

Fermilab

\bar{p} Note #383

F17 Proton Extraction and pbar Injection Beam Dynamics

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F17 Proton Extraction and Pbar Injection Beam Dynamics

Introduction

This will be a general description of the present design of the system which extracts 120-150 GeV protons from the Main Ring for pbar production, and which also serves as the injection system for cool 8 GeV pbars extracted from the Accumulator core. The emphasis of the discussion will be on the beam dynamics in the Main Ring and the extraction channel. A list of the required devices and their expected operating points will also be given.

Proton Extraction

1. General Description

The dynamics of the process of proton extraction for pbar production is relatively straightforward. The proton energy at extraction will be in the range of 120 to 150 GeV (although for all the calculations discussed below, 149 GeV has been assumed). The extraction of one booster bunch is carried out during a single turn, synchro@ such that it occurs roughly one-quarter of a synchrotron oscillation after the start of bunch rotation in the Main Ring. A new kicker at E17 (see pbar note 365 for kicker details) is energized to produce coherent betatron oscillations, which result in a beam displacement of roughly -42 mm at F17. This is sufficient to cross the magnetic septum of a Lambertson placed at this location. Prior to extraction, the closed orbit between D38 and F14 is modified by energizing small dipoles at these locations (an existing magnet at D38 and a new one at F14). The resulting orbit bumps are roughly out of phase with the kicker coherent oscillation, and serve to minimize excursions from the nominal Main Ring center until F17. Additional steering of the circulating beam horizontal position (of up to 13 mm) at F17 is provided by the F14 dipole and another new one at F19. The F14-F19 bump could be used to keep the accelerated beam away from the septum during acceleration, if necessary, and turned off as the D38-F14 pair is energized to prepare for extraction.

The extraction channel is formed by two 162" Lambertsons, followed by two 118.4" C-magnets. The extraction magnets kick the beam vertically up sufficiently far that the extracted beam line passes above the next Main Ring dipole. The total vertical distance above Main Ring center at the end of the extraction channel is 9.7". To

make room for the system, the Main Ring B2's at slots F17-4 and F17-5 are replaced with a modified B2, which has twice the number of turns, and which is run in series with the rest of the Main Ring. Additional components of the system are a horizontal trim magnet located 140" downstream from the second C-magnet; and a trim magnet located after the new B2. The first trim is intended to compensate for the differences in angle of the extracted beam at F17 as the E17 kicker is tuned; additionally, it is used to compensate for the difference in horizontal angle at F17 between the extracted and injected beams. The second trim compensates for small field differences between the modified B2 and the original standard B2's. The layout of the system is shown in fig. 1.

2. Betatron Emittance and Momentum Spread

The following calculations have been done for a momentum of 150 GeV/c, using a normalized emittance of 25π mm-mrad, and a momentum spread of $\pm 0.2\%$. These numbers correspond to 95% of the beam. The betatron beam width and the dispersion contribution have been added in quadrature; if the distributions are Gaussian, the beam envelopes shown correspond to ± 2.45 sigma. The lattice used for the calculations is the standard Main Ring lattice with no overpass modifications (horizontal tune=19.4). Considerations of the effect of the proposed overpass(es) on the vertical dynamics are discussed below.

Because of the large momentum spread of the extracted proton beam, the horizontal beam size tends to be dominated by the dispersion contribution (especially at F17).

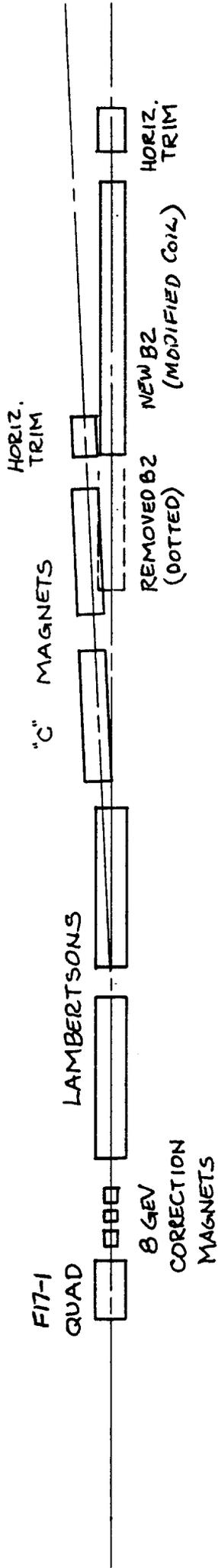
3. Main Ring Orbits, Apertures and Beam Sizes

a). horizontal

Fig. 2 shows the closed orbit with the D38, F14 pair; fig. 3 shows the D38, F14 bumps plus the extraction orbit produced by adding the E17 kicker. Fig. 4 shows the steering bump produced by the F14-F19 pair. Fig. 5 shows the horizontal beam envelope for the closed orbit with the D38, F14 pair; fig. 6 shows the extraction orbit (kicker plus D38, F14). The maximum aperture needed for the closed orbit with the D38, F14 pair is 30 mm (maximum excursion of the envelope is -30 mm at D42). Except near F17, the

FIGURE 1

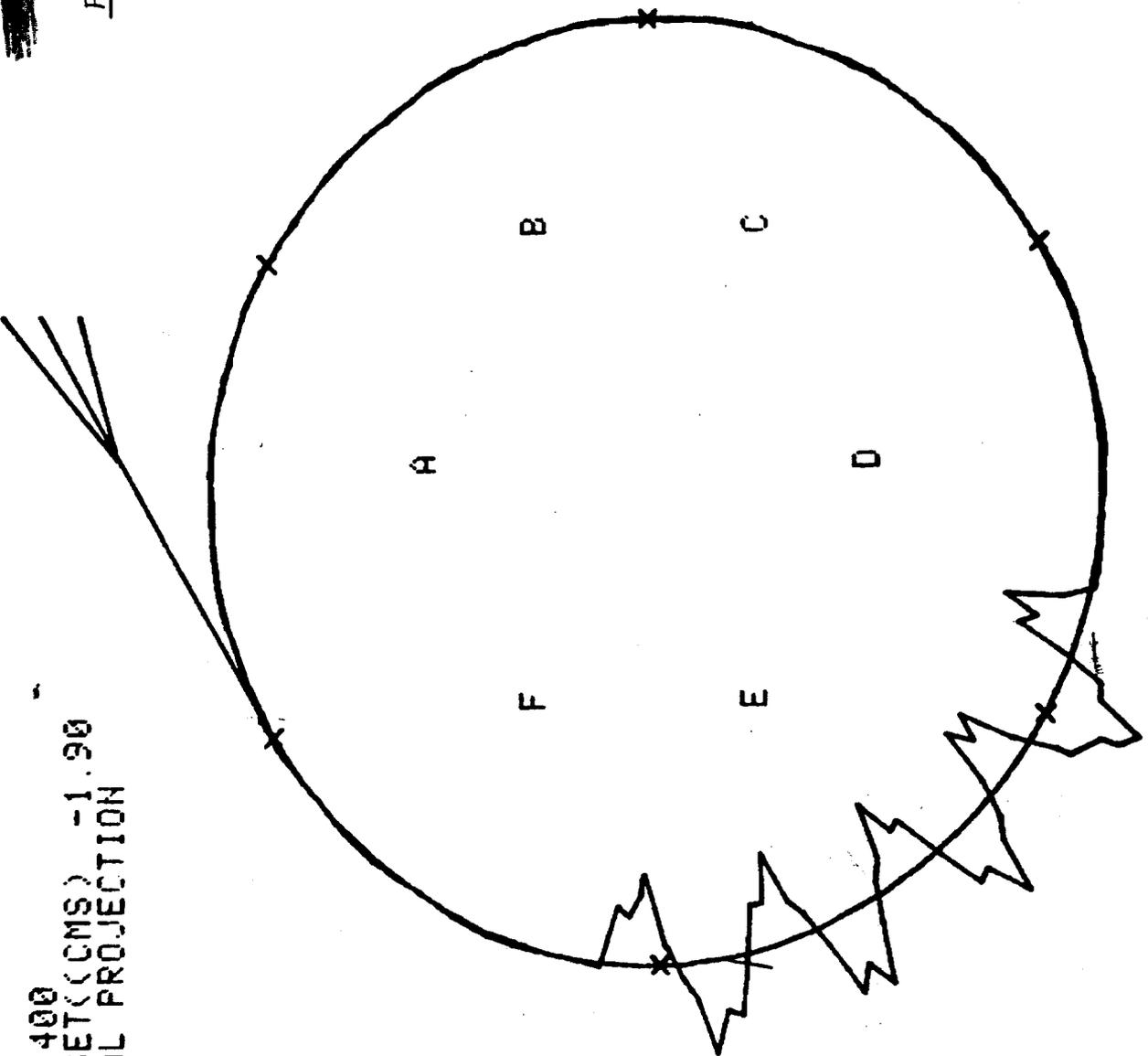
F17 SCHEMATIC
ELEVATION



D3B - F14 Ramp.



FIGURE 2

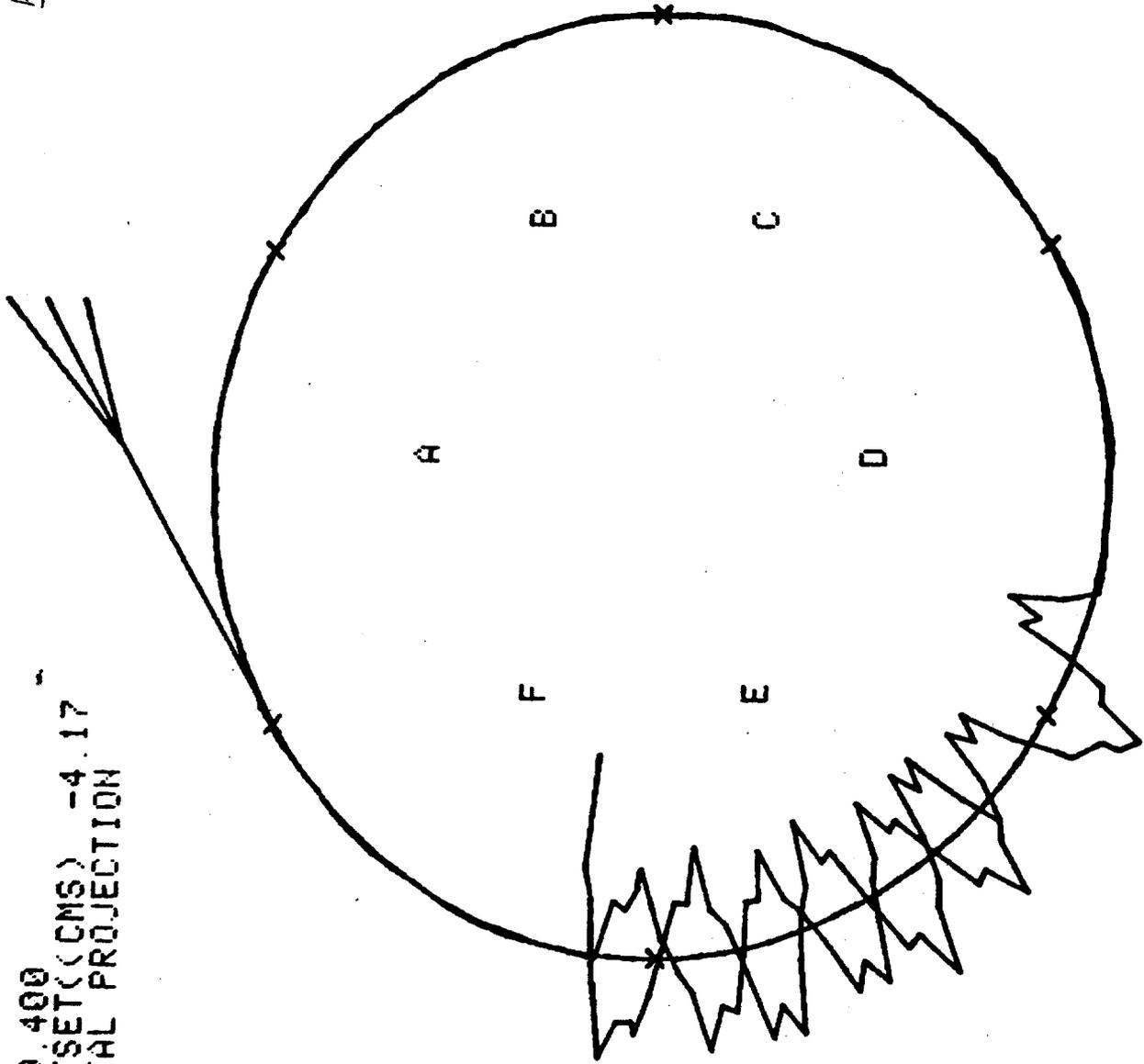


TUNE 19.400
MAX. OFFSET (CMS) -1.90
HORIZONTAL PROJECTION

D38-F14 BUMP
+ KICKER

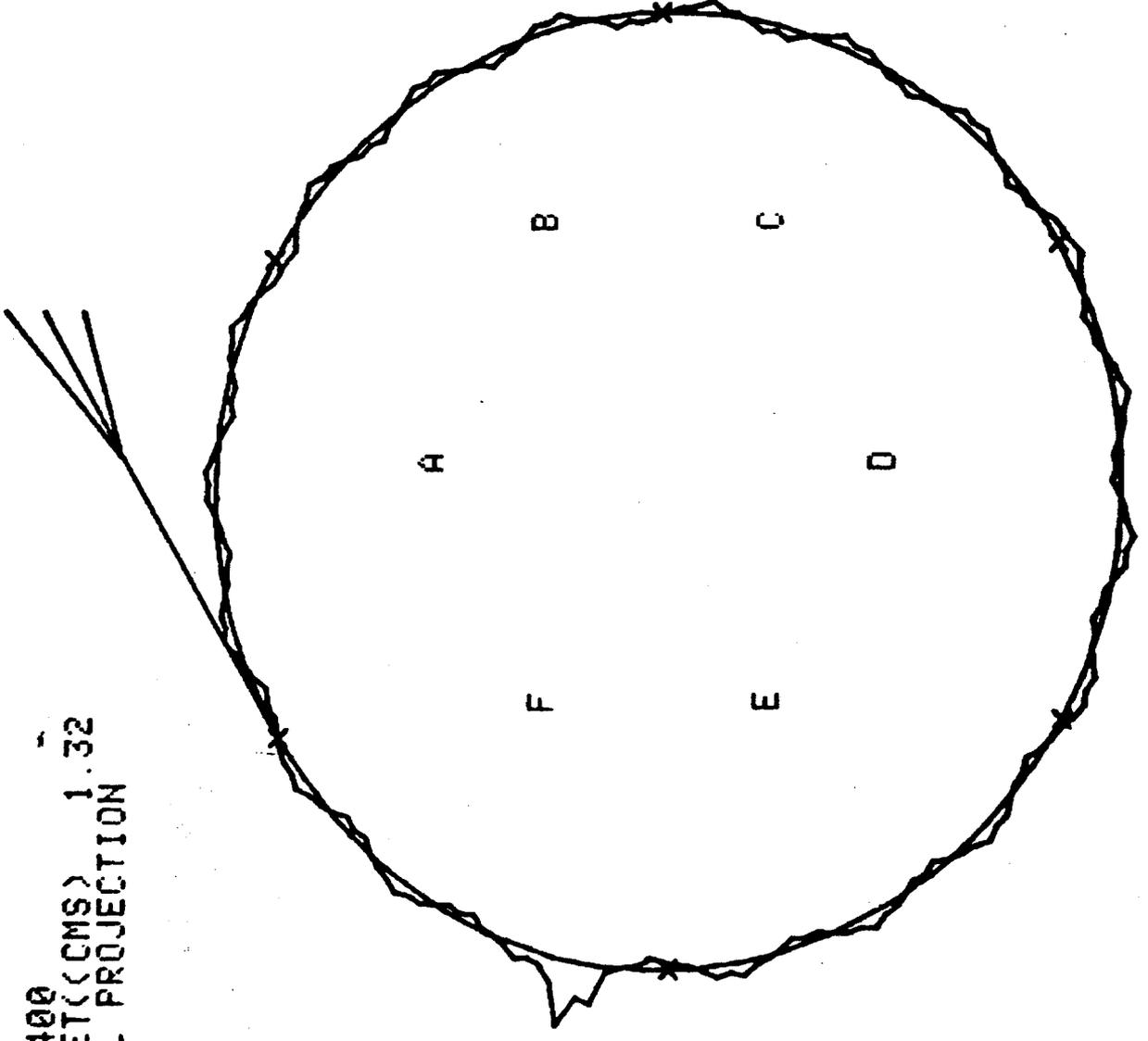
FIGURE 3

TUNE 19.400
MAX. OFFSET (CMS) -4.17
HORIZONTAL PROJECTION



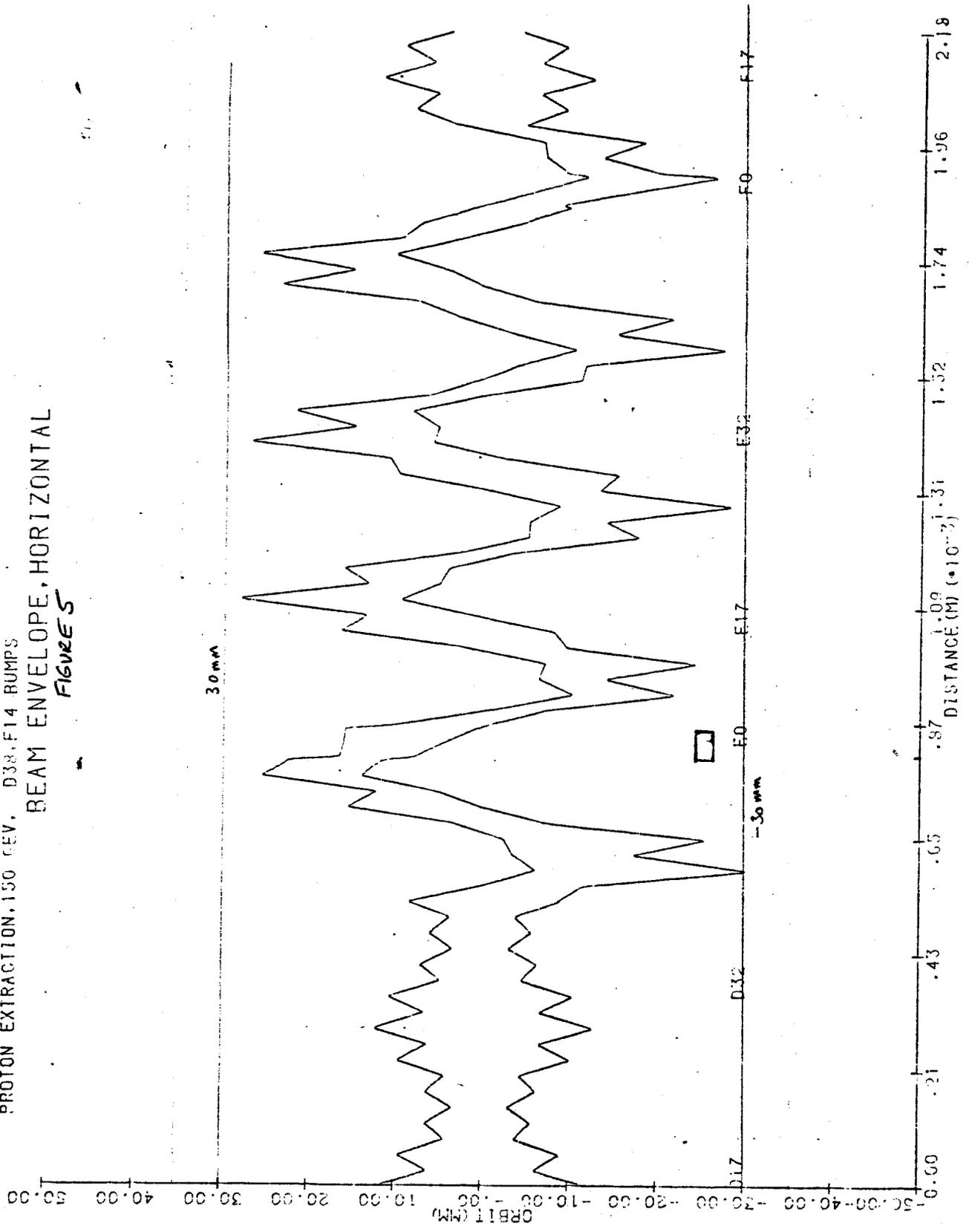
F14 - F19 Yes Bump

FIGURE 4

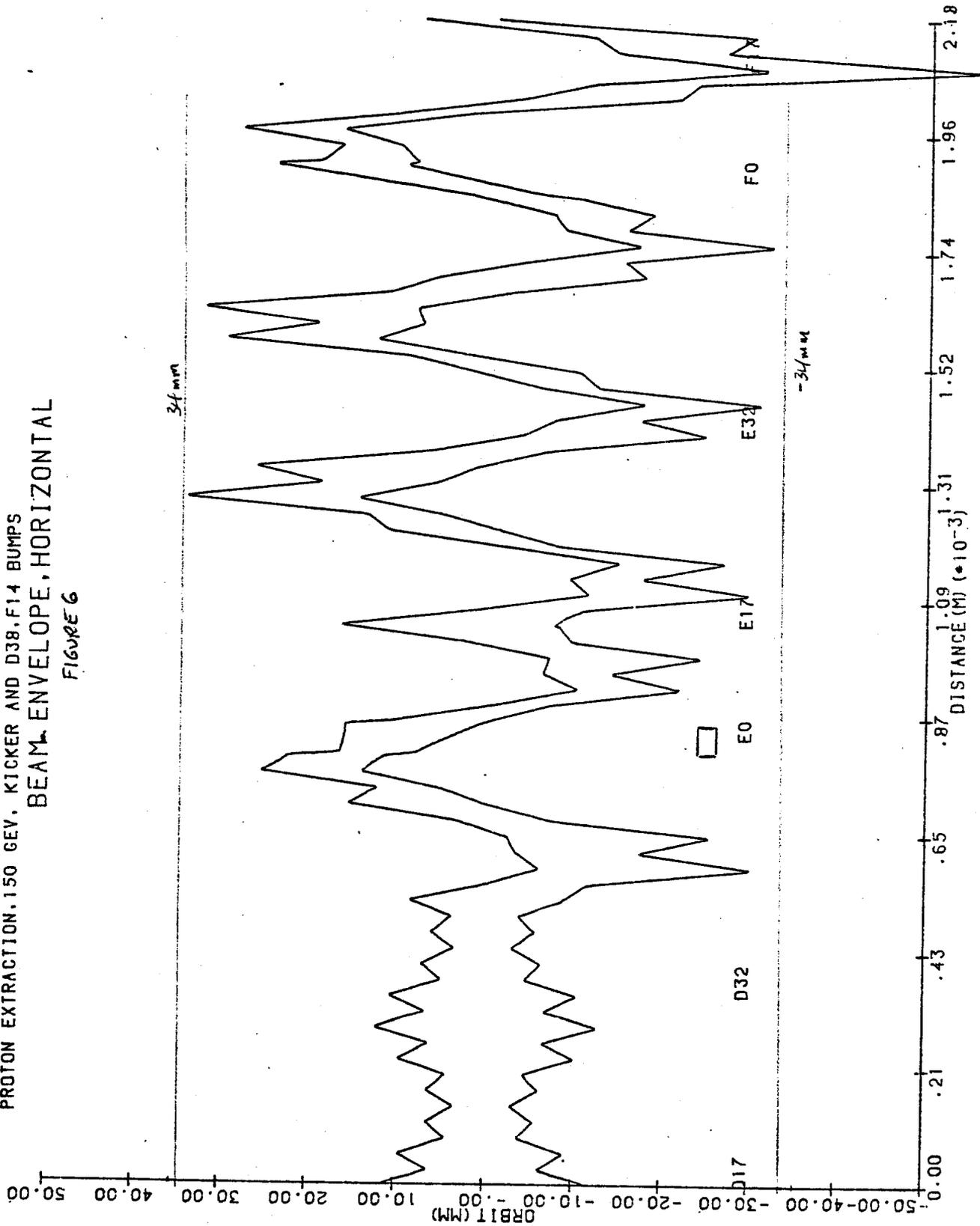


TUNE 19.400
MAX. OFFSET((CMS) 1.32
HORIZONTAL PROJECTION

PROTON EXTRACTION, 150 GEV, D38, F14 BUMPS
 BEAM ENVELOPE, HORIZONTAL
 FIGURE 5



PROTON EXTRACTION .150 GEV. KICKER AND D38, F14 BUMPS
 BEAM ENVELOPE, HORIZONTAL
 FIGURE 6



maximum aperture needed for the extracted beam is 34 mm (maximum excursion 34 mm at E26). Also shown in figs 5 and 6 are the EO Lambertson septa, which are at an outward excursion of the beam. The aperture restrictions of the new kicker at E17 (and that at E48 for pbar injection) are at 44 mm.

Fig. 7 shows the region near F17 in detail, indicating both the circulating and kicked beam envelopes. Note that the extracted beam explores nearly the full inner limit of the physical aperture of the dipoles and quad upstream of F17. The residual angle of 0.8 mrad of the extracted beam at the entrance to the first Lambertson is taken out by rolling the magnet by 5.2 degrees (see dotted line).

The above calculations of course assume no closed orbit errors in the Main Ring. In fact, as shown in fig. 8, the real closed orbit at high energy has significant local fluctuations around the ring. However, inspection of the figure and comparison with figs. 5 and 6 indicate that, even when the orbit fluctuations shown in fig. 8 are added to those in 5 or 6, the maximum required aperture is still everywhere less than 38 mm.

b). vertical

The vertical beam size is generally quite small, because of the small betatron emittance. The additional aperture limitations introduced by the kickers and the F17 Lambertsons are ± 19 mm (the F17 aperture has been taken as the vertical height at the center of the circulating beam with no steering). As seen in figure 9, there is no problem with these limits in general.

Fig. 10 shows the experimental vertical closed orbit; note that across F17, the orbit is low by 4 mm. An additional perturbation on the vertical beam dynamics will be the vertical dispersion introduced by the overpass (see table 5). The vertical size at the limiting aperture (F17) for the worst case (the WDB9+TCB21 DO, BO case) increases from 2.2 mm to 2.6 mm. However, even with these perturbations to the vertical motion, the circulating beam should still clear the septum (see fig. 12). The clearance is only 1 mm in this case; a bit of horizontal steering (with the F14-F19 pair) may be also be required.

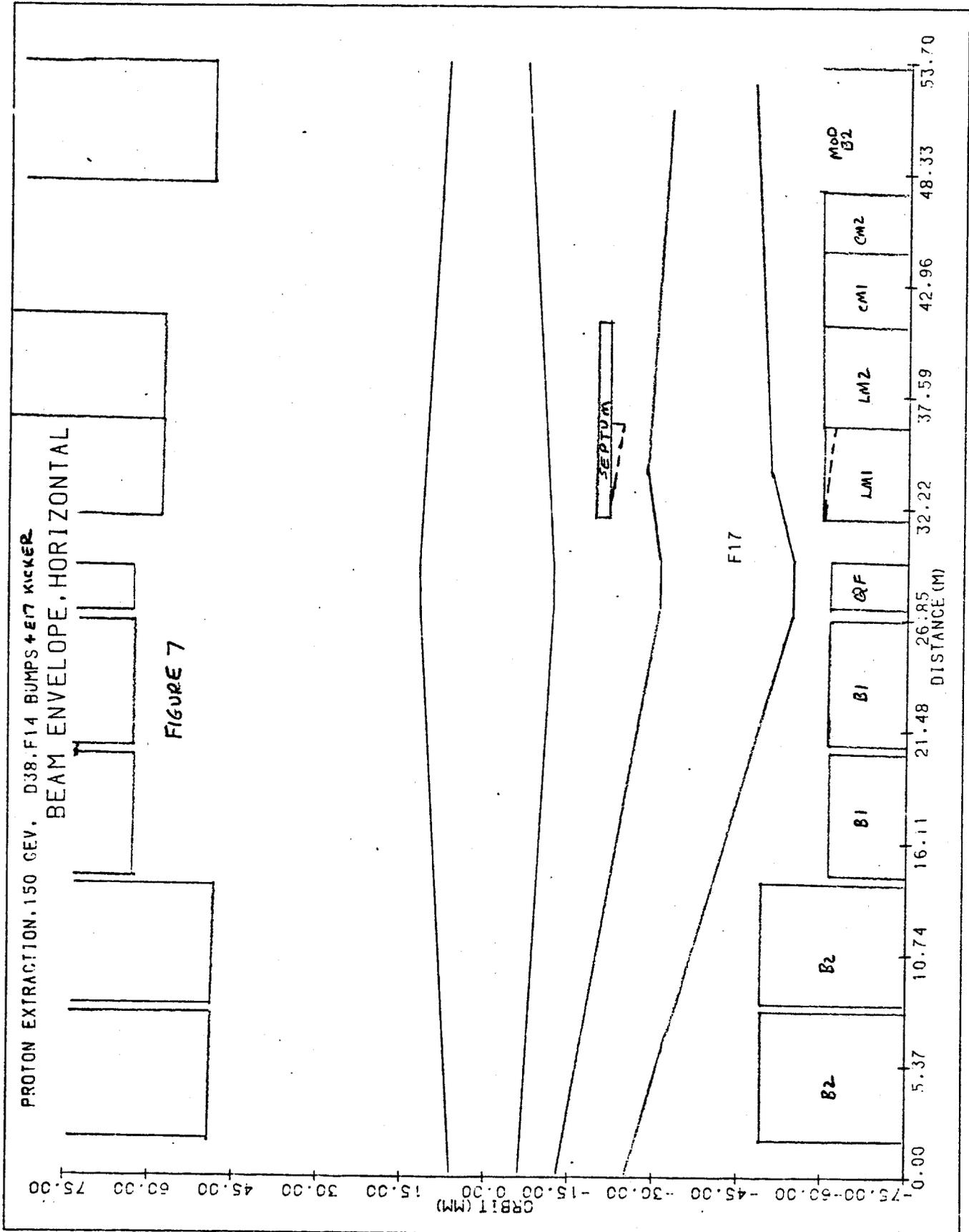
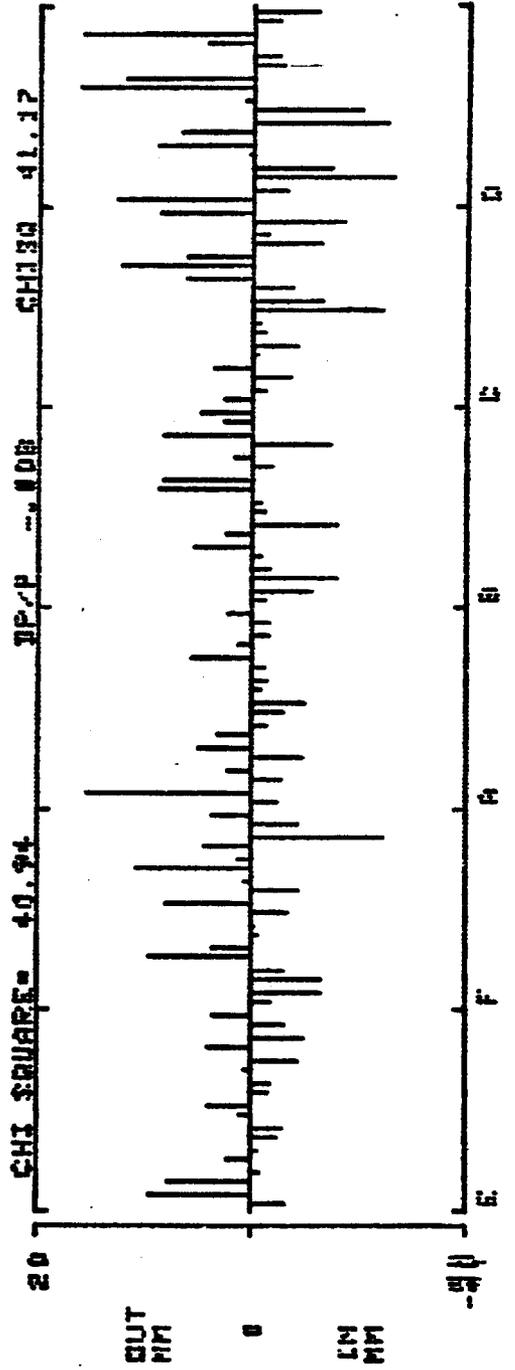


FIG. 8

HORIZONTAL CLOSED ORBIT	E	F	A	B	C	D
11	-3.259	-1.834	-2.49	-1.201	2.689	12.98
13	9.608	-4.992	15.44	9.634	-1.248	-2.282
15	7.967	-6.992	-2.795	-7.979	-3.568	-13.24
17	-7.51	-2.982	2.385	-1.623	3.627	-7.478
19	2.248	9.721	-4.787	-.626	-.428	5.37
22	-9.66	9.767	5.127	9.549	-4.154	9.165
24	-2.49	-.685	3.299	2.399	-1.177	6.314
26	-3.099	-.17	-1.435	-8.022	-.969	-12.76
28	1.189	-9.31	-2.599	-1.13	-12.21	-10.15
32	4.002	8.151	-4.914	-.873	-6.639	9.88
34	-1.646	-4.412	-.802	8.277	-3.732	16.35
36	-1.857	-.683	-1.318	8.226	6.209	12.13
38	-7.67	10.98	-1.194	-1.716	12.46	-2.701
42	-4.218	1.236	5.733	-1.729	6.324	-2.326
44	4.049	4.447	1.213	-7.369	-6.322	4.564
46	-4.928	-12.28	-1.392	8.302	-1.353	16.19
48	-2.193	-4.339	-1.223	2.289	-8.573	-2.443
49	3.603	3.637	2.314	4.893	8.959	-5.959

FILE 3
 UNCALIBRATED
 SAMPLE TIME= 3.951 SEC
 ENERGY DEY 184
 12/16/83 1856



PROTON EXTRACTION. 150 CEV. KICKER AND D38. F14 BUMPS
 BEAM ENVELOPE. VERTICAL

FIGURE 9

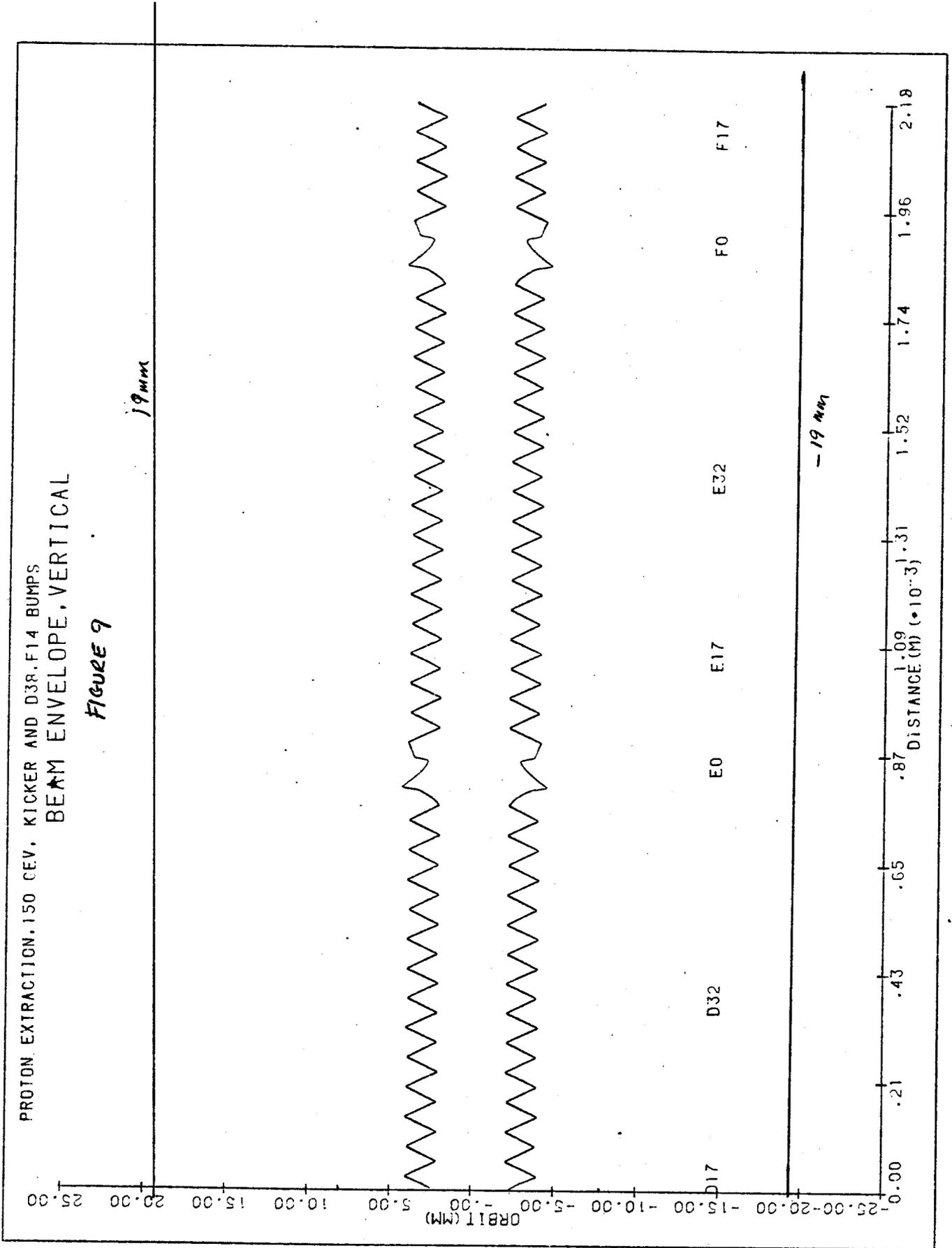


FIG. 10

VERTICAL CLOSED ORBIT	E	F	A	B	C	D
FILE 3	1.432	-1.848	-.002	-2.63	-.522	2.662
CALIBRATED	-.203	-.121	4.647	-2.208	-.266	1.027
SAMPLE TIME=	-.325	-.714	6.99	-1.903	1.903	-.352
3.901 SEC	-.622	-3.072	-2.419	-1.451	4.231	2.315
ENERGY	-.009	-4.775	-0.217	1.931	2.907	2.523
185 GEV	-.062	-2.03	-2.516	1.537	-3.711	-2.234
11/22/83 1419	-1.1	-.74	4.025	-.652	-4.779	-3.236
	-2.981	2.186	4.164	-2.999	1.509	1.017
	-.365	-.355	-.722	-4.353	3.063	-.231
	5.528	1.36	6.536	-1.716	3.39	-.837
	-3.228	-1.626	-5.189	.121	-3.157	-1.223
	-11.38	-2.12	1.593	-.257	-9.038	-2.77
	-4.327	1.114	4.164	.233	-.046	1.325
	7.69	1.349	.753	.042	4.348	-.046
	4.533	2.705	-2.892	-.253	.477	-.392
	-4.678	-0.133	-2.665	-2.337	-3.25	-1.109
	-9.003	-0.155	-.081	4.443	-3.214	-1.724
	-2.234	.806	5.876	2.239	1.672	-4.732

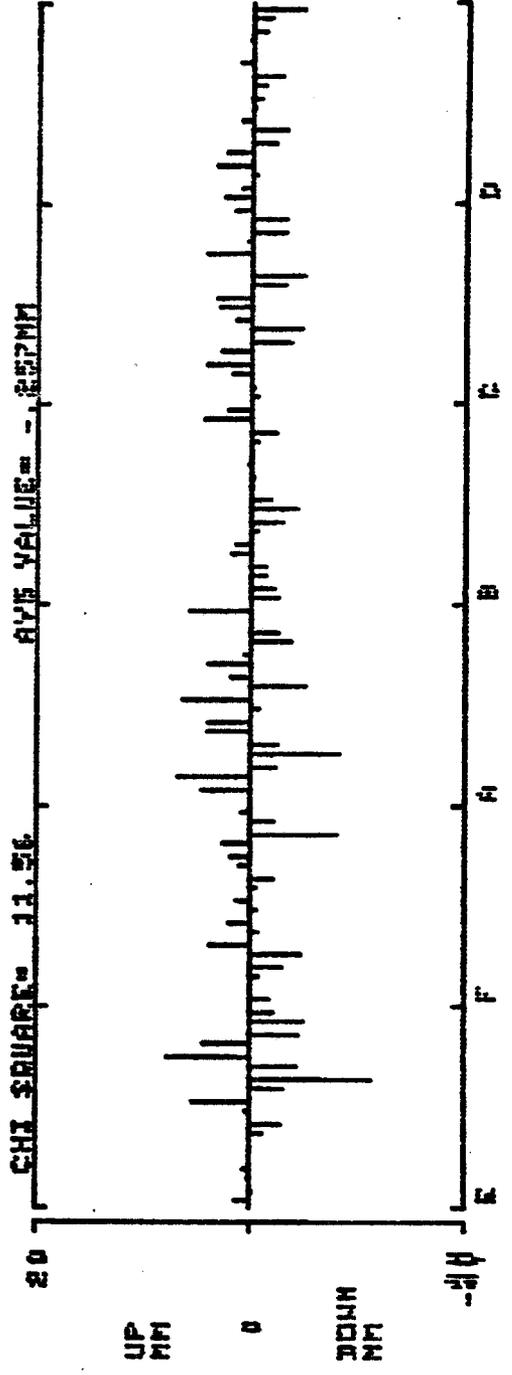


TABLE 5: VERTICAL DISPERSIONS WITH OVERPASS

DISPERSION CONTRIBUTION TO VERTICAL SIZE

$\delta p/p = 2.9\%$ $\delta p/p = 2.9\%$

OVERPASS	DO-STAND-ALONE W D51	04-BP WD81+ TCB21	D4-BP WD89+ TCB21	B_y	1.2 mm	.54 mm
<u>E17</u>	-.580	-.389	-.328	30.5	1.5 mm	.68 mm
<u>E48</u>	.768	.525	.541	29.6	1.4 mm	.63 mm
<u>F17</u>	.653	.469	.702	30.4		

3. Extraction Channel Apertures and Stray Fields

Figures 11, 12 and 13 show the beam size(s) at the downstream end of the F17-1 quad, and at the Lambertsons and the C-magnets; both the circulating and the extracted beams are shown. These beam envelopes include the effect of the worst-case overpass vertical dispersion. In the figures, the dotted line indicates the beam spot when the F14-F19 pair is energized to its nominal value (13 mm offset). In fig. 12, the beam in the extraction channel is shown at the entrance of the first and exit of the second Lambertson. In fig 13, we see the beam envelopes at the entrance to and exit from the C-magnets, as well as the circulating beam. The C-magnets are pitched at roughly 1.2 degrees vertically, so that the beam exits near the middle of the downstream aperture.

The residual body field in the field-free region of the Lambertson is estimated to be 30 g at 150 GeV. The body fields below the C-magnet, in the region of the circulating beam, are roughly a few tenths of a gauss at 8 GeV, rising to less than 80 gauss at 150 GeV. It is planned to further suppress these by using a magnetically-shielded beam pipe in this area.

4. Detailed specifications of the devices

Table 1 gives the details of the extraction system devices, locations, dimensions, and operating points. All the numbers correspond to operation at 150 GeV/c. The apertures given for the Lambertsons and C-magnets are for the extraction channel. Tables 2 and 3 present more detailed information on these extraction magnets. The bend angle for the dipole downstream from B2 corresponds to 2% of the integrated field strength.

Pbar Injection

1. General Description

The reverse injection of pbars from the Accumulator occurs through the F17 extraction channel, which is run at a current appropriate for 8.89 GeV/c momentum. The pbar beam, consisting of 13 (53 MHz) bunches, is kicked onto the closed orbit by a new kicker at E48 (see pbar note 365 for details). The orbit excursions of the injected beam between

FIGURE 11
150 GeV_e PROTONS
F17-1 QUAD
(full scale)

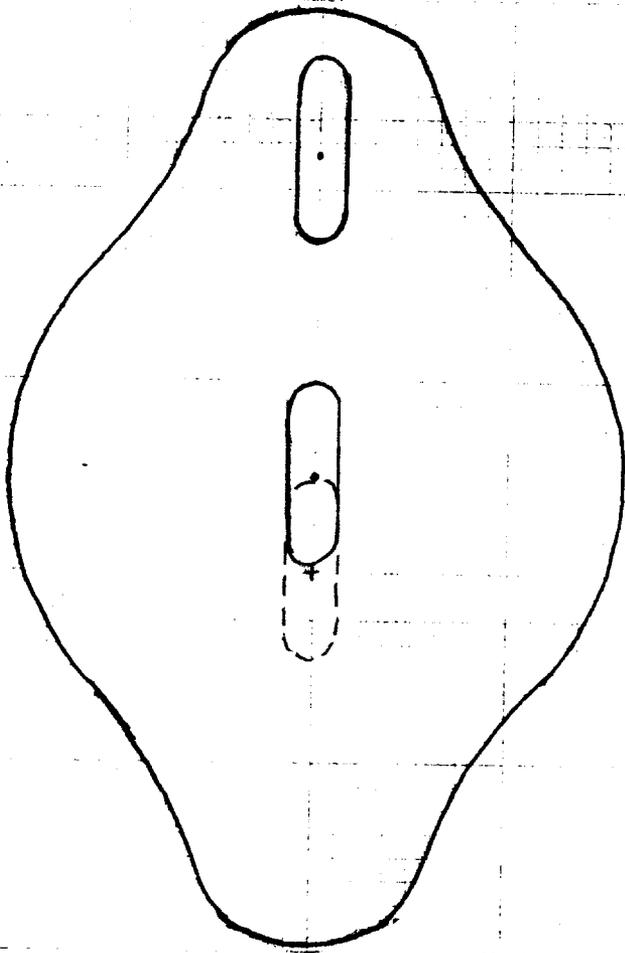


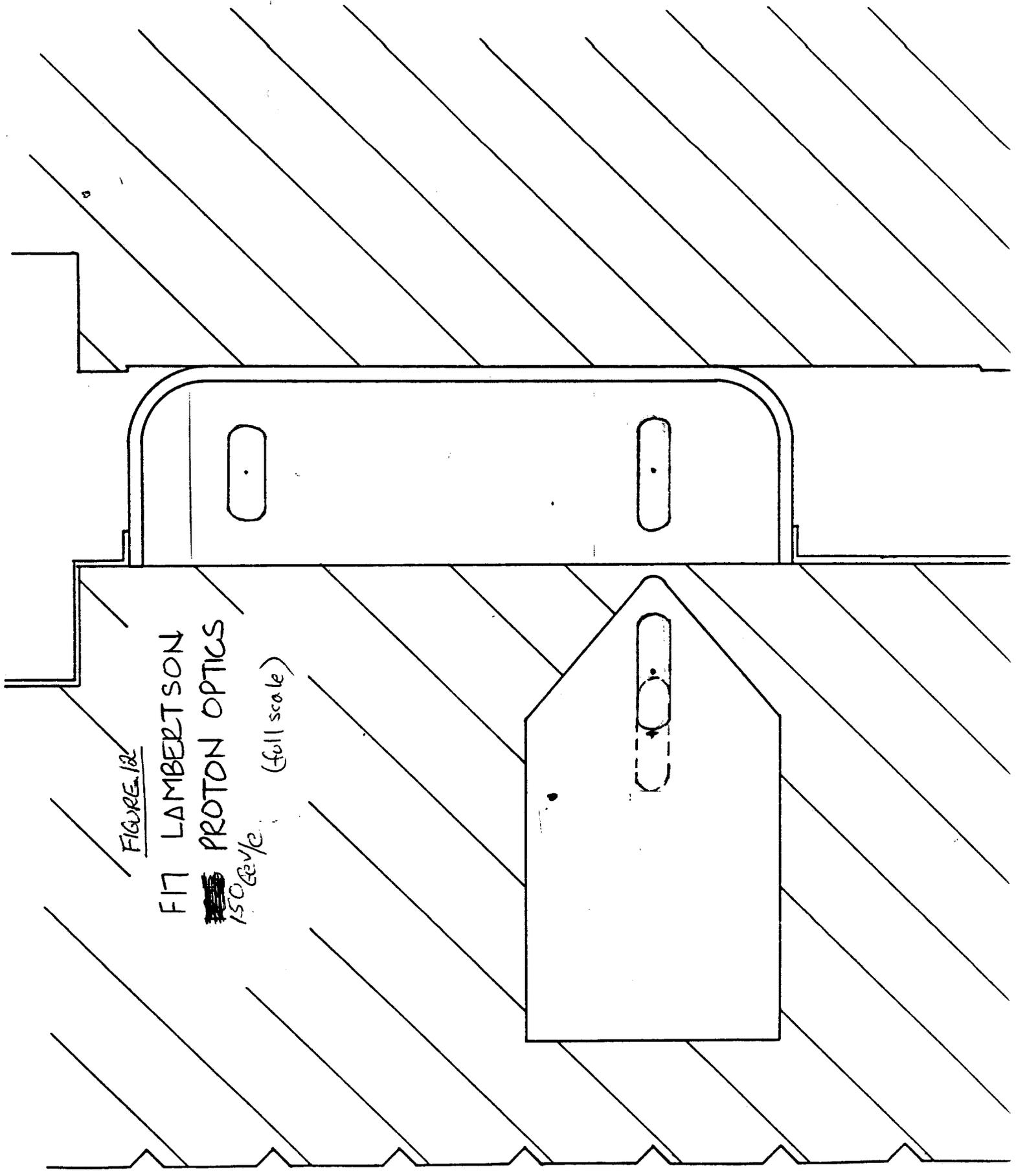
FIGURE 182

F17 LAMBERTSON

~~150 GeV/e~~ PROTON OPTICS

150 GeV/e

(full scale)



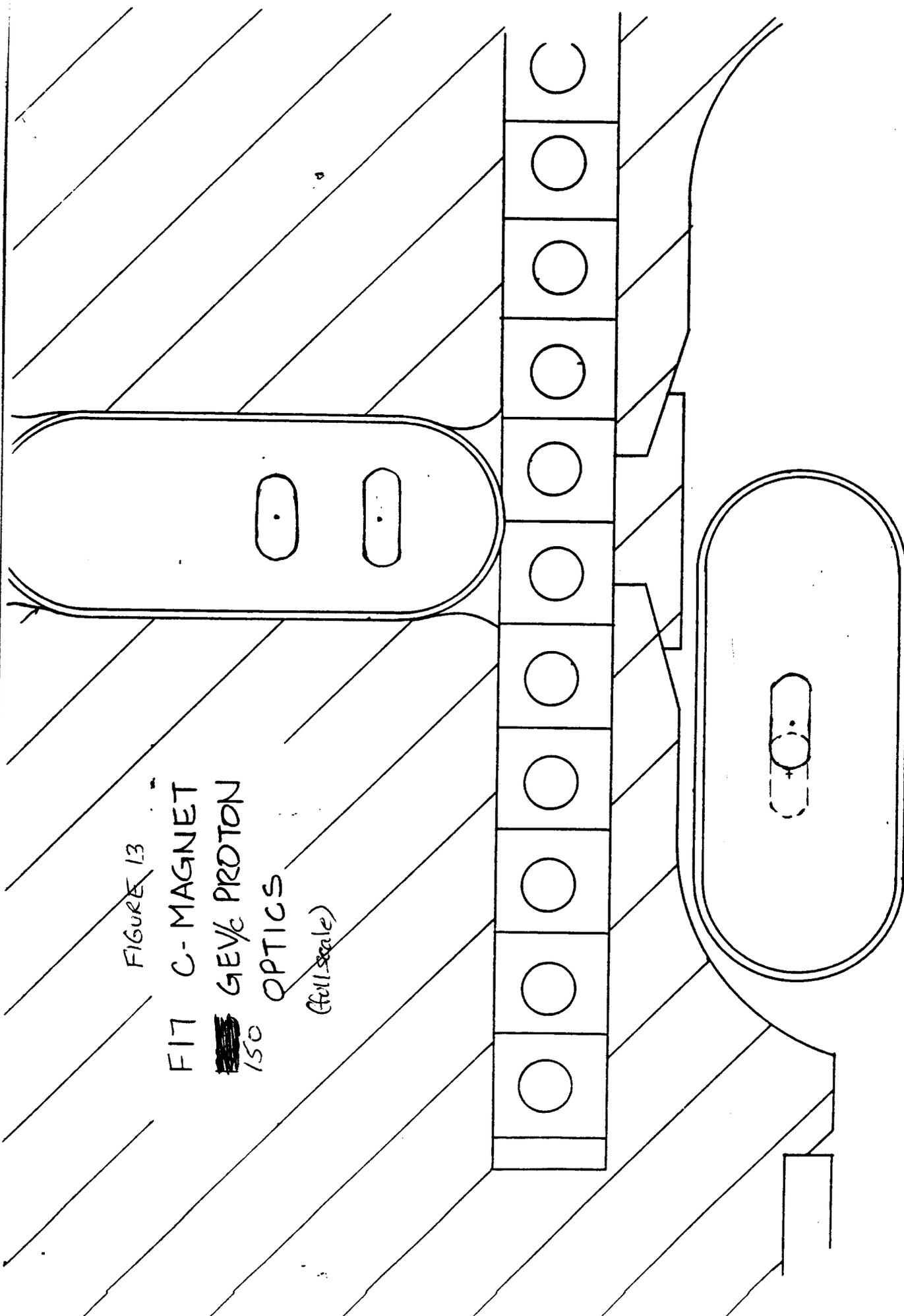


FIGURE 13

FIT C-MAGNET

150 GEV/c PROTON

OPTICS

(full scale)

 FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL CATEGORY	PAGE
	TABLE 1 F17 EXTRACTION DEVICES (150 GeV/c)		NAME	REVISION DATE

DEVICE	LOCATION	LENGTH (m)	BEAM APERTURE ±H ±V (mm)	# TURNES	BEND ANGLE (μrad)	BL (kg-in)	B (kg)	I (A)	β _x (m)	β _y (m)	η _x (m)	η _y (m)	β _x (MOD 360) (deg)
DIPOLE	D38	35	63 16	160	-200	-39.4	-0.99	-16	91.1	28.8	3.8	.49	66
DIPOLE	F14	20	49 22	200	-360 (+200)*	-70.8 (+39.4)*	-3.5 (+2.0)*	-70 (+46)*	29.1	94.3	1.7	-1.0	244
DIPOLE	F19	20	49 22	200	+160	+31.5	+1.6	+32	92.	28.8	4.1	.64	51
LAMBERTSON	F17	162	37 127	10	8730	1730	10.6	3500	92.3	32.9	5.5	0.7	343
"	"	"	"	"	"	"	"	"	76.6	40.2	5.0	-	346
C-MAGNET	F17	118.4	41 102	12	7630	1515	12.7	"	62.7	49.7	4.5	-	350
"	"	"	"	"	"	"	"	"	53.3	58.2	4.2	-	354
DIPOLE	140" AFTER C-MAG. IN MAP2	20	49 22	200	-130-7150	59.1	3.0	-35-725	46.3	67.9	3.9	-	357
MODIFIED B2 DIPOLE	F17-4.5	239	49 22	32	16,270	3205	13.4	1675	33.9	87.3	3.8	.97	6.5
DIPOLE	AFTER MOD B2	20	49 22	200	0-7507	64	3.2	0-7100	30.0	99.9	3.0	.97	13
KICKER	E17	75	43 19	1	-450	-90	-1.2	4800	93.5	30.4	5.6	-.33	259

* FOR OPERATION WITH F19 TO STEER ACROSS F17



SUBJECT

F17 LAMBERTSON

TABLE 2

NAME

DATE

ISSUE NO.

MAGNETIC FIELD:

Central Field * 10.6 kG max
Uniformity across 3.0" gap < 5%.

POWER:

DC Power * 19 KW (50% D.F.)
Current * 3500 A max
Voltage + 22 V max
Copper Temp. Ave. * 78° F
Resist @ Temp. * 6.2 mΩ
Inductance 2.6 mH

COOLING:

Water Temp. Rise * 27° F
Total Flow + 2.5 GPM
Pressure Drop + 50 PSI

COIL DATA:

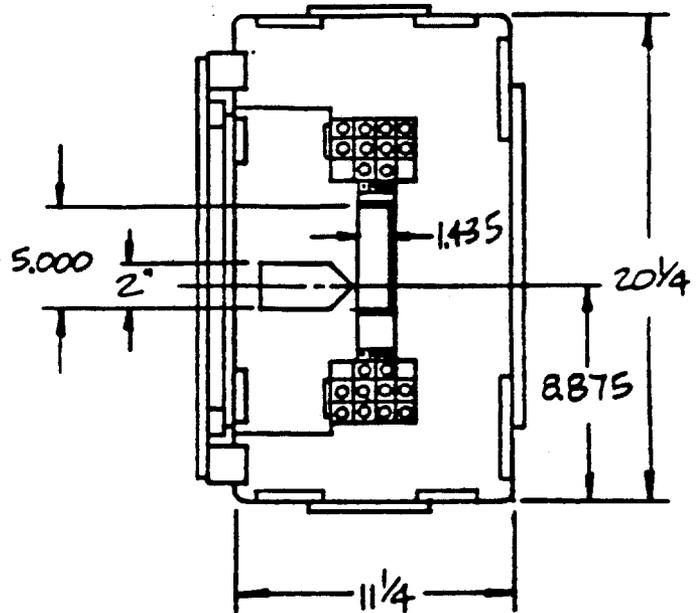
Conductor O.D. * 0.73" ± 0.73"
Hole Diameter * 0.375"
Turns 10
Water Paths 2
Ave. Turn Length 37.0"

WEIGHTS:

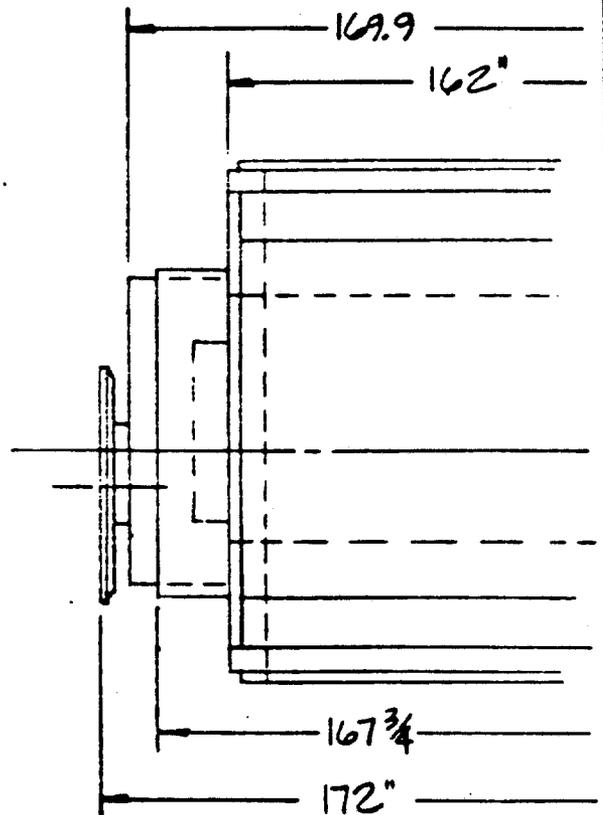
Coil & Insul. 549 LB.
Core
Support
Total Magnet Assembly

CALCULATION CONSTANTS:

OUTLINE DIMENSIONS



CROSS SECTION





SUBJECT

F17 C-MAGNET. TABLE 3

NAME

DATE

REVISION DATE

MAGNETIC FIELD:

Central Field * - 12.6 KG max
 Uniformity across 1.0" gap < 5%

POWER:

DC Power * 17 KW (50% DF)
 Current * 3500 A
 Voltage † 20 V
 Copper Temp. Ave. * 76° F
 Resist @ Temp. * 5.6 $\mu\Omega$
 Inductance 2.2 μH

COOLING:

Water Temp. Rise * 22° F
 Total Flow † 5.2 GPM
 Pressure Drop † 50 PSI

COIL DATA:

Conductor O.D. * 0.73" x 0.73"
 Hole Diameter * 0.375"
 Turns 12
 Water Paths 2
 Ave. Turn Length 245"

WEIGHTS:

Coil & Insul. 312 LB.

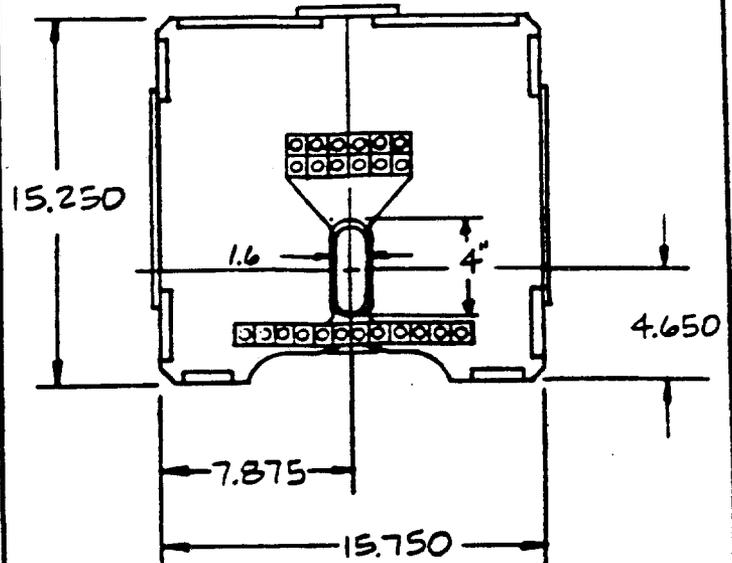
Core

Support

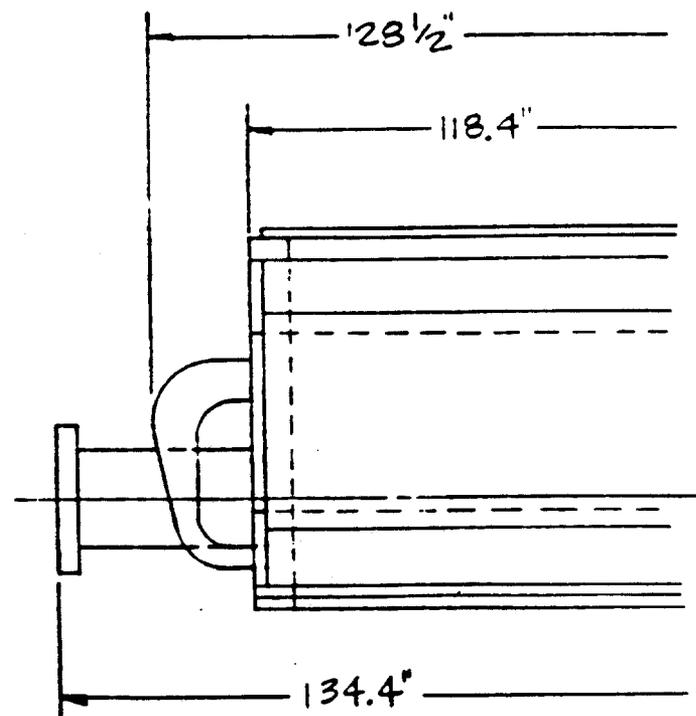
Total Magnet Assembly

CALCULATION CONSTANTS:

OUTLINE DIMENSIONS



CROSS SECTION



F17 and E48 are limited by a 4-bump centered at FO (produced by the horizontal correction dipoles at E48, E49, F11 and F13). An additional orbit bump centered at F17 (produced by the correction dipoles at F15, F17, F19, and F22) may be used to steer the beam up to 14 mm away from the Lambertson septum on the first turn, if this is necessary. These bumps will be on at pbar injection time, and will probably be left on throughout the acceleration cycle.

2. Betatron emittance and Momentum Spread

The following calculations have been done for a momentum of 8.89 GeV/c, emittance (at that energy) of 2π mm-mrad, and a momentum spread of $\pm 0.09\%$. These numbers correspond to 95% of the beam. Betatron beam spread and dispersion contributions have been added in quadrature. At F17, the horizontal betatron beam size is ± 13.6 mm and that due to the dispersion is ± 5 mm.

3. Injection Channel Apertures

Figures 14, 15 and 16 show the injected beam spot at the C-magnet, Lambertsons, and the upstream end of the F17-1 quad. In the figures, the dotted line indicates the beam spot for the circulating beam with the F17 steering bump on at maximum (14 mm). For the injected beam, the closest clearance in the Lambertson aperture is 3 mm (on both sides), and also 3 mm at the F17-1 quad.

4. Main Ring orbits, apertures and Beam sizes

a). horizontal

Figure 17 shows the orbit produced by the kicker at E48 alone; fig. 18 shows the kicker plus the kick-offsetting bump at FO; and fig. 19 shows the injected orbit and the F17 bump which steers the beam away from the septum on the first turn after injection. Fig. 20 shows the horizontal beam envelope for the injection orbit with the kicker and FO bump on, and fig. 21 shows the circulating beam (FO bump only). The maximum aperture needed for the circulating beam is 35 mm (-35 mm at the first quad downstream from FO). Except at F17, the maximum aperture needed for the kicked beam is 42 mm (-42 mm at the first quad downstream from FO; also, 38mm at F13 and -39 mm at F15).

FIGURE 14

F17 C-MAGNET.

~~18~~ 8 GEV PROTON

OPTICS full scale

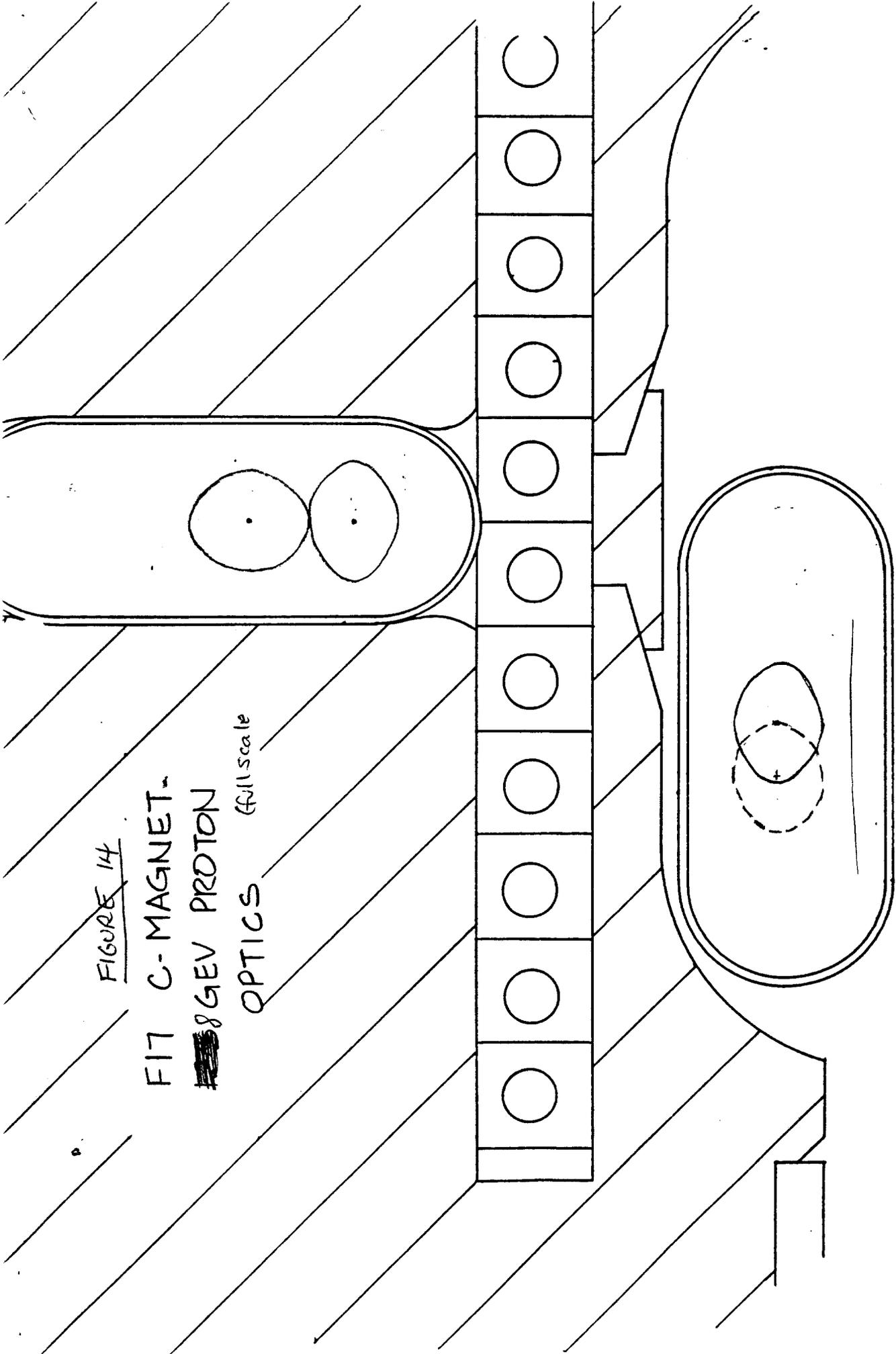


FIG 15

F17 LAMBERTSON
~~17~~ PROTON OPTICS
8 GeV

(full scale)

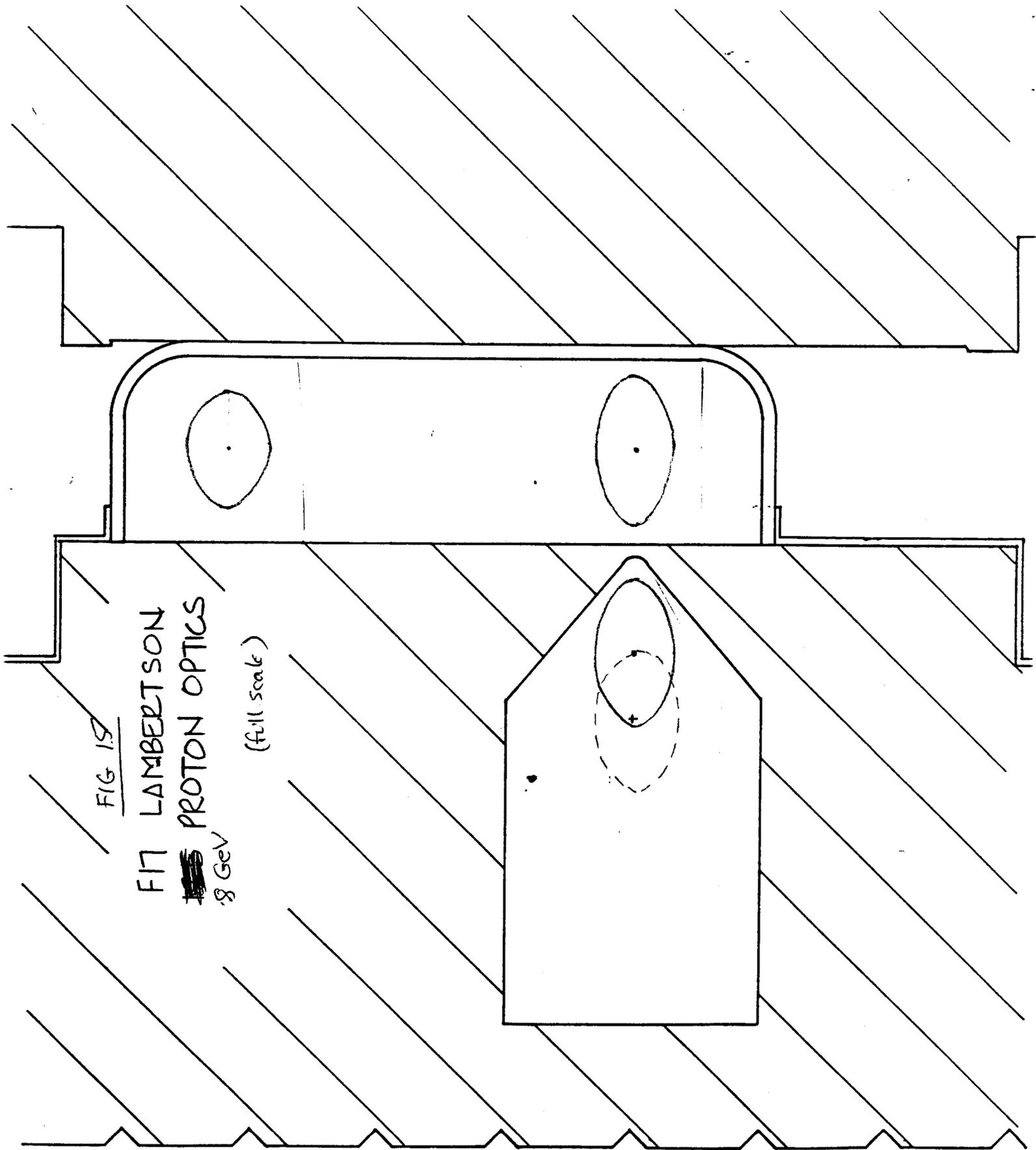
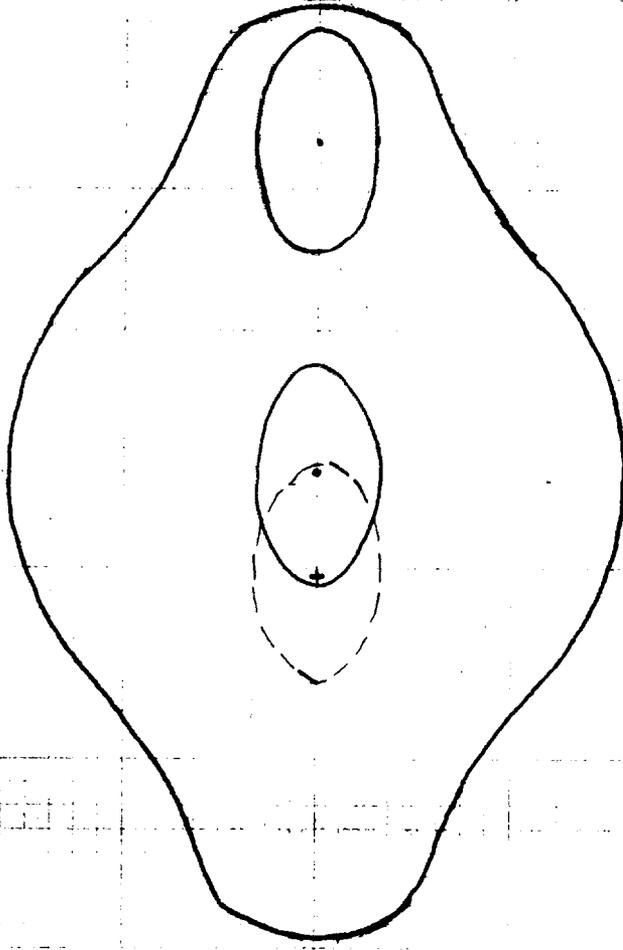


FIGURE 16

8 GeV PROTONS

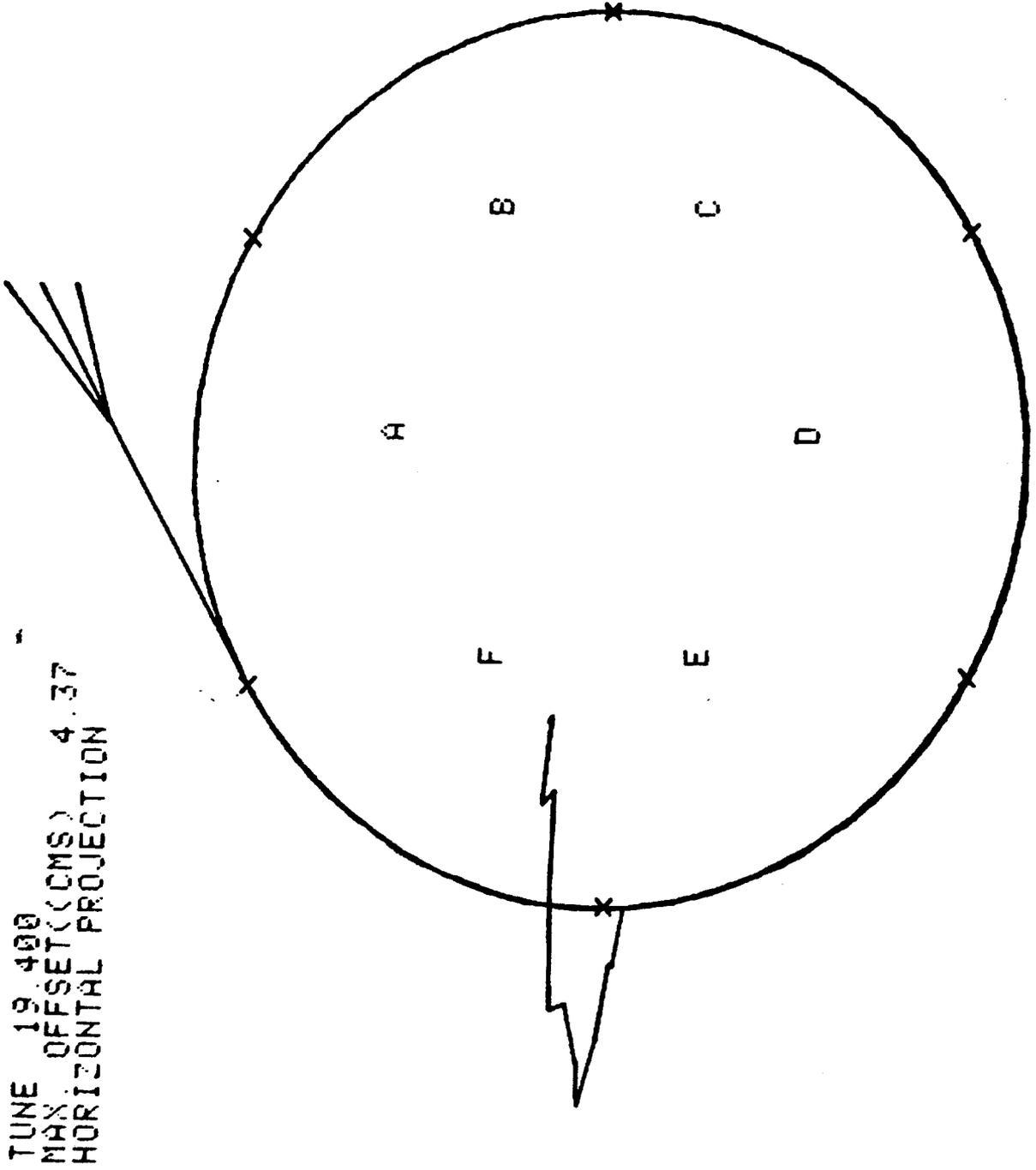
F17-1 QUAD

(full scale)



KICKER ONLY.

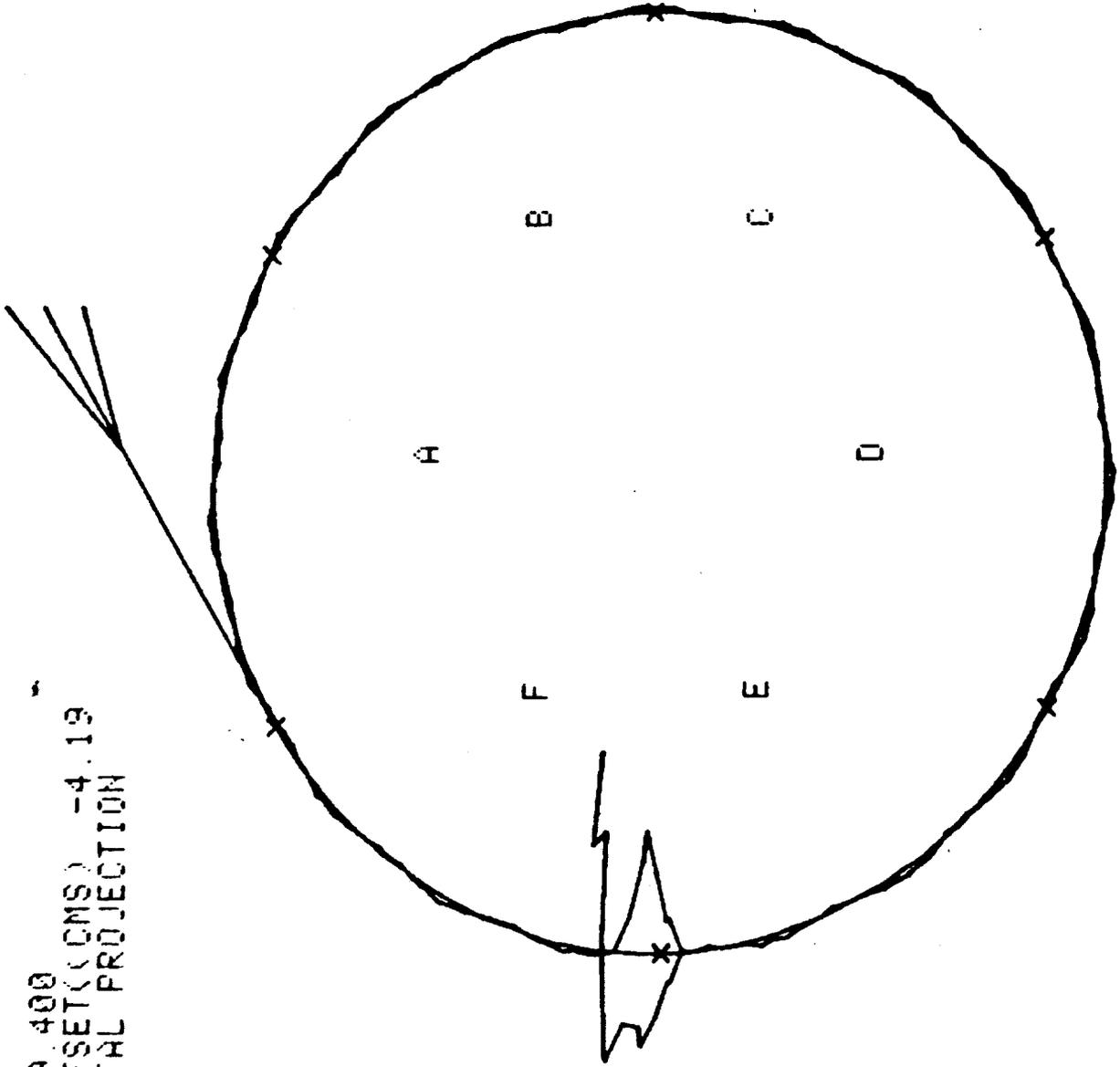
FIGURE 17



F ϕ 4 Bump

+ KICKER.

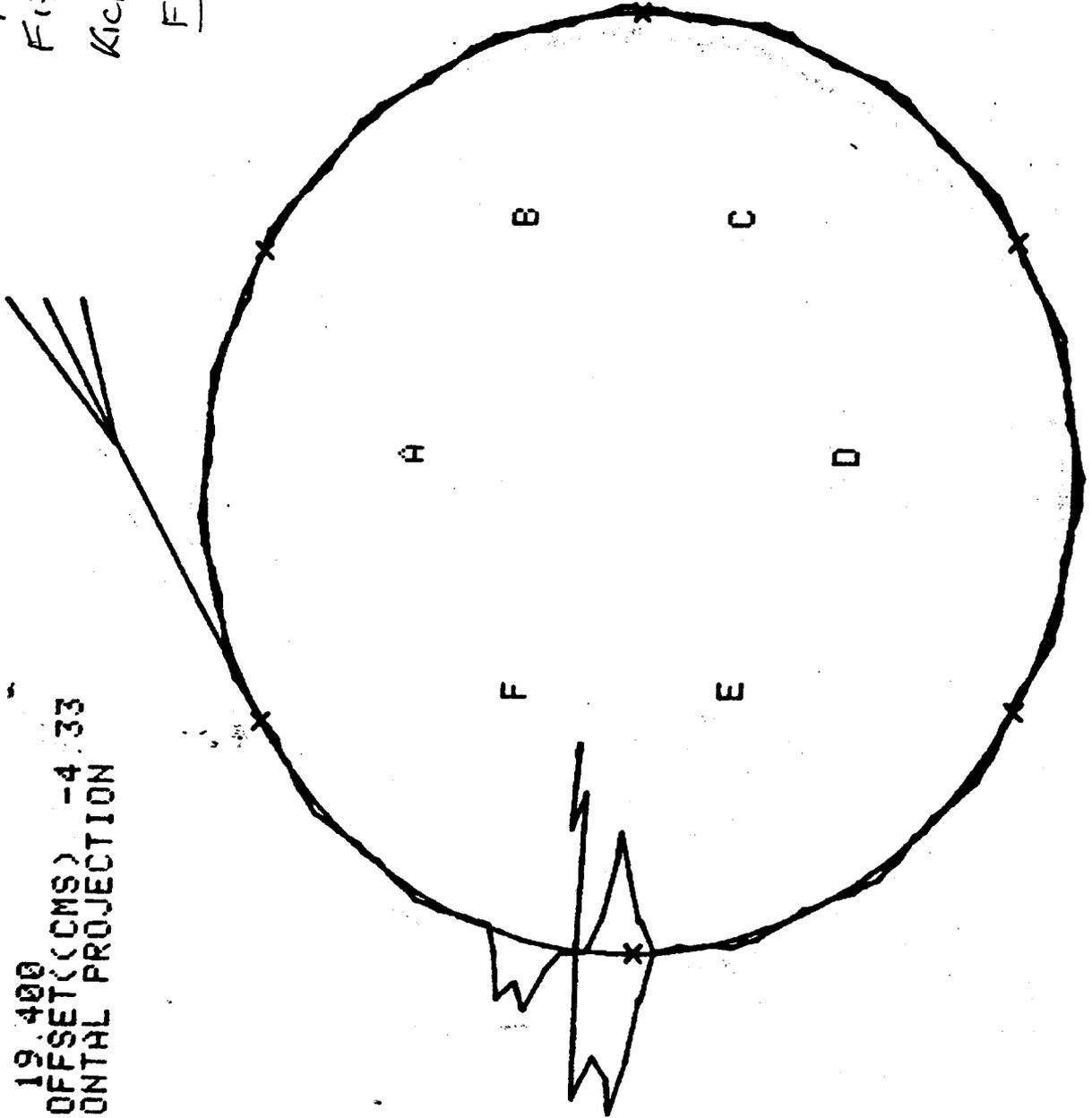
FIGURE 18



TUNE 19.400
MAX. OFFSET (CMS) -4.13
HORIZONTAL PROJECTION

F4 4-Bump
F17 4-Bump
KICKER,

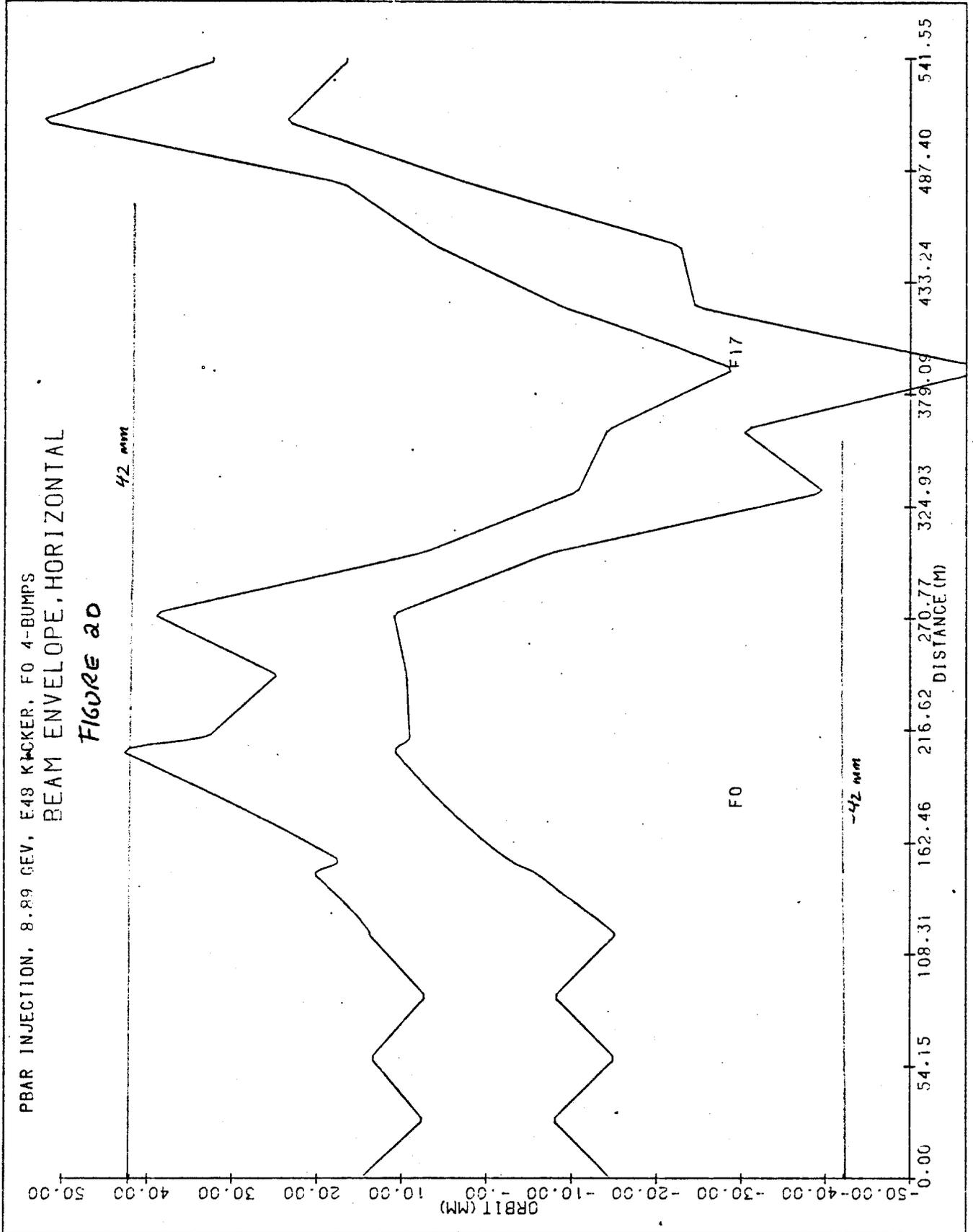
FIGURE 19



TUNE 19.400
MAX. OFFSET (CMS) -4.33
HORIZONTAL PROJECTION

PBAR INJECTION, 8.89 GEV, E48 KICKER, F0 4-BUMPS
 BEAM ENVELOPE, HORIZONTAL

FIGURE 20



PBAR INJECTION, 8.89 GEV, F0 4-BUMPS
 BEAM_ENVELOPE, HORIZONTAL
 FIGURE 21

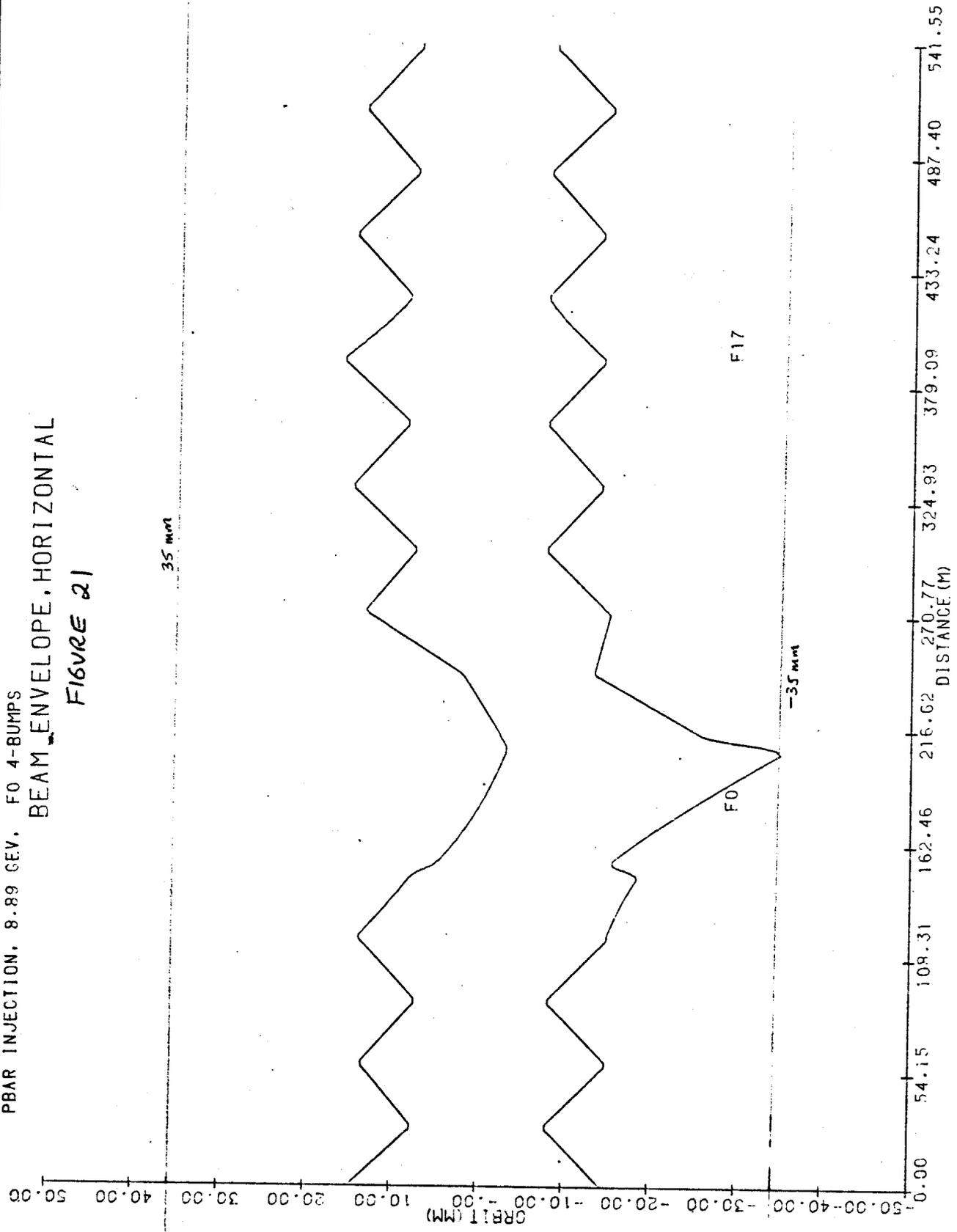


Figure 22 shows the region near F17 in detail, indicating both the circulating and injected beam envelopes. Again, nearly the full inner limits of the physical aperture of the quad at F17-1 and the dipoles at F16-4 to F16-7 are explored.

The horizontal injection angle necessary at F17 is .95 to 1.05 mrad (depending on the size of the F17 steering bump). The difference between this angle and the 0.8 mrad introduced by the rolled Lambertson can be achieved using the trim dipole in the AP1 line. In the worst case, this produces a 4 mm beam offset from the C-magnet center line, which is tolerable (see fig 14).

If it is necessary to use the steering bump at F17 on the first turn, the kicker and the FO bump must also be increased (see table 4). For the extreme case of a 14 mm offset at F17, the kicker goes up by 33% and the FO bump by 40%. The resulting injected beam envelope (corresponding to the orbit shown in fig 19) is shown in fig 23; the circulating beam envelope is shown in fig 24. For this scenario, the aperture requirements are increased. For the circulating beam, we need 42 mm (-42 mm at the first quad downstream from FO); for the injected beam, we need 50 mm (+50 mm at the first quad downstream from FO, 44 mm at F11, 46 mm at F13, and -48 mm at F15.)

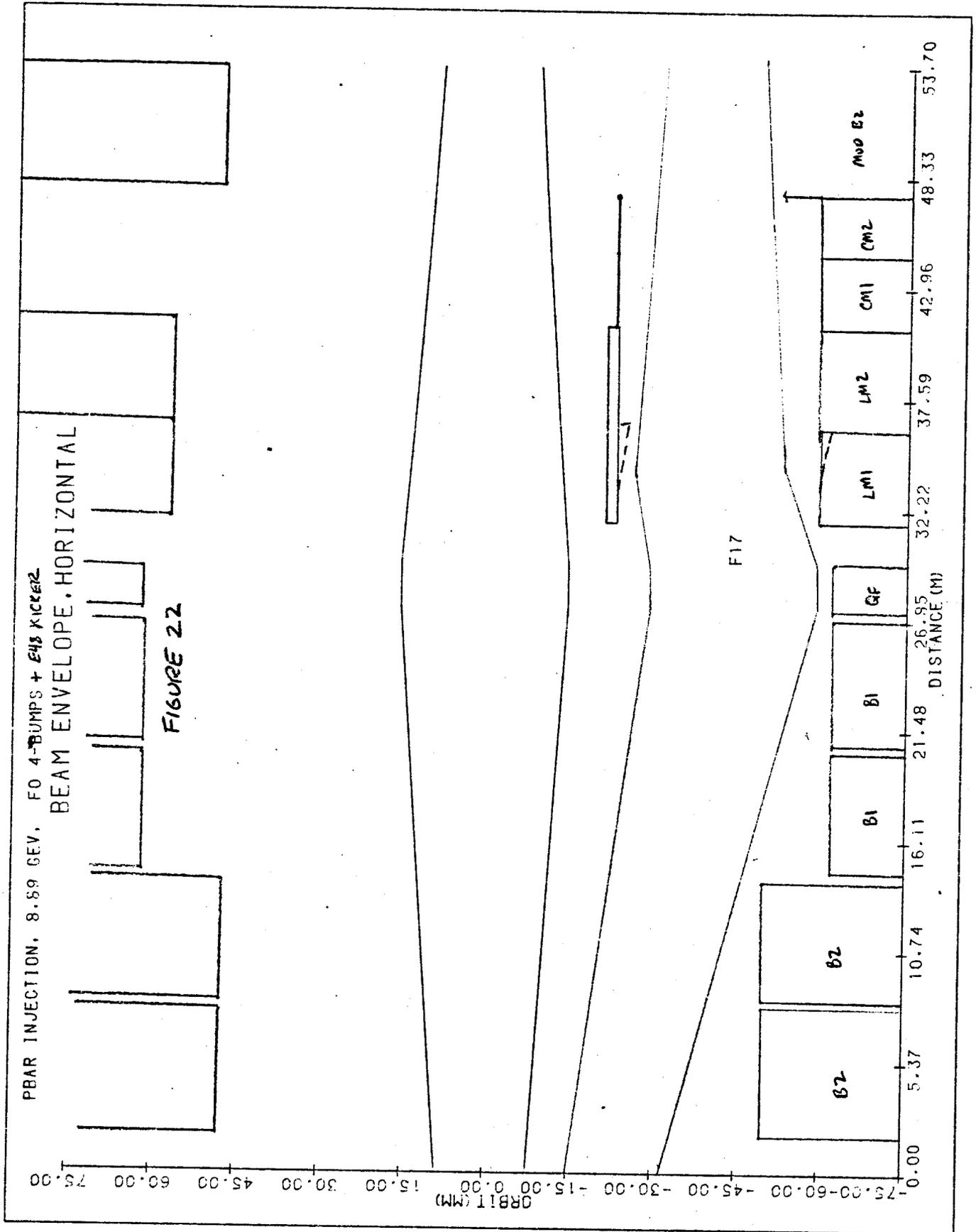
Fig. 25 shows the measured horizontal closed orbit in the Main Ring at 8 GeV. Note that the orbit deviations in the E48-F17 region are all quite small (maximum 3 mm).

b). vertical

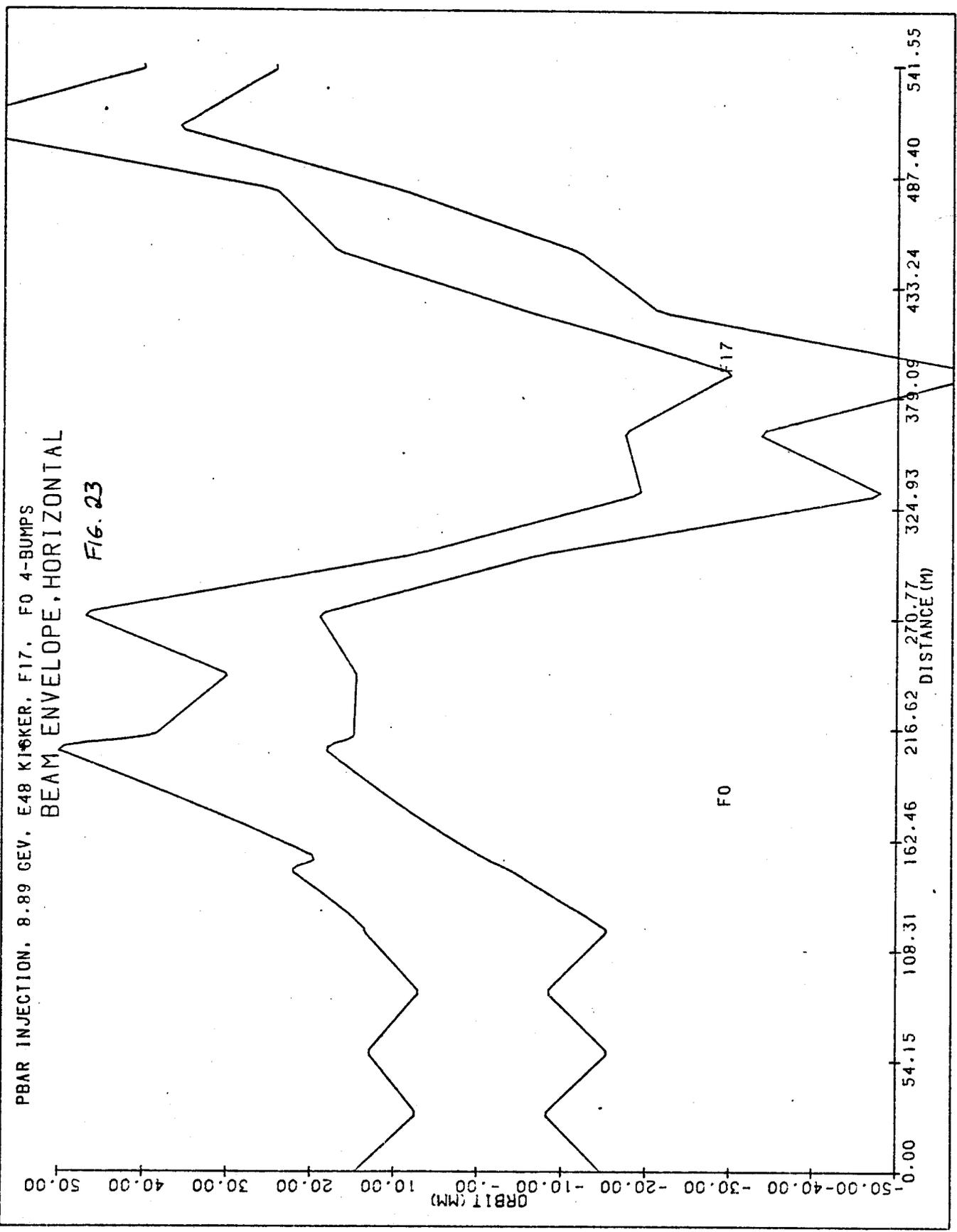
Fig. 26 shows the vertical beam envelope from E44 to F23. The maximum aperture required is 16 mm (at the first quad upstream from FO). The beam size at the Lambertsons and the E48 kicker is +8 mm; the aperture restrictions here are +19 mm. Fig 27 shows the measured vertical closed orbit at 8 GeV; again, the deviations are small in the E48-F17 region.

5. Detailed specifications of the devices

Table 4 gives the details of the injection system operating points for two cases: with no steering of the circulating beam at F17, and with 14 mm of steering. The dipole in the AP1 line runs at very low current and serves now to produce the correct injection angle at F17.



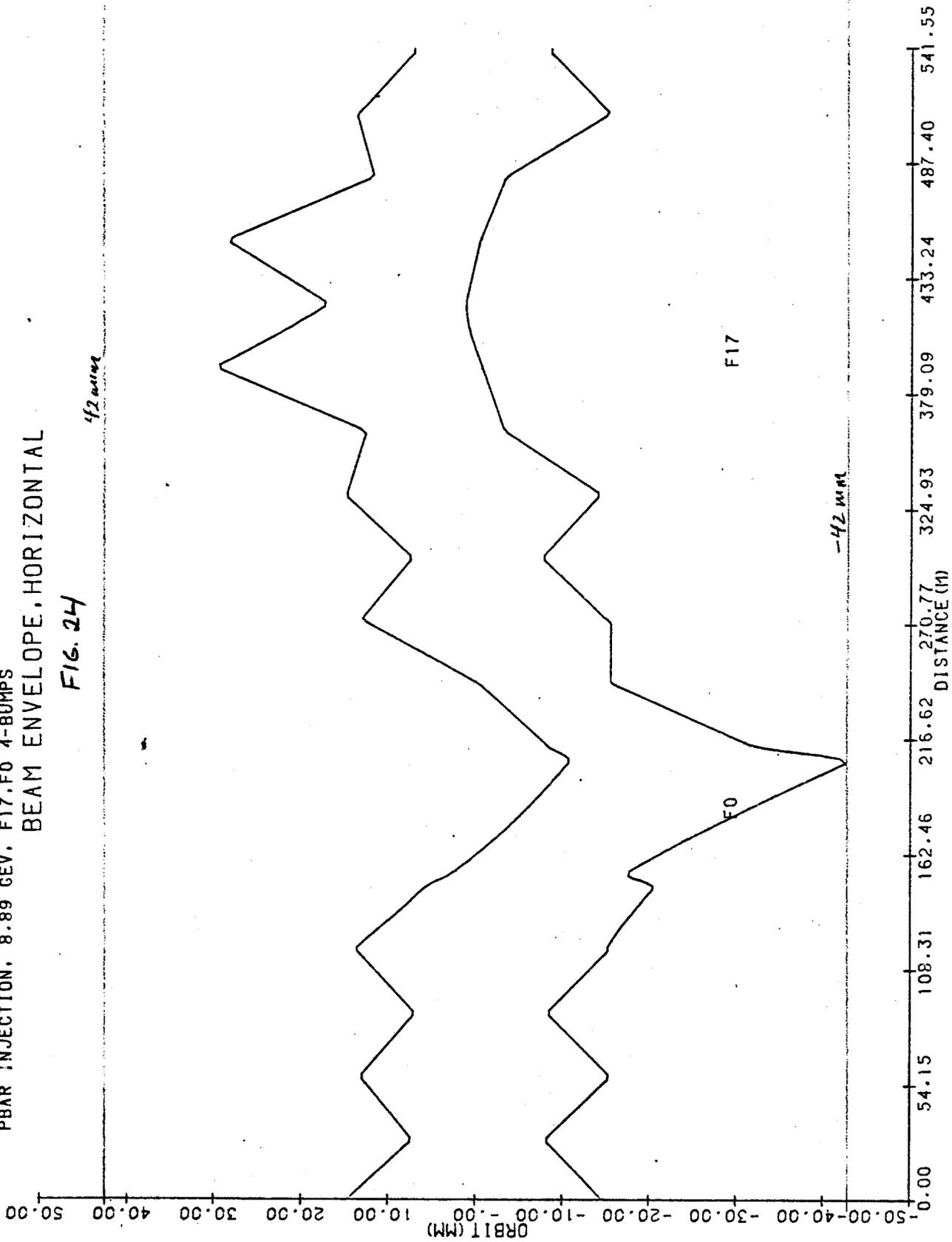
PBAR INJECTION, 8.89 GEV, E48 KICKER, F17, F0 4-BUMPS
 BEAM ENVELOPE, HORIZONTAL
 FIG. 23



PBAR INJECTION, 8.89 GEV, F17, F0 4-BUMPS
BEAM ENVELOPE, HORIZONTAL

FIG. 24

42 mm



42 MM

FIG. 25

HORIZONTAL CLOSED ORBIT

FILE 2

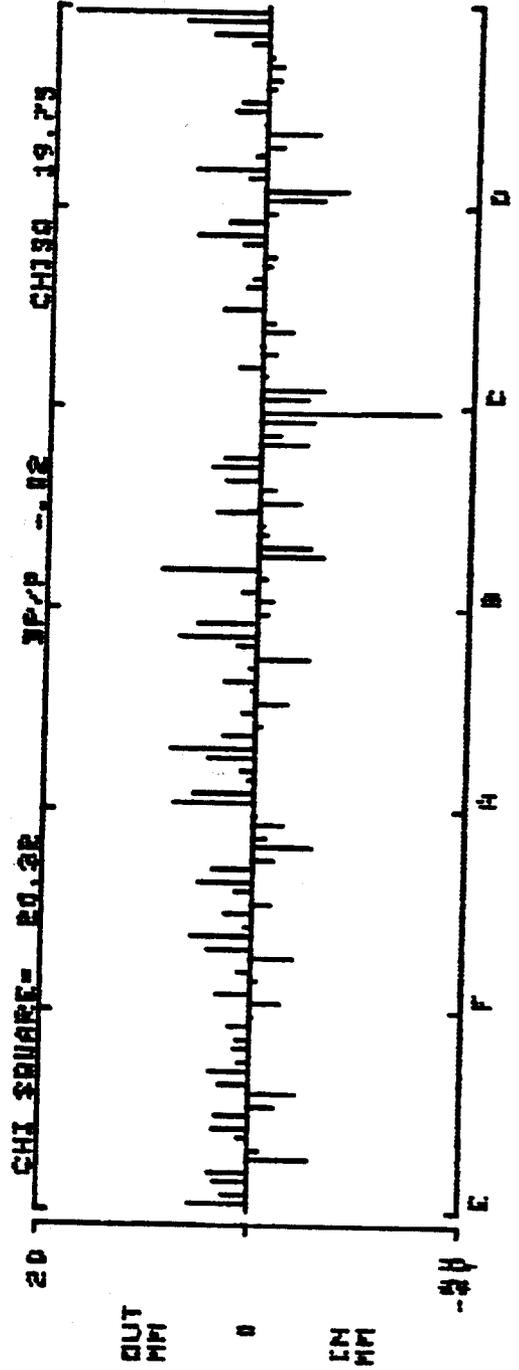
CALIBRATED

SAMPLE TIME= .991 SEC

ENERGY 8 DEY

01/25/84 1103

	E	F	A	B	C	D
11	5.648	-2.842	7.811	-1.318	-4.342	-5.533
12	2.408	3.228	5.9	1.423	-5.725	-7.712
13	3.203	-3.44	1.673	-3.873	-9.57	1.615
14	3.908	1.377	1.833	3.323	2.361	6.749
15	-5.842	-3.92	4.494	-6.146	-1.13	1.193
16	-1.06	4.26	6.198	-4.928	2.05	-1.552
17	1.189	5.854	3.111	-8.26	-2.888	-4.951
18	3.556	7.44	-5.68	4.73	-9.66	2.99
19	3.322	2.76	1.377	4.049	3.823	3.864
20	-2.467	-1.74	-3.099	-3.732	8.64	2.455
21	-4.342	1.681	5.9	-1.482	1.681	-6.38
22	2.83	3.361	3.158	3.322	1.119	-1.248
23	2.953	2.838	7.44	4.882	-6.15	-1.482
24	1.048	-2.845	-5.092	3.453	-1.072	-4.98
25	1.423	-5.561	1.939	-4.412	2.021	1.775
26	1.33	-1.13	7.447	-1.74	6.428	5.385
27	2.858	-2.842	5.713	-3.092	3.521	7.918
28	-2.64	-1.22	-1.99	-16.78	-1.072	18.32



PBAR INJECTION. 8.89 GEV. E48 KICKER. F17. F0 4-BUMPS
 BEAM ENVELOPE, VERTICAL

FIG. 26

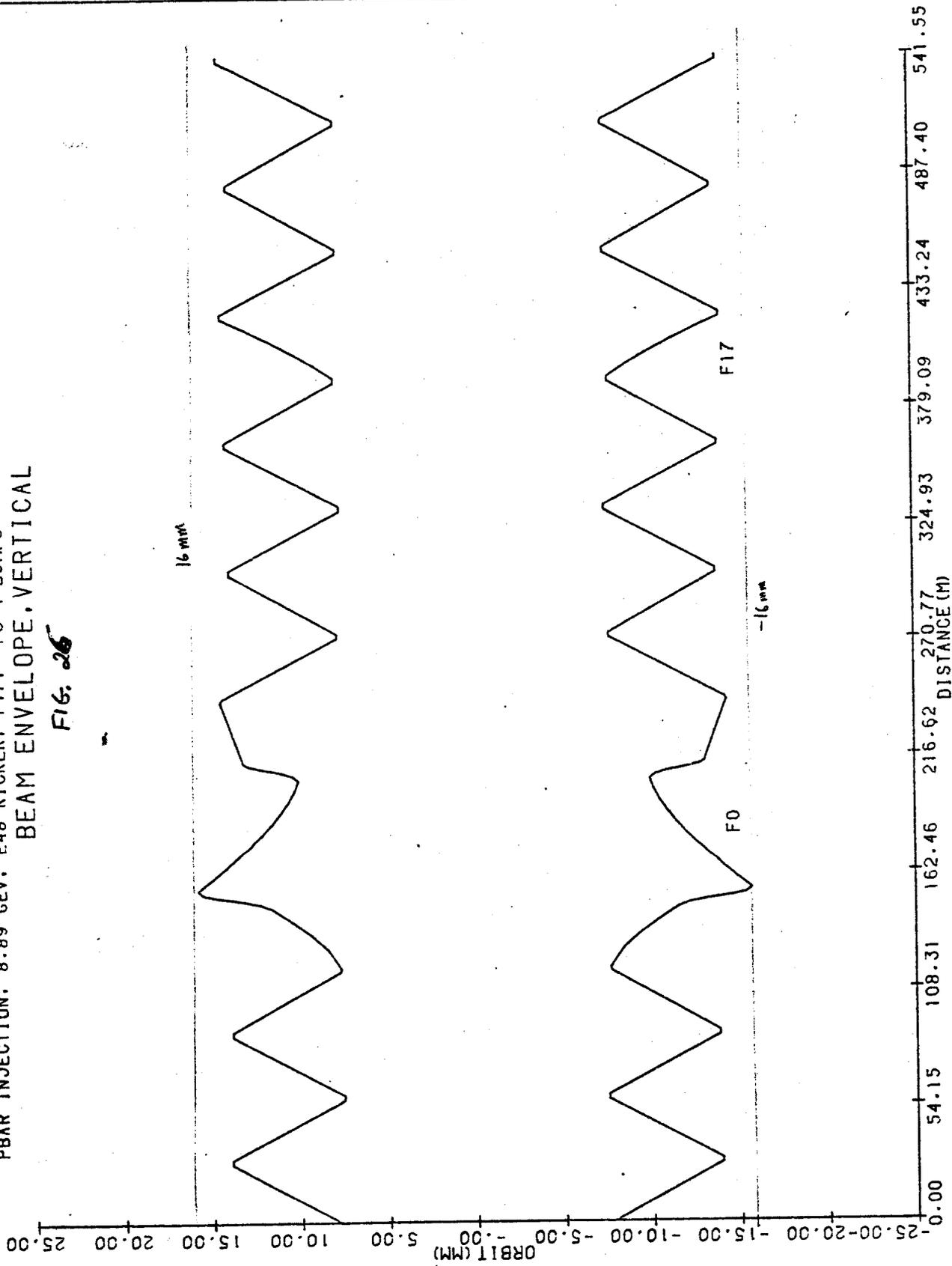
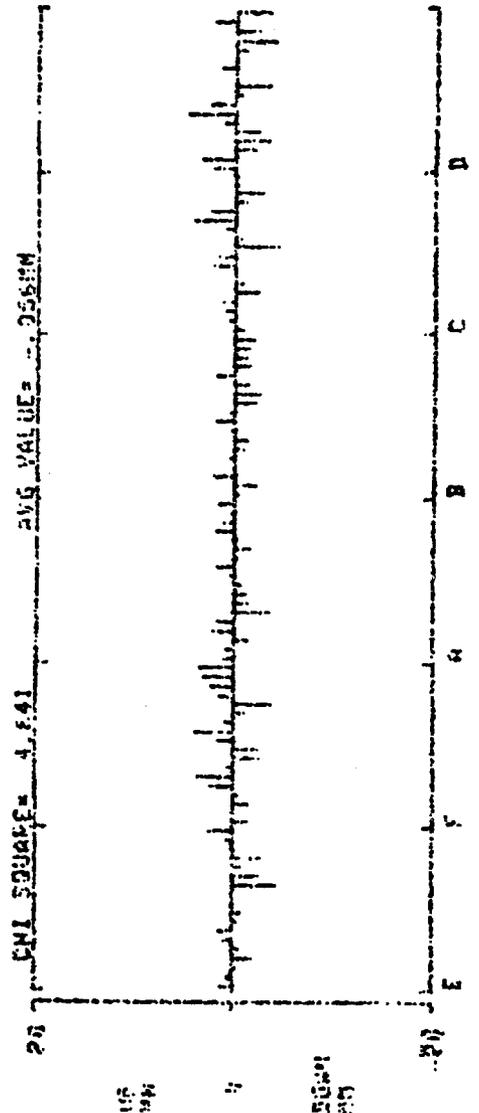


FIG. 27

VERTICAL CHANNEL ORBIT	E	F	A	B	C	D
11	1.414	-1.557	1.229	-2.407	-0.873	2.293
12	.72	.226	.92	-2.393	.936	3.45
14	-1.484	-1.663	-1.443	2.559	1.122	-1.758
16	-1.907	-1.433	2.283	.138	1.272	-3.356
18	-1.823	2.599	1.726	.516	-2.445	-2.294
21	1.114	3.979	-3.562	-.907	-.793	1.395
23	1.5	.667	-1.426	-1.434	.077	4.276
25	-1.326	-2.691	-1.171	-1.433	2.405	2.88
27	-1.16	-2.472	-.696	1.755	1.739	-.391
29	-.465	1.711	.49	.56	-4.318	-3.509
32	.204	3.822	1.957	-2.19	-.522	-.02
35	-4.572	.824	-.116	-2.547	.641	1.519
37	-2.788	-1.751	-1.522	-1.433	4.26	.261
39	-.969	-3.711	-.75	1.575	2.59	-1.417
43	-2.7	1.349	1.808	-1.501	-1.125	-4.063
45	-.106	2.757	1.21	-1.241	-2.302	-2.185
47	.841	3.292	.532	-1.427	-.824	2.271
49	2.432	3.61	1.667	-2.015	-.261	-3.43



Acknowledgements

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FERMILAB
ENGINEERING NOTE

SECTION

PROJECT

SERIAL-CATEGORY

SUBJECT

TABLE 4
F17 INJECTION DEVICES (8.29 GV/c)

NAME

DATE

REVISION

DEVICE	LOCATION	NO STEERING		14mm STEERING AT F17	
		BEND ANGLE (μRAD)	I (A)	BEND ANGLE (μRAD)	I (A)
HCD	E48	-178	-1.5	-250	-2.2
"	E49	-21	-2	-30	-2.6
"	F11	+107	+9	+150	+1.3
"	F13	-178	-1.5	-250	-2.2
HCD	F15	0	0	150	+1.3
"	F17	0	0	35	+0.3
"	F19	0	0	35	+0.3
"	F22	0	0	150	+1.3
KICKER	E48	+450	480	+600	640
LAM 1	F17	8730	207	8730	207
LAM 2	F17	"	"	"	"
CMAG 1	F17	7630	"	7630	"
CMAG 2	F17	"	"	"	"
DIPOLE	140" AFTER C-MAG IN AP1	150	1.7	250	2.8