CHAPTER 12

MAGNETS

12.1 Magnets

The main magnet systems of the Debuncher and Accumulator rings and all five beam lines will with few exceptions utilize four magnet cross-section types, a small and a large dipole and a small and large quadrupole. These magnets will each come in a number of different lengths, but will retain the advantages of common laminations and coil designs. In addition, many of the correction elements in the ring and beam lines will be of the same design. Table 12-I shows the magnet types and lengths to be used and their disposition around the project.

The parameters of the major dipole and quadrupole types are given in Tables 12-II and 12-III.

In these designs, higher multipole content has been minimized by empirical chamfering of the poles of the end packs. These end packs are made of standard laminations glued to make a rigid assembly.

These magnets are rich in copper in order to lower the excitation and therefore to decrease operating cost.

Figures 12-1 through 12-4 show the four types of magnet cross sections.

Measured field data are now available on a number of the magnet types listed in Tables 12-I, 12-II, and 12-III. One result of the measurements is that the excitation currents for the magnets have changed. The magnet currents expected at this time are as follows:

I. Debuncher

SDD: 1,176A

SQC: design tunes 277A, top tunes 290A

SQD: " 232A, " 244A

LQE: " 1500A, " close to 1700A

II. Accumulator

SDA, SDB, SDC, LDA: not measured

SQA:	design tunes 234A,	top tunes 241A
SQB:	250	260
SQC:	250	260
SQD:	234	240

SQE:	250	260

LQA: not measured

LQB: design tunes	1325A, top tunes	1345A
LQC:	1305A,	1330A
LQD:	1305A,	1330A

In addition, extensive measurements of field quality have been made. These are depicted in Figs. 12-5 through 12-10. Figures 12-5 and 12-6 show the change of field shape (all well within the acceptance area) with current (for the small quadrupole SQC). The remaining graphs show measured field shapes for the small dipole SD and several lengths of large quadrupole.

12.2 Magnet Power Supplies

12.2.1 Debuncher. The Debuncher ring has 111 small quadrupoles, 3 larger quadrupoles, and 66 small dipoles. The small dipoles and large quadrupoles are in series and fed by one ring bus using a 1200-A power supply. Three 300-A supplies run the SQ elements (QF, QD, and QSS buses). The total tunnel equipment consists of the 180 major magnetic elements, 33 shunts, and 186 correction magnets, dipoles and sextupoles. These elements are operated from 57 power supplies and 33 shunt controllers placed in the service buildings. The table below shows the relationship of tunnel and service building equipment.

TABLE 12-IV DEBUNCHER POWER SUPPLIES

Magnetic Element	Type	Power Supply (A)
B	66 SD	1200
D2Q5, D4Q5, D6Q6	3 LQ	
QF	42 SQ-27.6	300
D1Q5, D3Q5, D5Q5, D6Q5	4 SQ-32.6	
QD	39 SQ-27.6	300
DnQ6, (n=1,5)	5 SQ-32.6	
DnQ0, (n=1,3,5)	21 SQ-27.6	300
DnQ2, Q3, Q4, (n=1,6)		
D2Q5, D4Q5, D6Q6	3 LQ-32.6	3-50 (shunt)
D2Q5, D4Q5, D6Q6	3 LQ-32.6	3-200 (trim)
D1Q5, D3Q5, D5Q5, D6Q5	9 SQ-32.6	30-40 (shunt)
DnQ6, (n=1,5)		
DnQ0, (n=1,3,5)	21 SQ-27.6	

TABLE 12-I TEVATRON I MAGNETS

Magnet	Length (in.)	Debuncher	Accum	AP1	AP2	DA	AP3	AP4	Refer
Small Quadrupole									
SQA	18		18		5	1	16	5	1
SQB	25.2		6		6		3	2	1
SQC	27.6	102	18		14	1	5	2	2
SQD	32.6	9	6		5	4	5	1	1
SQE	51.6		6		3	1	1		1
Large Quadrupole									
LQA	17.2		6						1
LQB	25.3		6						1
LQC	30.4		12						1
LQD	32.6	3							1
LQE	34.4		6						1
Large Dipole									
LDA	180		12						1
Small Dipole									
SDA	180		6						1
SDB	120		6						1
SDC	60		4						1
SDD	65.2	66			1		2		1
SDE	98.4				6		4		1
Modifed Main Ring B1's									
MWGB1	60		2		1		2	1	1
MWGB2	120					1			1
Existing Dipoles									
EPB	120			10				3	
AVB	60							2	1
Existing Quadrupoles									
3Q120A	120			14					15
Lambertsons									
Lamb	204			2					1
Lamb	115						1		
Septum Magnets									
Sept	84					4		1	1
Booster Septum								1	
Correction Elements									
RSex	8	138	12						1
SSex	12		12						1
BL Trim Dipole		28	30	3	7	3	7	5	1

TABLE 12-II DIPOLE MAGNET PARAMETERS

MAGNET DATA LATEST REVISION 8/10/83

INPUT PARAMETERS AND COMPUTED FIELDS

DIPOLES * INPUT DATA

MAGNET TYPE		SDA	SDB	SDC	SDD	SDE	SDP	LDA	LDP
GAP *	IN	2.375	2.375	2.375	2.375	2.375	2.375	2.375	2.375
GOOD FIELD WIDTH *	IN	4	4	4	4	4	4	10	10
ARC LENGTH *	IN	180	120	60	65.3702	98.4252	48	180	48
RADIUS OF CURVATURE *	IN	687.549	687.549	687.549	687.549	926.083	687.549	687.549	687.549
BEND ANGLE	RAD	.2617995	.1745330	.0872665	.0950772	.1062812	.0698132	.2617995	.0698132
FE LENGTH	IN	176.9364	117.2977	57.43096	62.79558	95.82888	45.44025	176.9364	45.44025
FE SAGITTA	IN	5.715439	2.505982	.5999127	.7172840	1.240349	.3754970	5.715439	.3754970
FE WIDTH *	IN	45.25	45.25	45.25	45.25	45.25	45.25	57	57
FE HEIGHT *	IN	29	29	29	29	29	29	35	35
COIL PROTRUSION *	IN	11	11	11	11	11	11	11	11
PANCAKE TURNS *		56	56	56	56	56	56	56	56
SADDLE TURNS *		16	16	16	16	16	16	16	16
PANCAKE H2O PATHS *		4	4	4	4	4	4	4	4
SADDLE H2O PATHS *		1	1	1	1	1	1	1	1
WATER FLOW	GAL/MIN	6.517570	7.726468	10.04321	9.746194	8.364456	10.82087	6.428168	10.41549
FIELD	KG	16.98848	16.98848	16.98848	16.98848	12.61268	16.98848	17.01224	17.01224
CURRENT *	AMP	1178.61	1178.61	1178.61	1178.61	875.03	1178.61	1179.44	1179.44
AMPFAC *		1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
MAGNET RESISTANCE	OHM	.0197479	.0141110	.0084727	.0089774	.0120845	.0073449	.0202802	.0078773
VOLTAGE	VOLT	23.27503	16.63136	9.986067	10.58091	10.57431	8.656817	23.91932	9.290813
POWER	WATT	27432.18	19601.86	11769.68	12470.76	9252.836	10203.01	28211.40	10957.96
H2O TEMP RISE	DEG C	15.99404	9.638024	4.453234	4.862299	4.203594	3.583025	16.67712	3.997914
STORED ENERGY	JOULE	113569.1	75833.05	37952.65	41347.08	34311.22	30365.59	163040.8	43593.12
INDUCTANCE	HENRY	.1635121	.1091813	.0546427	.0595298	.0896232	.0437191	.2344092	.0626753
L/R TIME	SEC	8.279991	7.737322	6.449224	6.631042	7.416368	5.952279	11.55851	7.956432
CAPACITANCE *	NF								
TOTAL MAGNET WT	LB	58372.03	39286.32	20150.44	21864.57	32418.56	16319.41	90766.62	16843.74

MAGNET DATA LATEST REVISION 8/10/83

INPUT PARAMETERS AND COMPUTED FIELDS

DIPOLES * INPUT DATA

MAGNET TYPE		SDA	SDB	SDC	SDD	SDE	SDP	LDA	LDP
LENGTH EXTENSION *	IN	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
THICKNESS LAMS **	IN	.0598	.0598	.0598	.0598	.0598	.0598	.0598	.0598
NUMBER LAMS		5918	3923	1921	2100	3205	1520	5918	1520
CHAMFER *	IN	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
REDUCED ANGLE	RAD	.2507277	.1635126	.0762763	.0840851	.0981179	.0588265	.2507277	.0588265
PANCAKE END *	IN	30.1	30.1	30.1	30.1	30.1	30.1	36.31	36.31
SADDLE END *	IN	64.25	64.25	64.25	64.25	64.25	64.25	68	68
TOTAL PANCAKE LENGTH	IN	22678.61	15962.57	9244.892	9846.212	13548.12	7901.161	23374.13	8596.681
TOTAL SADDLE LENGTH	IN	7572.403	5653.534	3734.198	3906.004	4963.690	3350.275	7692.403	3470.275
TOTAL CU LENGTH	IN	30251.01	21616.10	12979.09	13752.22	18511.81	11251.44	31066.53	12066.96
WT/IN CU *	LB/IN	.36632	.36632	.36632	.36632	.36632	.36632	.36632	.36632
TOTAL CU WT.	LB	11081.55	7918.411	4754.500	5037.712	6781.245	4121.626	11380.29	4420.367
WATER HOLE DIAM *	IN	.375	.375	.375	.375	.375	.375	.375	.375
H2O PRESSURE **	PSI	70	70	70	70	70	70	70	70
TURB FLOW PARM **	ENGLISH	19600	19600	19600	19600	19600	19600	19600	19600
LAM FLOW PARM **	ENGLISH	31900	31900	31900	31900	31900	31900	31900	31900
TURB PANCAKE FLOW	GAL/MIN	5.358423	6.386954	8.392557	8.132248	6.932753	9.078200	5.278098	8.703217
LAM PANCAKE FLOW	GAL/MIN	31.15425	44.26199	76.42438	71.75705	52.15006	89.42168	30.22723	82.18696
TURB SADDLE FLOW	GAL/MIN	1.159147	1.341514	1.650656	1.613946	1.431703	1.742669	1.150070	1.712274
LAM SADDLE FLOW	GAL/MIN	5.831497	7.810768	11.82542	11.30528	8.896294	13.18055	5.740527	12.72477
LAMINATION AREA *	SQ IN	447.51	447.51	447.51	447.51	447.51	447.51	759.44	447.51
IRON DENSITY **	LB/CU IN	.284	.284	.284	.284	.284	.284	.284	.284
LAM WT.	LB	7.600152	7.600152	7.600152	7.600152	7.600152	7.600152	12.89772	7.600152
TOTAL LAM WT.	LB	44974.70	29815.41	14598.13	15961.74	24358.33	11550.26	76323.62	11550.26
STRUCTURE AREA *	SQ IN	44	44	44	44	44	44	57.75	57.75
UNIT STRUCT VOL *	CU IN	279	279	279	279	279	279	448	448
STRUCTURE WT.	LB	2315.785	1552.497	797.8151	865.1251	1278.986	647.5254	3062.703	873.1118
RESIST/LENGTH *	OHM/IN	6.528E-7	6.528E-7	6.528E-7	6.528E-7	6.528E-7	6.528E-7	6.528E-7	6.528E-7
INDUCT/LENGTH *	HENRY/IN	.000911	.000911	.000911	.000911	.000911	.000911	.001306	.001306
H2O SP HT *	GAL/MIN WATT OC	.0038	.0038	.0038	.0038	.0038	.0038	.0038	.0038
TRANSFER CONST *	KG/IN AMP	.014414	.014414	.014414	.014414	.014414	.014414	.014424	.014424

TABLE 12-III QUADRUPOLE MAGNET PARAMETERS

MAGNET DATA LATEST REVISION 8/10/83

INPUT PARAMETERS AND COMPUTED FIELDS

QUADS * INPUT DATA

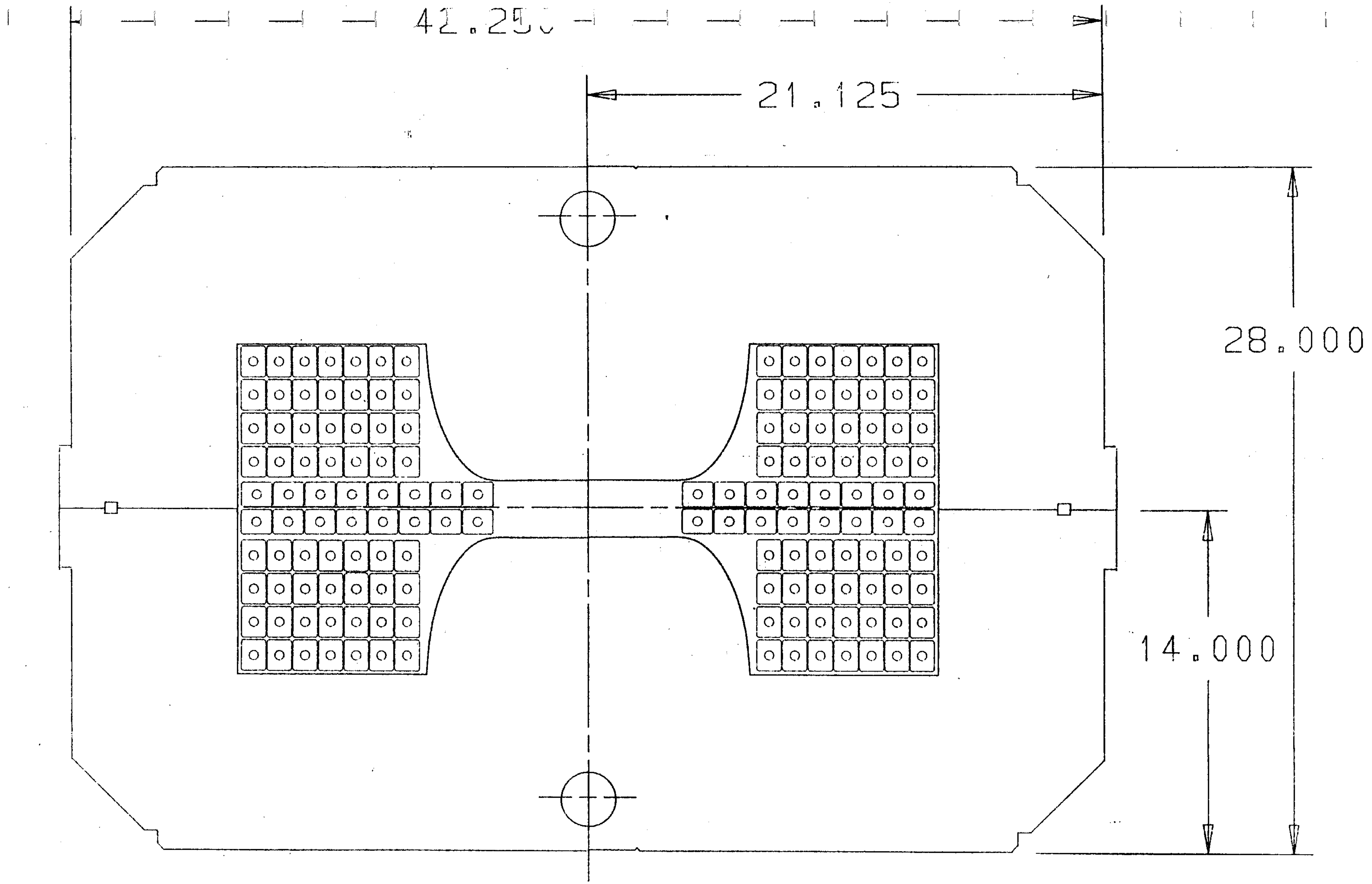
MAGNET TYPE		SQA	SQB	SQC	SQD	SQE	SQP	LQA	LQB	LQC	LQE	L
POLE TIP DIAMETER*	IN	3.5	3.5	3.5	3.5	3.5	3.5	6.625	6.625	6.625	6.625	6.625
GOOD FIELD WIDTH *	IN	5	5	5	5	5	5	10	10	10	10	10
EFFECTIVE LENGTH *	IN	18	25.2	27.6	32.6	51.64	49.42	17.284	25.3	30.4	34.4	32.
FE LENGTH	IN	16.58	23.78	26.18	31.18	50.22	48	14.604	22.62	27.72	31.72	
COIL PROTRUSION *	IN	4	4	4	4	4	4	6	6	6	6	
FE WIDTH *	IN	30.5	30.5	30.5	30.5	30.5	30.5	54.75	54.75	54.75	54.75	54.75
FE HEIGHT *	IN	29	29	29	29	29	29	51.75	51.75	51.75	51.75	51.75
NUMBER TURNS *		132	132	132	132	132	132	40	84	84	84	
NUMBER H20 PATHS *		4	4	4	4	4	4	1	2	2	2	
WATER FLOW	GAL/MIN	1.512802	1.373134	1.334519	1.263527	1.070031	1.088122	1.763305	3.147041	2.994803	2.889726	2.9335
GRADIENT *	KG/IN	2.499471	2.499471	2.499471	2.499471	2.499471	2.499471	2.250133	2.250133	2.250133	2.250133	2.250133
CURRENT *	AMP	234.45	234.45	234.45	234.45	234.45	234.45	1206.7	1206.7	1206.7	1206.7	1206.7
AMPFAC *		1	1	1	1	1	1	1.015	1.015	1.015	1.015	1.0
MAGNET RESISTANCE	OHM	.0323385	.0392517	.0415561	.0463569	.0646385	.0625069	.0029507	.0074107	.0081833	.0087892	.00852
VOLTAGE	VOLT	7.581752	9.202554	9.742821	10.86838	15.15450	14.65475	3.560550	8.942462	9.874730	10.60592	10.291
POWER	WATT	1777.542	2157.539	2284.204	2548.091	3552.972	3435.806	4296.516	10790.87	11915.84	12798.16	12418.76
H2O TEMP RISE	DEG C	4.464997	5.970757	6.504200	7.663267	12.61767	11.99871	9.259184	13.02980	15.11958	16.82963	16.08683
STORED ENERGY	JOULE	1182.336	1655.270	1812.915	2141.342	3391.990	3246.169	12583.83	18419.98	22133.10	25045.35	23793.[illegible]
INDUCTANCE	HENRY	.04302	.060228	.065964	.077914	.1234196	.1181138	.017284	.0253	.0304	.0344	.032
L/R TIME	SEC	1.330305	1.534406	1.587349	1.680742	1.909382	1.889611	5.857690	3.413994	3.714904	3.913897	3.8317
CAPACITANCE *	NF											
TOTAL MAGNET WT	LB	2927.012	4069.174	4449.895	5243.063	8263.446	7911.280	7703.009	12766.49	15380.70	17431.06	16549.40

MAGNET DATA LATEST REVISION 8/10/83

INPUT PARAMETERS AND COMPUTED FIELDS

QUADS * INPUT DATA

MAGNET TYPE		SQA	SQB	SQC	SQD	SQE	SQP	LQA	LQB	LQC	LQE	LQD
LENGTH EXTENSION *	IN	1.42	1.42	1.42	1.42	1.42	1.42	2.68	2.68	2.68	2.68	2.68
THICKNESS LAMS **	IN	.0598	.0598	.0598	.0598	.0598	.0598	.0598	.0598	.0598	.0598	.0598
NUMBER LAMS		555	795	876	1043	1680	1605	488	757	927	1061	1003
END LENGTH *	IN	17.1	17.1	17.1	17.1	17.1	17.1	26.3	26.3	26.3	26.3	26.3
TOTAL CU LENGTH	IN	8891.52	10792.32	11425.92	12745.92	17772.48	17186.4	3272.32	8218.56	9075.36	9747.36	9458.4
WT/IN CU *	LB/IN	.06576	.06576	.06576	.06576	.06576	.06576	.26519	.26519	.26519	.26519	.26519
WATER HOLE DIAM *	IN	.1875	.1875	.1875	.1875	.1875	.1875	.375	.375	.375	.375	.375
H20 PRESSURE **	PSI	70	70	70	70	70	70	70	70	70	70	70
TURB FLOW PARM **	ENGLISH	19600	19600	19600	19600	19600	19600	19600	19600	19600	19600	19600
LAM FLOW PARM **	ENGLISH	31900	31900	31900	31900	31900	31900	31900	31900	31900	31900	31900
TURB WATER FLOW	GAL/MIN	1.512802	1.373134	1.334519	1.263527	1.070031	1.088122	1.763305	3.147041	2.994803	2.889726	2.933536
LAM WATER FLOW	GAL/MIN	4.966355	4.091655	3.864761	3.464516	2.484653	2.569383	13.49454	21.49206	19.46301	18.12119	18.67481
LAMINATION AREA *	SQ IN	239.72	239.72	239.72	239.72	239.72	239.72	801.01	801.01	801.01	801.01	801.01
IRON DENSITY **	LB/CU IN	.284	.284	.284	.284	.284	.284	.284	.284	.284	.284	.284
LAM WT.	LB	4.071213	4.071213	4.071213	4.071213	4.071213	4.071213	13.60371	13.60371	13.60371	13.60371	13.60371
TOTAL LAM WT.	LB	2257.549	3237.908	3564.694	4245.499	6838.003	6535.726	6644.436	10291.50	12611.87	14431.77	13649.21
STRUCTURE AREA *	SQ IN	18	18	18	18	18	18	46	46	46	46	46
UNIT STRUCT VOL *	CU IN	0										
STRUCTURE WT.	LB	84.75696	121.5634	133.8322	159.3922	256.7246	245.376	190.7867	295.5077	362.1341	414.3901	391.92
TOTAL CU WT.	LB	584.7064	709.7030	751.3685	838.1717	1168.718	1130.178	867.7865	2179.480	2406.695	2584.902	2508.273
RESIST/LENGTH *	OHM/IN	3.637E-6	3.637E-6	3.637E-6	3.637E-6	3.637E-6	3.637E-6	9.017E-7	9.017E-7	9.017E-7	9.017E-7	9.017E-7
INDUCT/LENGTH *	HENRY/IN	.00239	.00239	.00239	.00239	.00239	.00239	.001	.001	.001	.001	.001
H2O SP HT *	GAL/MIN WATT OC	.0038	.0038	.0038	.0038	.0038	.0038	.0038	.0038	.0038	.0038	.0038
TRANSFER CONST *	KG/IN AMP	.010661	.010661	.010661	.010661	.010661	.010661	.0018647	.0018647	.0018647	.0018647	.0018647



SMALL DIPOLE units are in inches

Figure 12-1

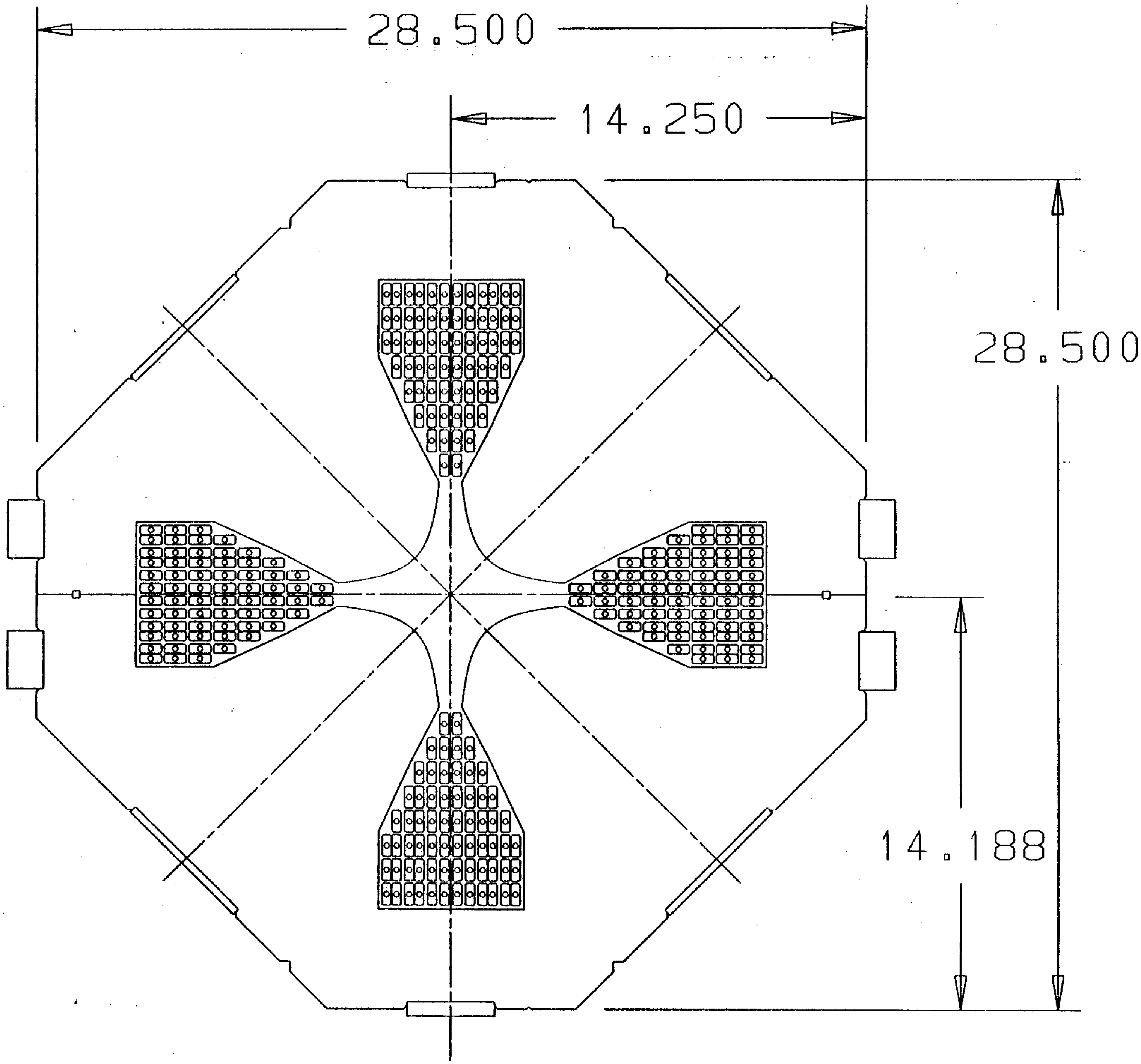
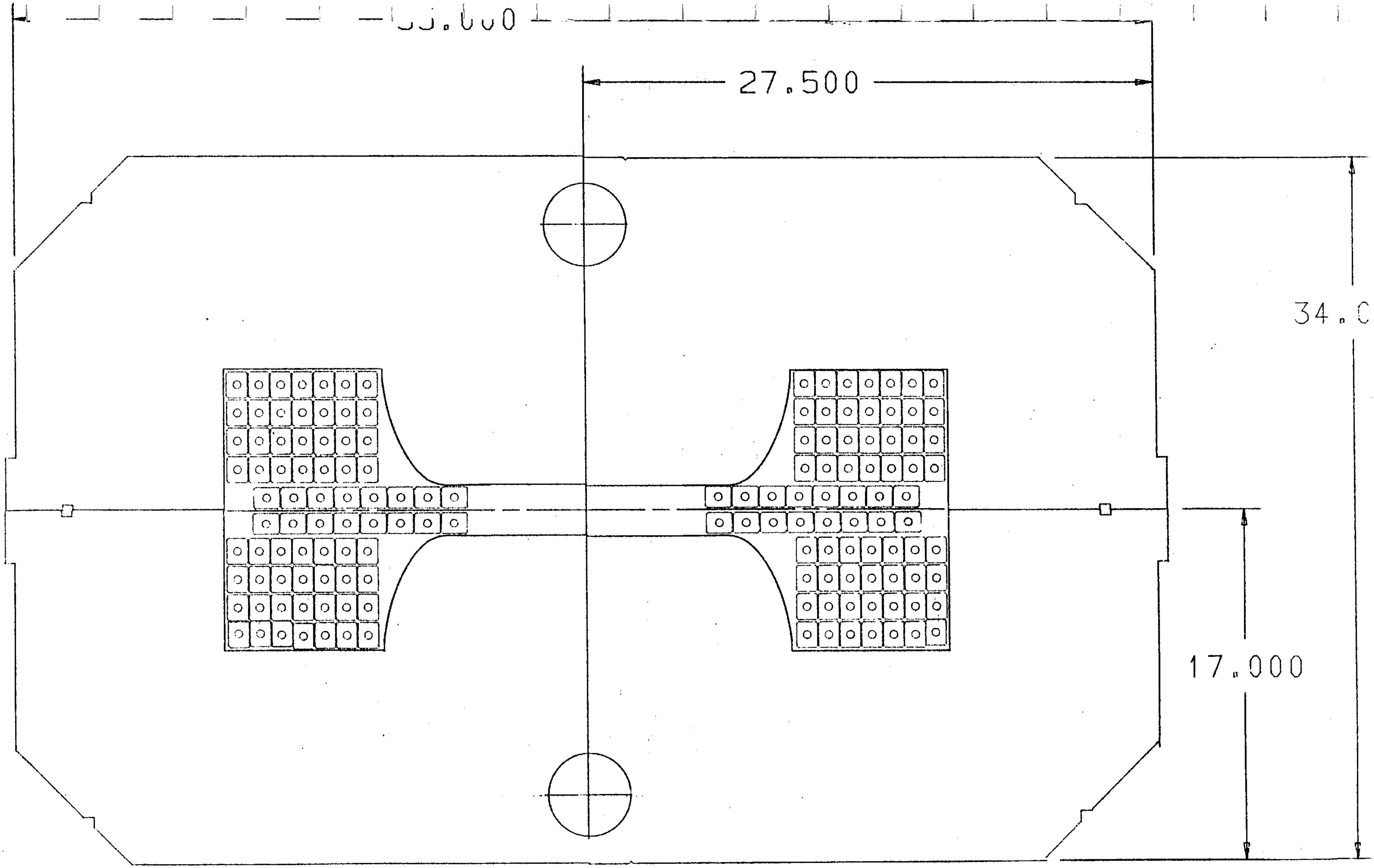


Figure 12-2 SMALL APERTURE QUAD (SQ) units are in inches



LARGE DIPOLE (LD)

Figure 12-3

units are in inche

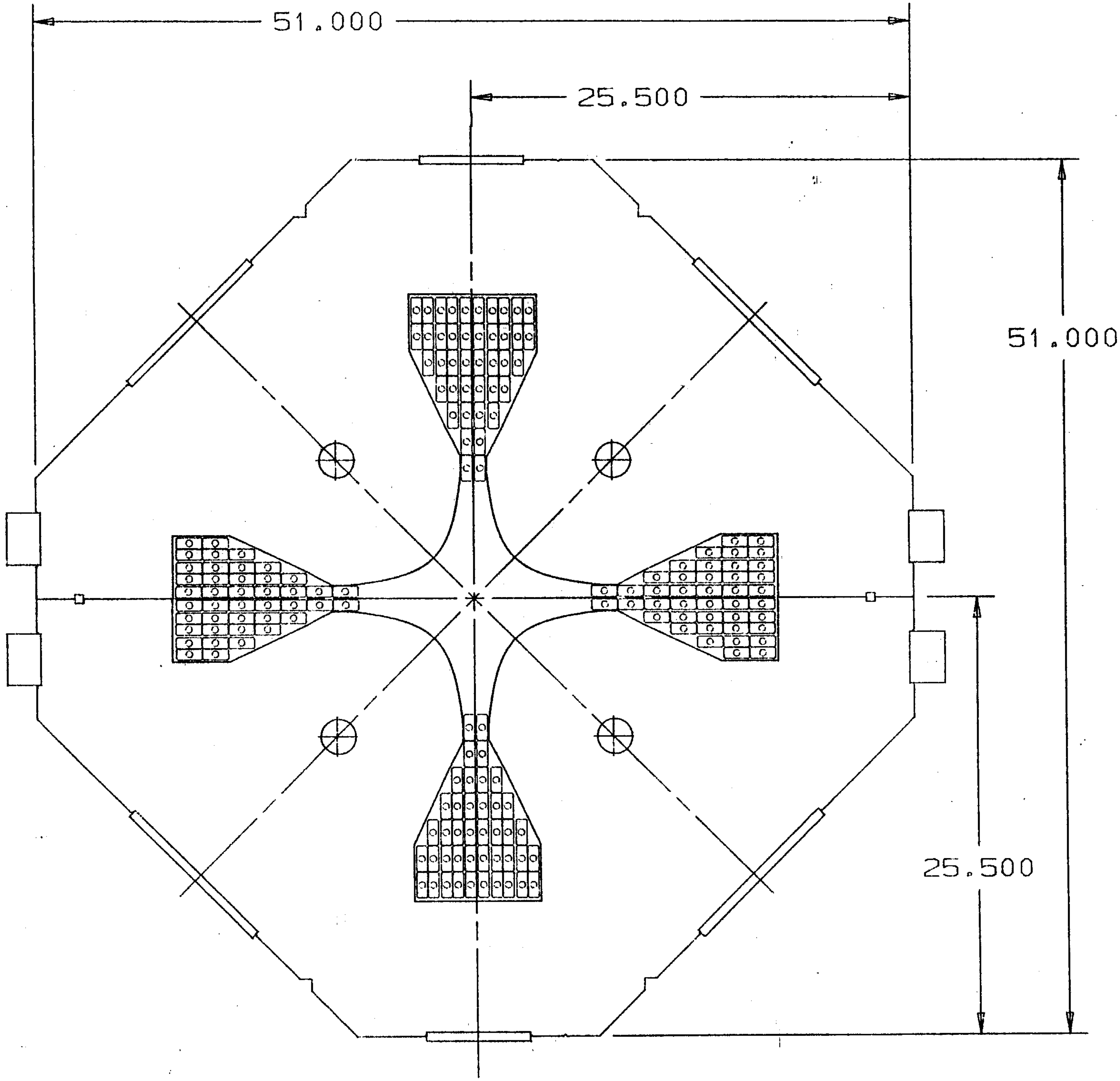


Figure 12-4 LARGE QUAD (LQ) units are in inches

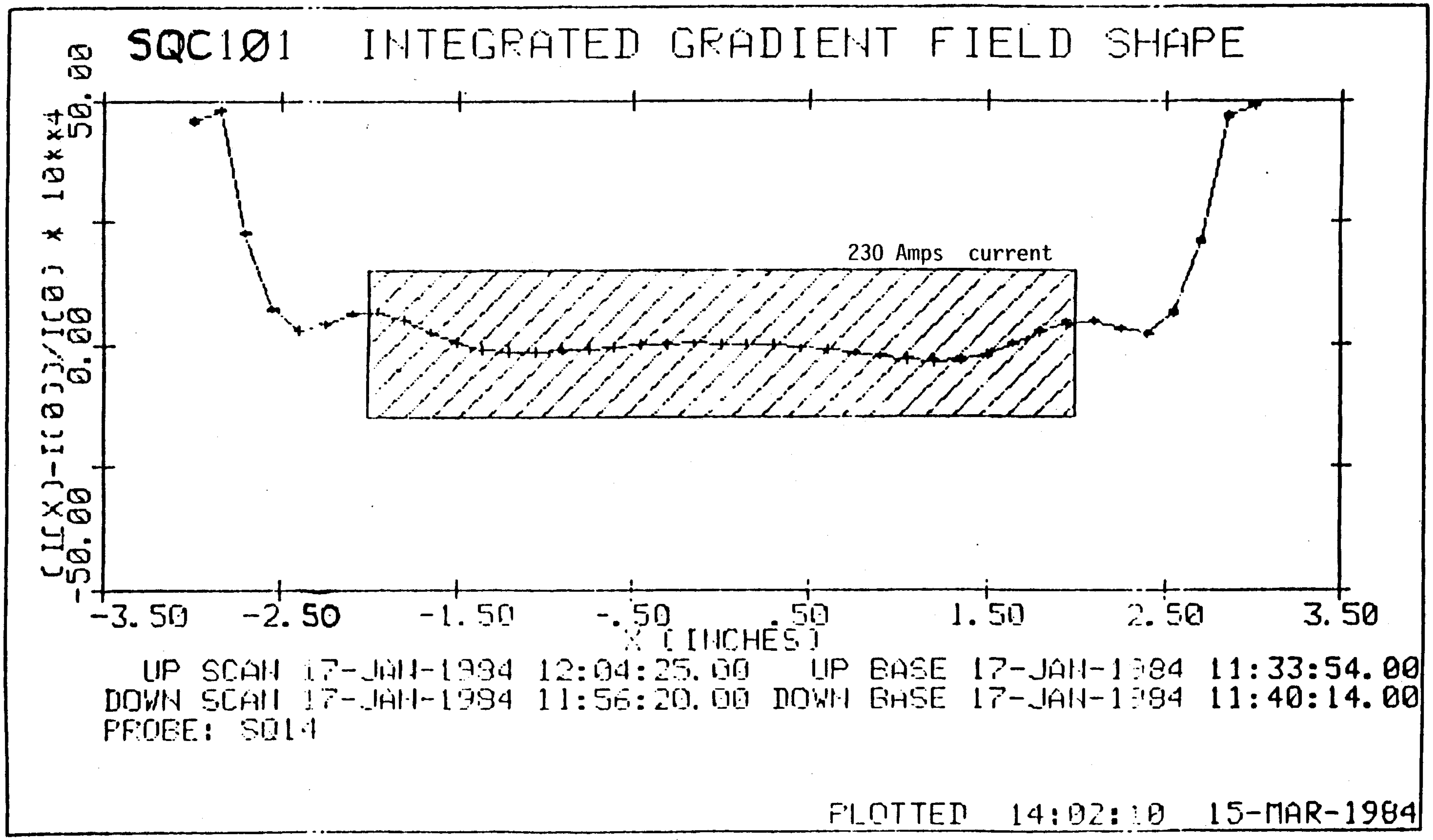
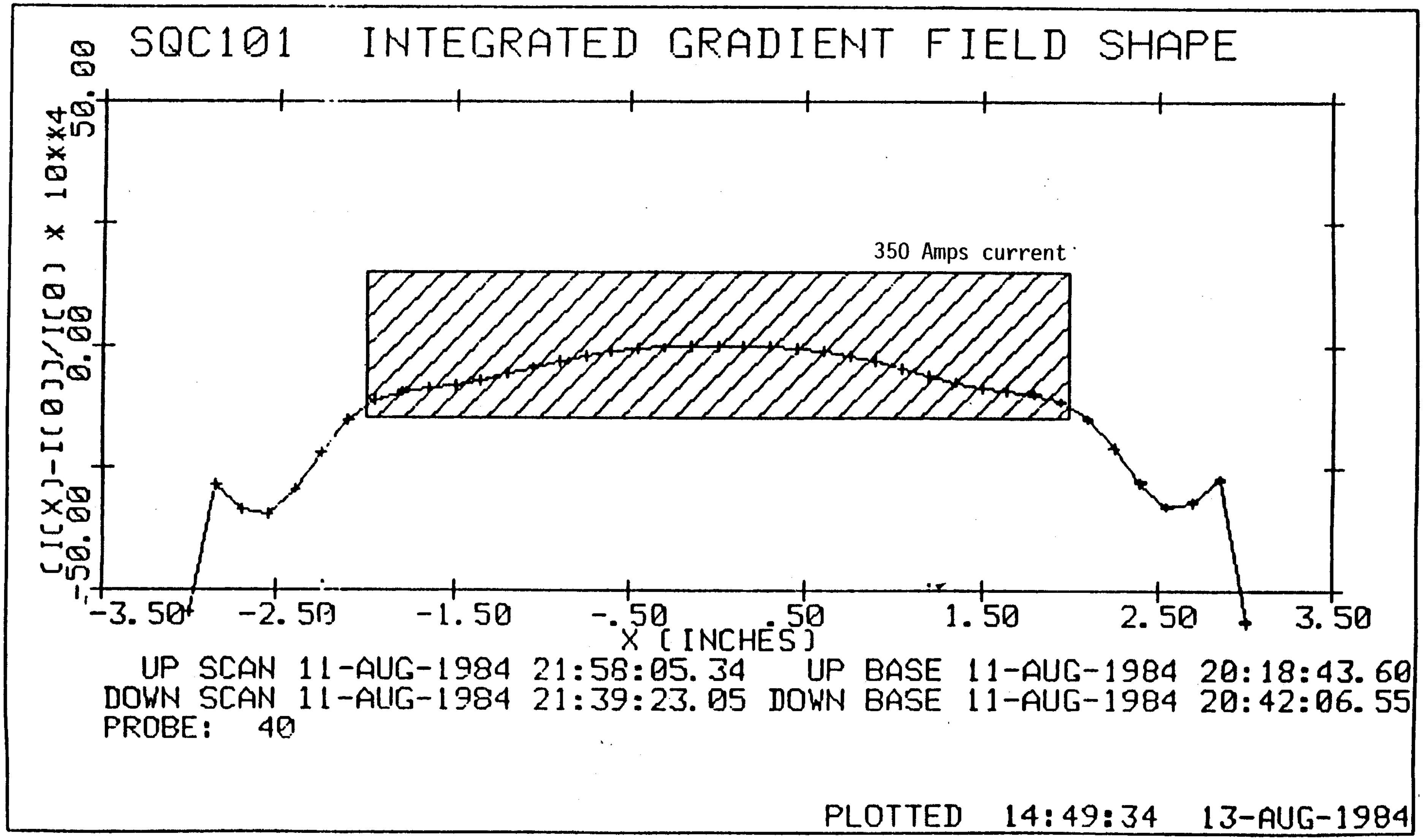

SQC1Ø1 INTEGRATED GRADIENT FIELD SHAPE
(I[X]-I[Ø])/I[Ø]) * 1Ø**4
50.00
0.00
-50.00
230 Amps current
-3.50
-2.50
-1.50
-.50
.50
1.50
2.50
3.50
X [INCHES]
UP SCAN 17-JAN-1984 12:04:25.00 UP BASE 17-JAN-1984 11:33:54.00
DOWN SCAN 17-JAN-1984 11:56:20.00 DOWN BASE 17-JAN-1984 11:40:14.00
PROBE: SQ14
PLOTTED 14:02:10 15-MAR-1984

Figure 12-5



SQC101 INTEGRATED GRADIENT FIELD SHAPE
[I[X]-I[0]]/I[0] x 10**4
50.00
0.00
-50.00
350 Amps current
-3.50
-2.50
-1.50
-.50
.50
1.50
2.50
3.50
X [INCHES]
UP SCAN 11-AUG-1984 21:58:05.34 UP BASE 11-AUG-1984 20:18:43.60
DOWN SCAN 11-AUG-1984 21:39:23.05 DOWN BASE 11-AUG-1984 20:42:06.55
PROBE: 40
PLOTTED 14:49:34 13-AUG-1984

Figure 12-6

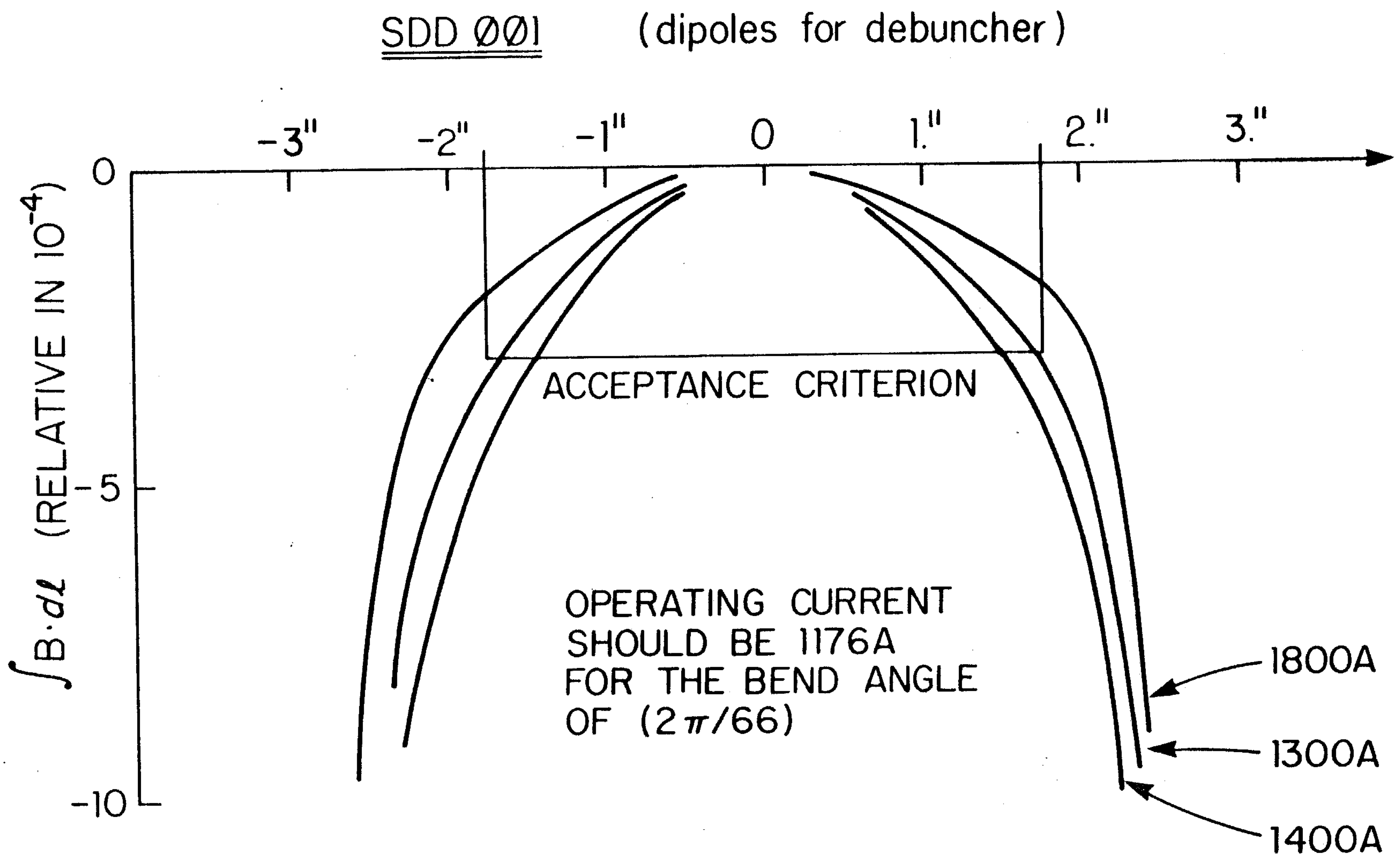

SDD ØØ1 (dipoles for debuncher)
-3"
-2"
-1"
0
1."
2."
3."
X
0
-5
-10
∫B·dℓ (RELATIVE IN 10^-4)
ACCEPTANCE CRITERION
OPERATING CURRENT
SHOULD BE 1176A
FOR THE BEND ANGLE
OF (2π/66)
1800A
1300A
1400A

Figure 12-7

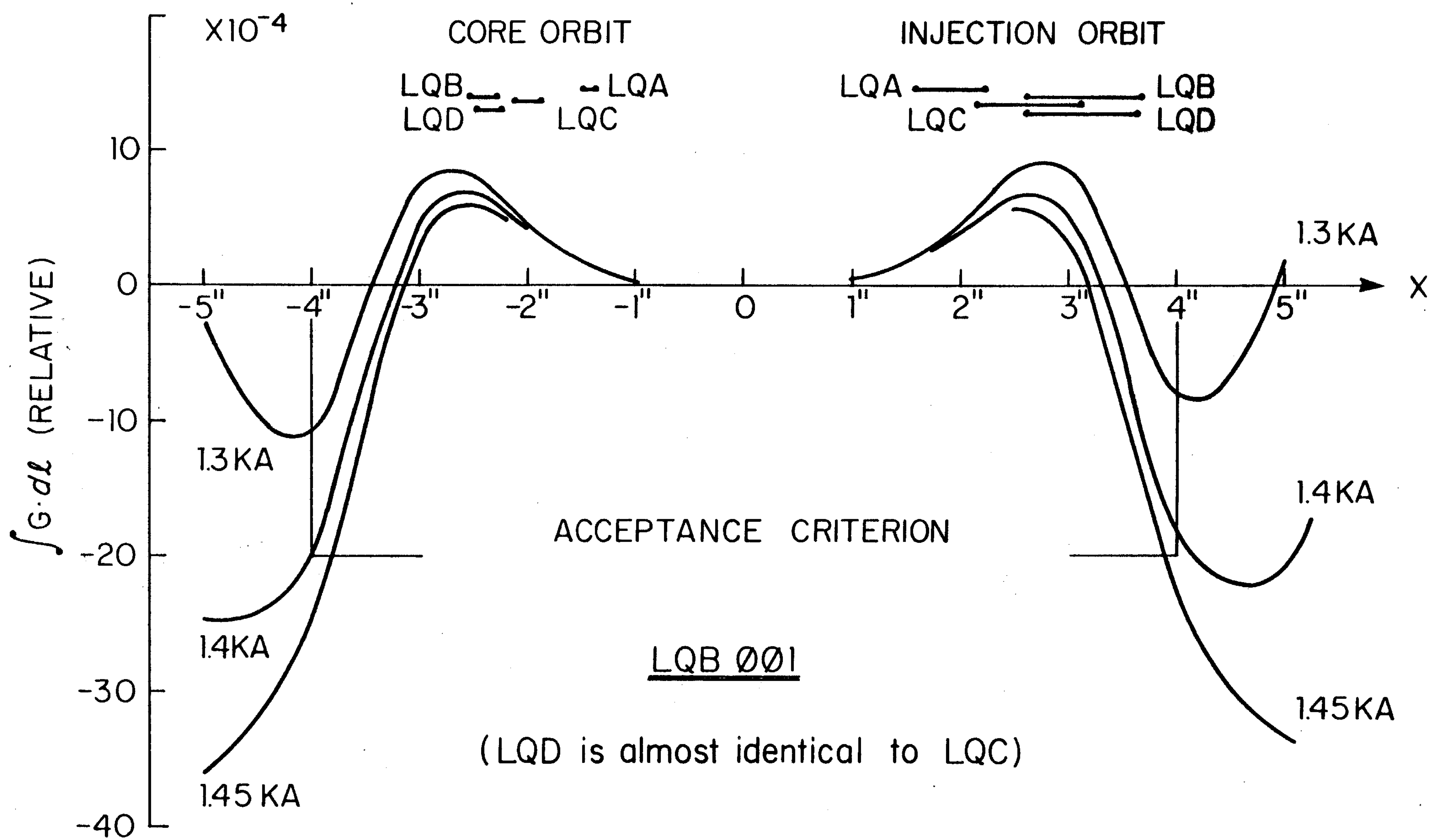

X10^-4
CORE ORBIT
INJECTION ORBIT
LQB
LQD
LQA
LQC
LQA
LQC
LQB
LQD
10
0
-10
-20
-30
-40
∫G·dℓ (RELATIVE)
-5"
-4"
-3"
-2"
-1"
0
1"
2"
3"
4"
5"
X
1.3KA
1.4KA
1.45KA
1.3KA
1.4KA
1.45KA
ACCEPTANCE CRITERION
LQB ØØ1
(LQD is almost identical to LQC)

Figure 12-8

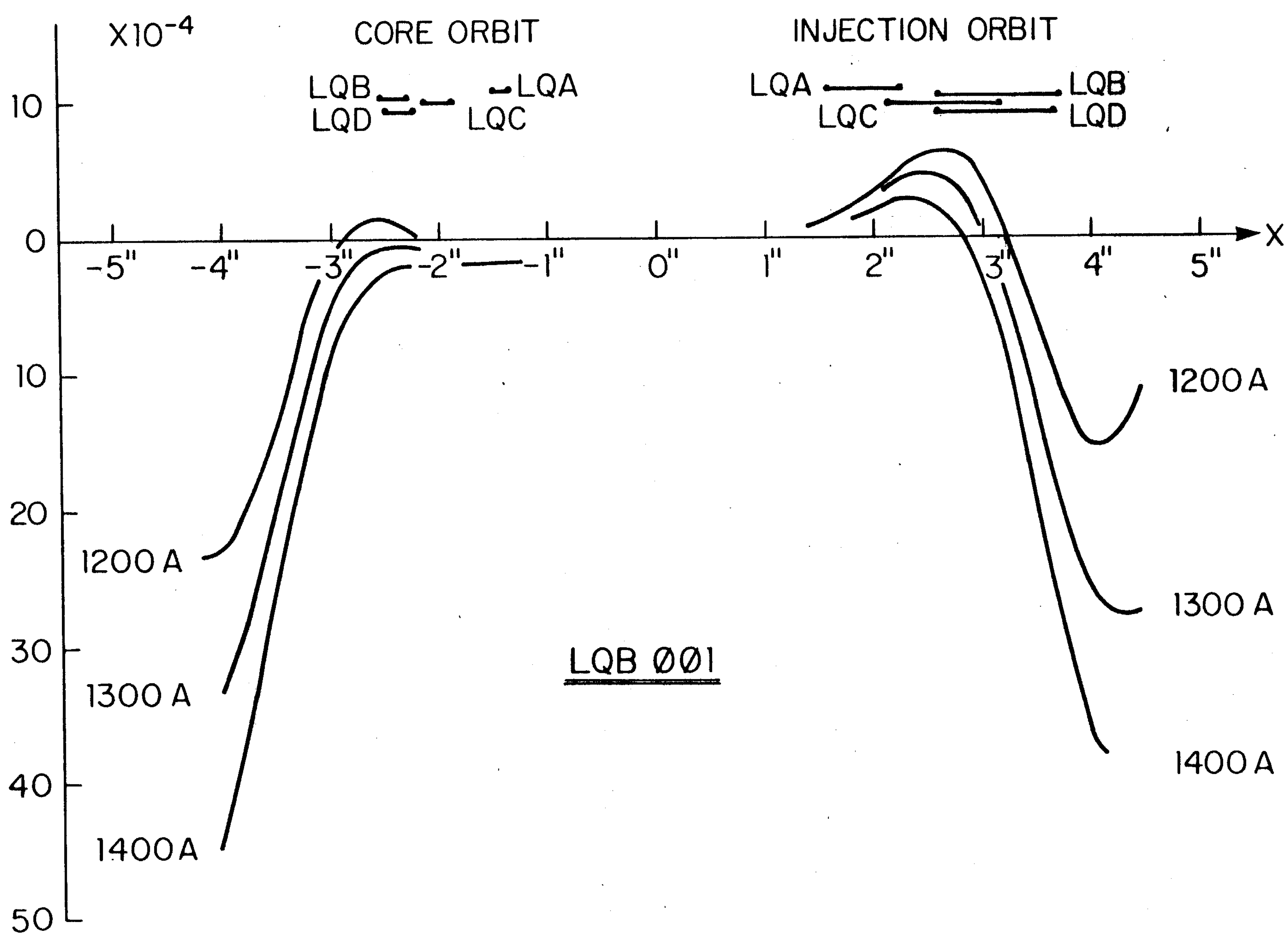

X10^-4
CORE ORBIT
INJECTION ORBIT
LQB
LQD
LQA
LQC
LQA
LQC
LQB
LQD
10
0
10
20
30
40
50
-5"
-4"
-3"
-2"
-1"
0"
1"
2"
3"
4"
5"
X
1200 A
1300 A
1400 A
1200 A
1300 A
1400 A
LQB Ø01

Figure 12-9

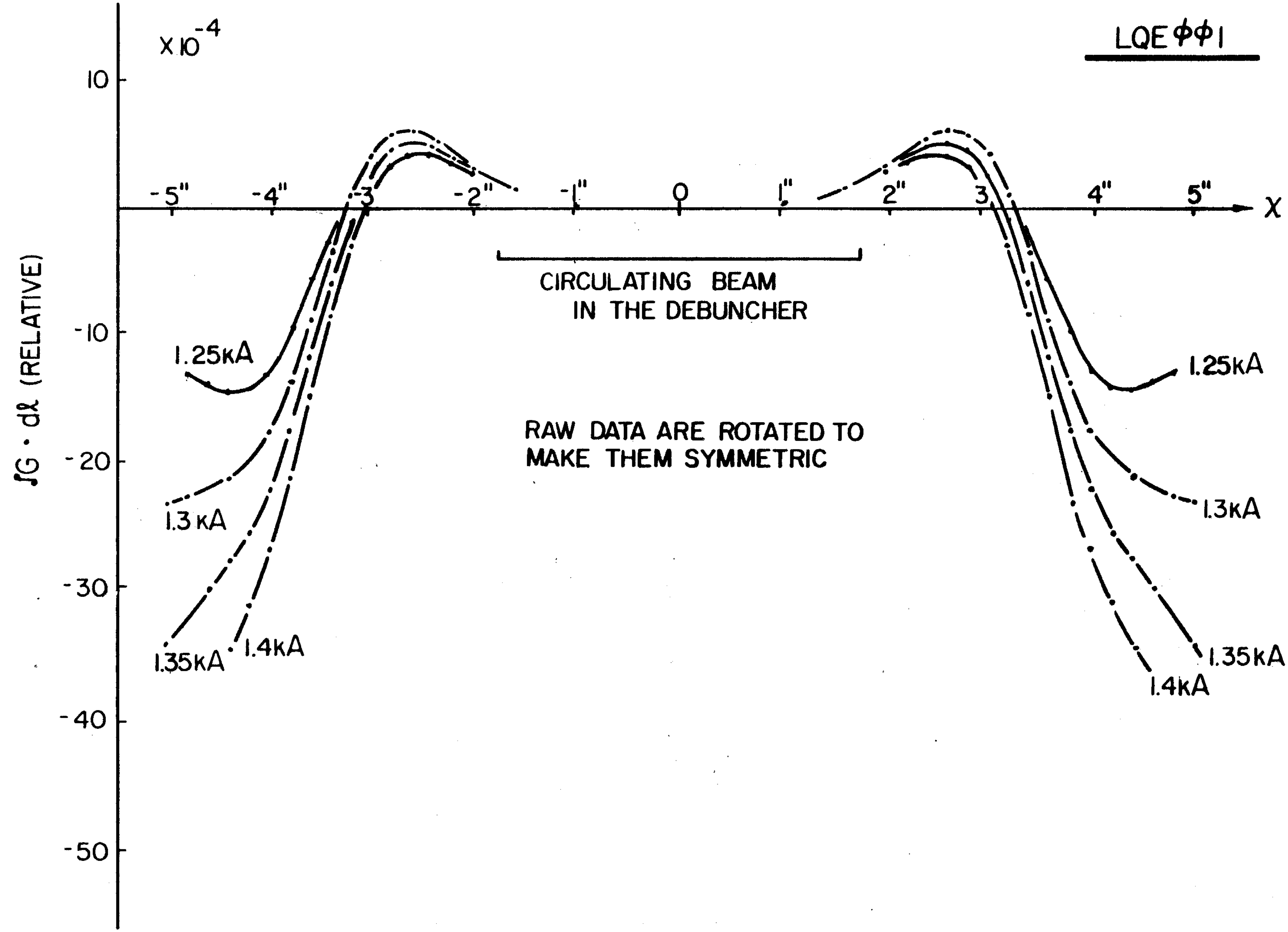

LQE ΦΦ1
X 10^-4
10
-10
-20
-30
-40
-50
∫G · dℓ (RELATIVE)
-5"
-4"
-3
-2"
-1"
0
1"
2"
3
4"
5"
X
CIRCULATING BEAM
IN THE DEBUNCHER
RAW DATA ARE ROTATED TO
MAKE THEM SYMMETRIC
1.25kA
1.3kA
1.35kA
1.4kA
1.25kA
1.3kA
1.35kA
1.4kA

Figure 12-10

DnQ2, Q3, Q4, (n=1,6)

Hor Corr Dipoles	24	24-10 (bipolar)
Ver Corr Dipoles	24	24-10 (bipolar)
SF Sextupoles	72 - S	200
SD Sextupoles	66 - S	200

12.2.2 Accumulator. The Accumulator has 54 small quadrupoles, 30 large quadrupoles, 12 large dipoles, and 18 small dipoles. There are two 1200-A supplies, one feeding all the dipoles, and the other feeding the LQ. There are two 300-A supplies feeding the SQ. Each of the 30 dipoles in the Accumulator has a shunt. These supply horizontal corrections.

In addition, there are 24 standard vertical-correction magnets. Besides the dipole shunts there are shunts on the quadrupoles. In the Accumulator there are also 4 kinds of sextupoles. There are 2 families of "regular" sextupoles, 6 of each and two systems of combination sextupole-octupole correction magnets. In the tunnel are 114 major magnetic elements, 114 shunts, and 48 correction elements. These connect to 34 power supplies and 114 shunt controllers. The table below summarizes these requirements.

TABLE 12-V ACCUMULATOR POWER SUPPLIES

Magnetic Element	Type	Power Supply
B	2 MOD-B1-60 4 SD-60 6 SD-120 6 SD-180 12 LD	1200
Q10 F Q14 F Q12, Q13 D Q11 F	6 LQ-18 6 LQ-25.3 12 LQ-30.4 6 LQ-34.4	1200
QF: Q1 Q3, 6 Q4, 8	6 SQ-25.2 12 SQ-27.6 12 SQ-18	300
QD: Q2 Q5 Q7 Q9	6 SQ-51.64 6 SQ-32.6 6 SQ-27.6 6 SQ-18	300
B (Hor corr)	18 SD 12 LD	30-10 (shunt)

Q10 - Q14	30 LQ	30-60 (shunt)
Q1 - Q9	54 SQ	54-25 (shunt)
Vert Corr Dipoles	24	24-10 (bipolar)
S7 - Sextupoles	6	200
S9 - Sextupoles	6	200
S-0-10 Sext-Oct	6	200 Sext winding
		200 Oct winding
S-0-12 Sext-Oct	6	200 Sext winding
		200 Oct winding

12.2.3 Beam Lines. Next we consider the five beam lines in the Tevatron I project. AP-1 has 26 major elements powered by 13 power supplies.

In addition there are 3 correction magnets. AP-1 contains the only ramped supplies in the project. These power the Lambertsons, the 45 degree horizontal bend, and the bend in a plane rotated 45 degrees relative to horizontal. In addition to three standard correction trim magnets, there are 13 additional AP-1 supplies that power the main elements during reverse injection.

During operation of AP-1, there are three systems in the Main Ring that have to be controlled and their effect on the beam monitored: (1) C48 kicker, (2) four-magnet orbit bump at F17 consisting of standard 35-in. long bump magnets at F15, F17, F18, and F22. Two ramped power supplies are used for this bump. The F17 Lambertson is included in the list below.

TABLE 12-VI AP-1, 120-GEV MR TO TARGET

Magnetic Element	Type Power Supply
PLAM1, PLAM2	2 LAM-204 500 KW Blue Tr
PB1,2 2 EPB-120	500 KW Blue Tr
PBR1, 2 2 EPB-120	
PQ1,2 2 3Q120A	2 200
PBR3, PB3-5	4 EPB-120 500 KW Blue Tr
PQ3,4 2 3Q120A	2 500
PQnA,B (n=5,9)	10 3Q120A 5 500
PBV1,2 2 EPB-120	1200
F17 Kicker	
PLAM1, PLAM2 rev	2 LAM-204 100

PB1,2 rev	2 EPB-120 100
PBR1, 2 rev	2 EPB-120
PQ1,2 rev	2 3Q120A 2 30
PB3, PB3-5 rev	4 EPB-120 100
PQ3,4 rev	2 3Q120A 2 30
PQnA,B (n=5,9) rev	10 3Q120A 5 30
PBV1,2 rev	2 EPB-120 100
3 Trim Dipoles	3 New Trim 3 100 (Bipolar)

AP-2 transports antiprotons from the target to the Debuncher. The first two elements in this line are the Li-lens and the C-magnet. The transport consists of 33 standard Tevatron I quadrupoles, IQ1 - IQ33, and 8 bending magnets, IB1 - IB7, and IBV1. The first 7 bending magnets in the line are standard Tevatron I SD's. The vertical bend, IBV1 is a rotated 5 ft modified B1.

Tentatively, 7 correction elements have been placed in this line. Finally, there are 12 shunts.

From an operational point of view the I-line also includes D4Q5. The lithium lens is discussed in Section 3.2.2.

TABLE 12-VII AP-2, 8-GEV TARGET TO DEBUNCHER

Magnetic Element		Type Power Supply (A)
Li-Lens		
C - Magnet		
IQ1, 4-6	5 SQ-27.6	500
IQ2, 3	2 SQ-27.6	500
IB1	SD-65.37	1200
IQ7 - 14	7 SQ-27.6	200
IQ15	SQ-18	
IQ16, 23	2 SQ-25.2	500
IQ17, 22	2 SQ-32.6	
IQ18 -21	4 SQ-25.2	200
IQ24, 26 - 28		4 SQ-18
IQ25	SQ-32.6	
IB 2 - 7	6 SD-98.4	1200
IQ 29 - 30		2 SQ-32.6 500
IQ 31 - 33		3 SQ-51.64 500
IBV1	MOD-B1-60	1200

IQ1, 4	2 SQ	2 10 (shunt)
IQ15	SQ	20 (shunt)
IQ16, 17, 22		3 SQ 3 20 (shunt)
IQ24, 25	2 SQ	2 20 (shunt)
IQ26, 27, 28, 30		4 SQ 4 20 (shunt)
ISEPT	SEPT-84	
IKICK	3 Kickers	1-PS
7 Trims	7 New Trim	7 50 (bipolar)

The line transfering antiprotons from the Debuncher to the Accumulator is relatively simple. It consists of 2 kickers and 2 septa, one of each in each ring, a series of 7 quadrupoles requiring 3 supplies and 1 shunt, a modified B1 and 5 trim magnets.

TABLE 12-VIII DA 8-GEV D TO A

Magnetic	Element	Type Power Supply (A)
DKICK	3 500 g-3 m	1-PS
TDSEP	SEPT-84	
TB1	MOD-B1-120	1200
TQ1	SQ-51.64	500
TQ2, 3	2 SQ-32.6	
TQ4	SQ-27.6	200
TQ5	SQ-51.64	
TQ6	SQ-32.6	
TQ7	SQ-27.6	100
TQ2, 3, 4, 6		4 SQ 4 20 (shunt)
TASEP	SEPT-84	
AKICK	3 Kickers	1-PS
5 Trim Magnets		5 New Trim 5 50 (bipolar)

AP-3 has 30 quads, EQ1-EQ29 (EQ3A and EQ3B are run as a pair), 1 Lambertson, and 8 dipoles, EBV1 - EBV2, and EB1 - EB6. The E-line shares PQ7B with the P-line. There are 15 large power supplies, 7 trim magnet supplies, and 8 shunts.

TABLE 12-IX AP-3, IX-GV A TO MR

Magnetic	Element	Type Power Supply (A)
EKICK	1 Kicker	1-PS
E-LAM	LAM-115	1200
EQ1, 5	2 SQ-27.6	500
EQ2, 6	2 SQ-22.6	
EQ4	SQ-25.2	
EQ3A, B	2 SQ-32.6	500
EQ7	SQ-18	30
EQ8	SQ-51.64	100
EQ9	SQ-18	
EQ10-13	4 SQ-18	200
EQ14	SQ-18	200
EQ16	SQ-27.6	200
EQ15	SQ-18	500
EQ17	SQ-27.6	
EQ18, 19	2 SQ-18	
EQ20	SQ-25.2	200
EQ21 - 24		4 SQ-18
EQ25, 26	2 SQ-18	200
EQ27	SQ-25.2	500
EQ28	SQ-27.6	
EQ29	SQ-32.6	
EBV1, 2	2 MOD-B1-60	1200
EB1 - 4	4 SD-98.42	1200
EB5, 6	2 SD-65.37	1200
EQ15	SQ-18	40 (shunt)
EQ17	SQ-27.6	20 (shunt)
EQ18	SQ-18	40 (shunt)
EQ10	SQ-18	10 (shunt)
EQ27	SQ-25.2	40 (shunt)
EQ29	SQ-32.6	10 (shunt)
EQ26	SQ-18	20 (shunt)
EB4	SD-98.42	40 (shunt)
7 Trim Magnets		7 New Trim 7 50 (bipolar)

AP- 4 has 10 quads, BQ1 - BQ10, and 6 vertical dipoles, BBV1 - BBV6. They require 10 power supplies. In addition are BSEPT (at Booster), and BDSEP (at Debuncher) and kickers in each ring.

From an operational point of view the B-line also includes D4Q5.

TABLE 12-X AP-4, 8 GEV BOOSTER TO DEBUNCHER

Magnetic	Element	Type Power Supply (A)
BKICK		
BSEPT	SEPT-84	
BQ1	SQ-32.6	500
BQ2,3	2 SQ-25.2	
BBV1	MOD-B1-60	1200
BB2, 3	2 AVB-60	1200
BB4, 5	2 EPB-120	1200
BQ4	SQ-18	100
BQ5	SQ-18	100
BQ6, 7	2 SQ-18	500
BQ8, 9	2 SQ-27.6	500
BQ10	SQ-18	100
BQ8	SQ-27.6	40 (shunt)
BB6	EPB-120	1200
BDSEP	SEPT-84	
DKICK (same as IKICK?)		1 Kicker 1-PS K
5 Trim magnets		5 New Trim 5 50 (bipolar)