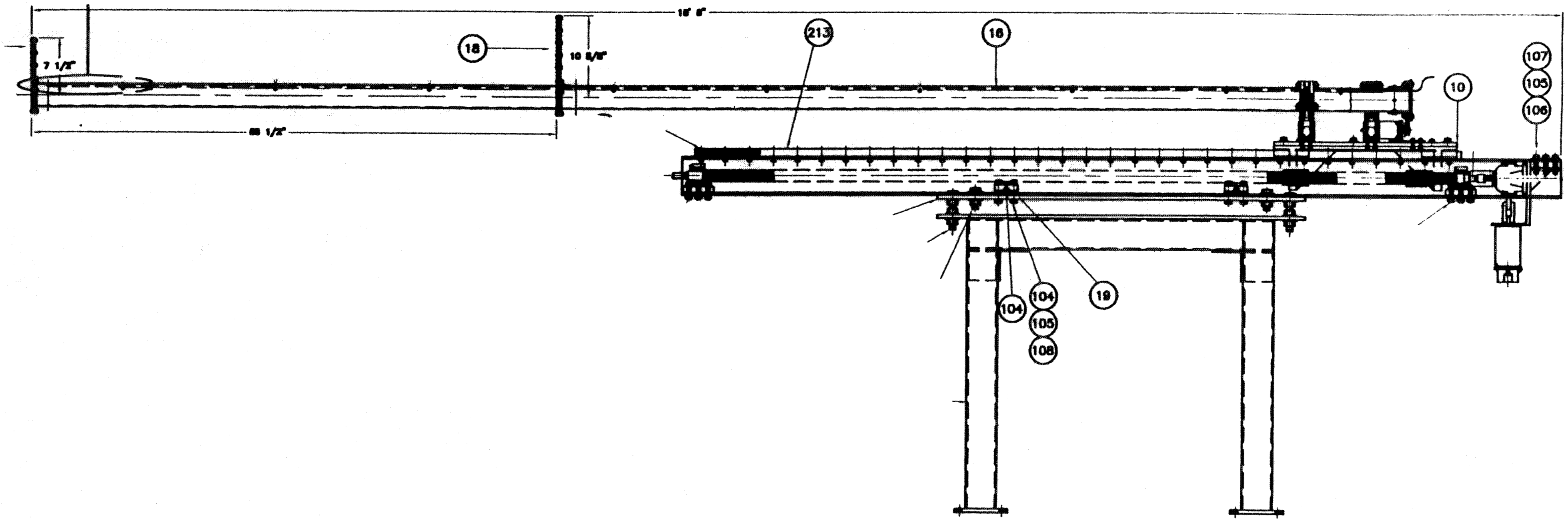
III) FUTURE MEASUREMENTS UP TO I=100% (2.2 T.) WITH YOKE STEEL IN M-13 AREA.

- Magnet will be moved back to M-13 area and measurements done using the automated dual rotating arm survey equipment.

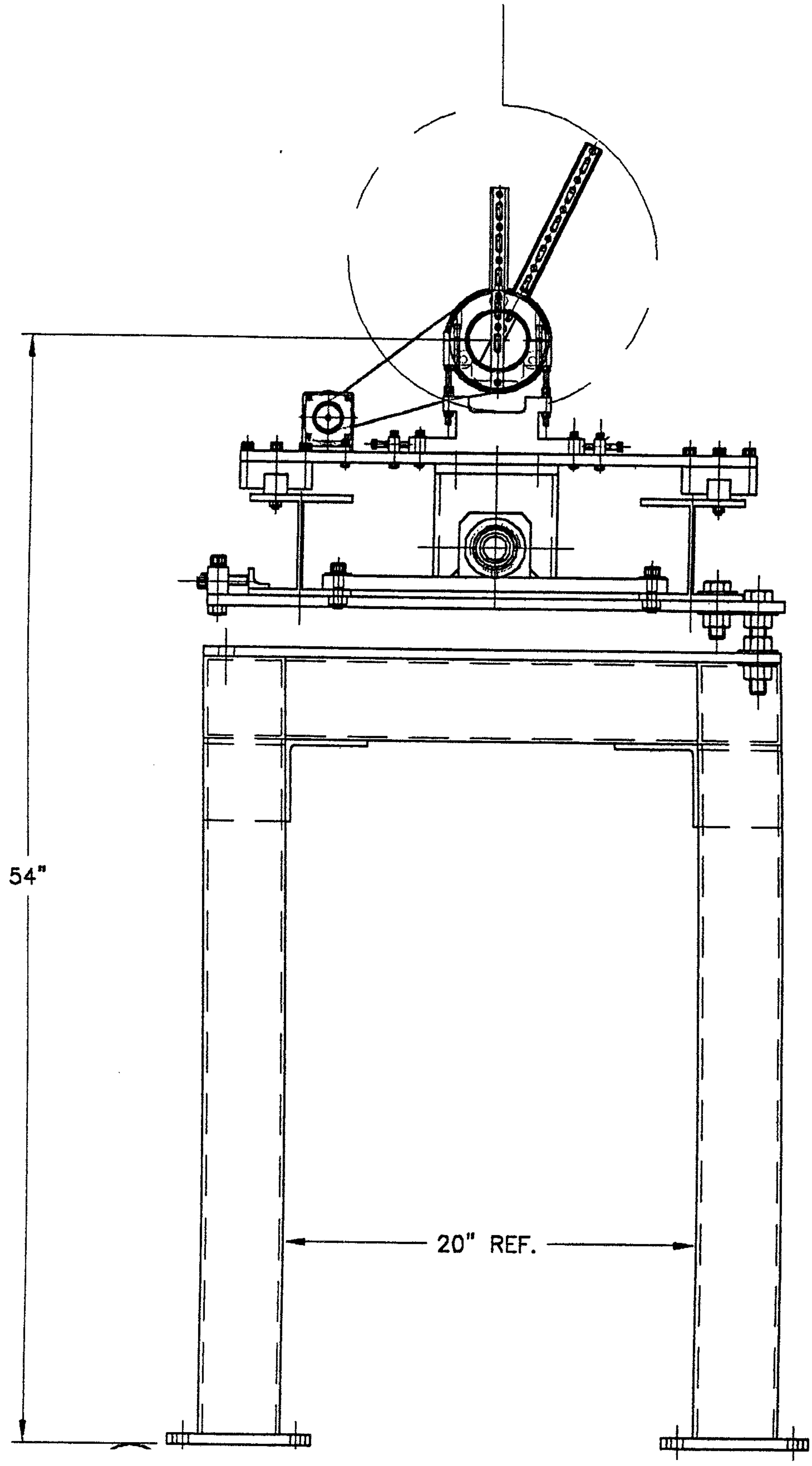
EQUIPMENT:

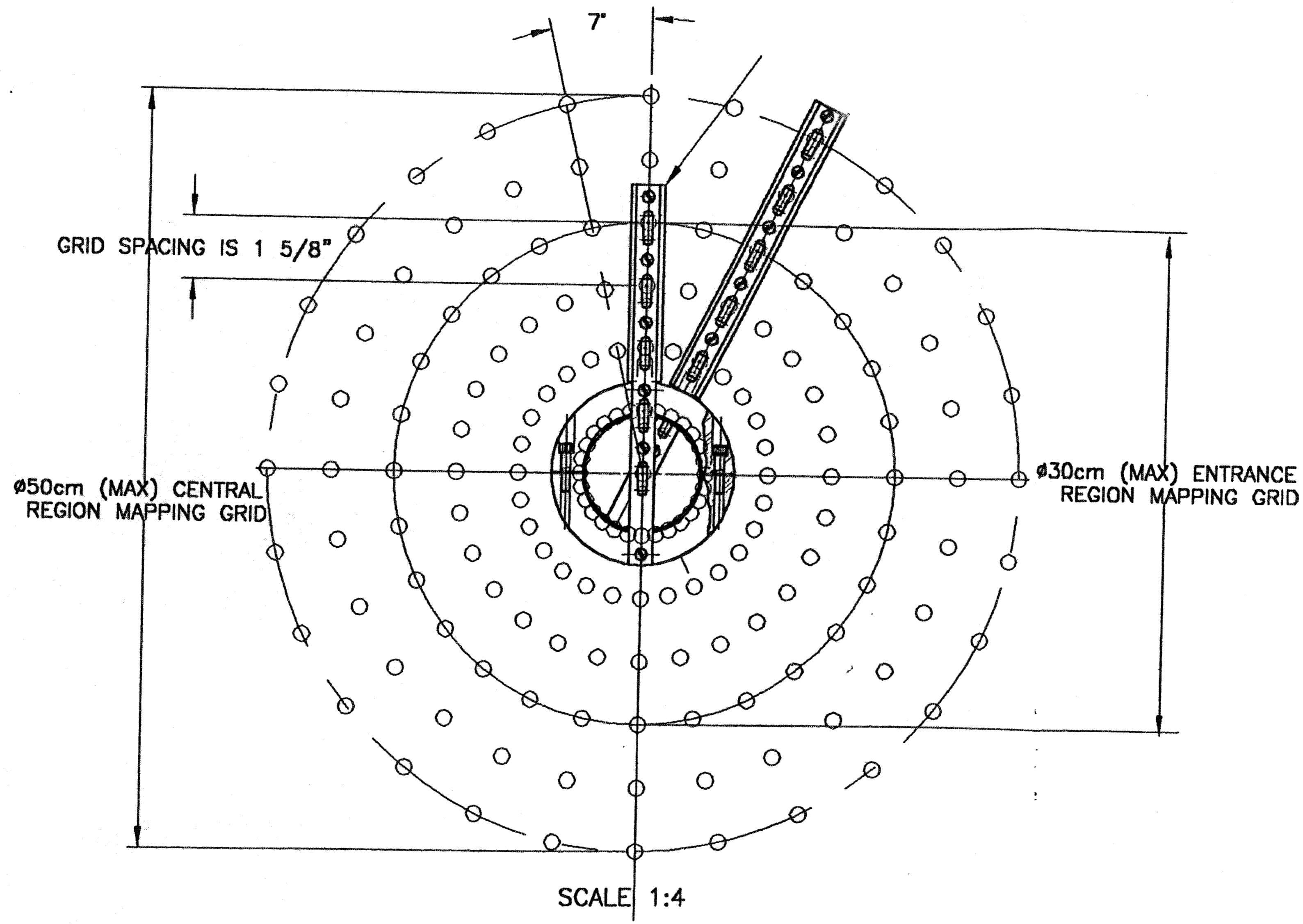
a) Pentium PC with GPIB card and Network card
b) HP 3497A Data Acquisition Unit (DVM, 20 channel mux and digital IO).
c) 12 Bell BHT-910 hall probes
d) Custom built automated dual rotating arm magnet survey mechanism.
e) Dual stepping motor system

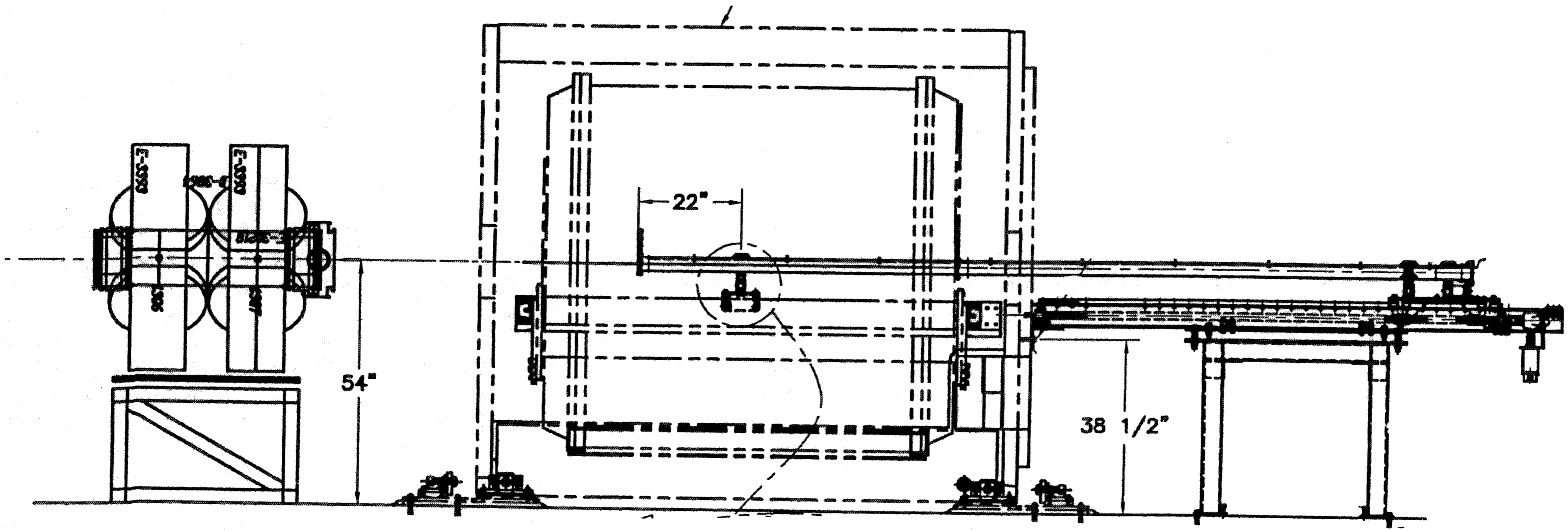


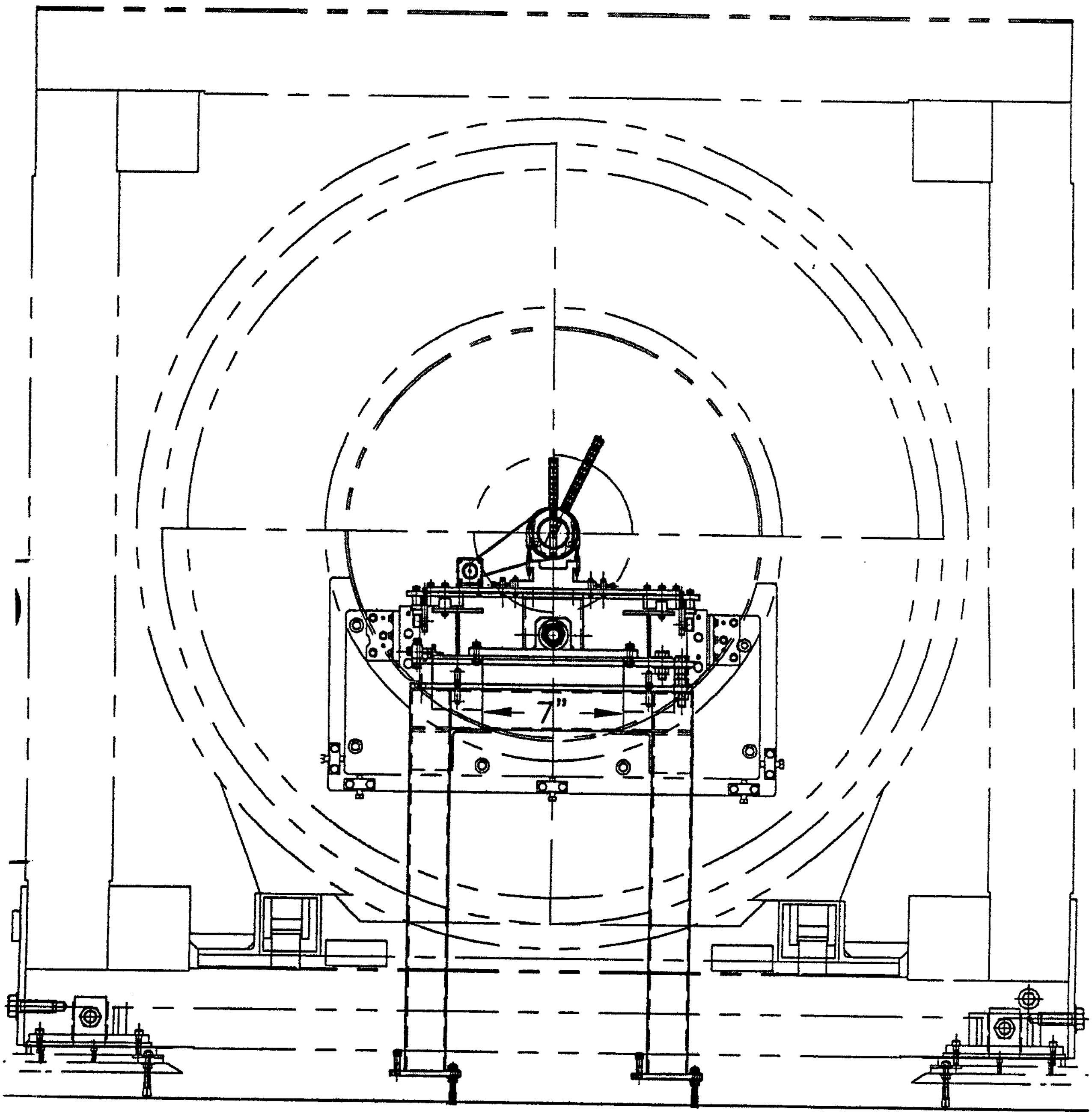


7 1/2"
18
10 5/8"
213
16
10
107
105
106
104
104
105
106
19


54"
20" REF.


7°
GRID SPACING IS 1 5/8"
ø50cm (MAX) CENTRAL REGION MAPPING GRID
ø30cm (MAX) ENTRANCE REGION MAPPING GRID
SCALE 1:4


22"
54"
38 1/2"


7"