ACCESS

C. Johnstone
3/15/01
NIU Workshop

TEST FACILITY BEAMLINE DESIGN

I. **Access:**
- Component installation, removal, and maintenance
- Personnel evacuation

II. **Safety Issues:**
- Approved primary beam controls
- Accident control

III. **Shielding and Radiation Control**
- Occupancy requirements
- Passive shielding and labyrinth requirements

IV. **Beam Requirements for Hydrogen Absorber Test Stand**
- Beam size, intensity, stability, and variability required

V. **Beam Optics and Components**
- Achievable optics given the available components
- Components to be built

Design Report

LINAC EXPERIMENTAL AREA

March, 1995

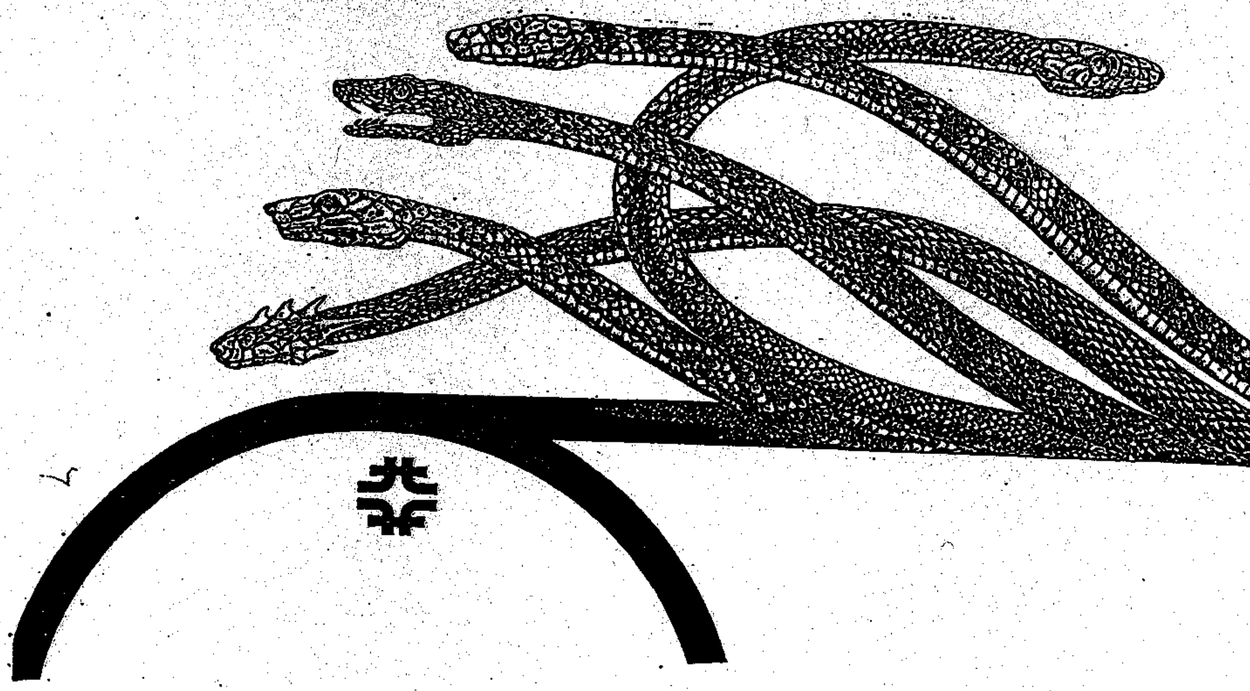

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Table 1: General Linac beam parameters

Parameter	Value	Unit
Kinetic Energy	401.5	MeV
Energy Spread	1	MeV
Peak Current	52	mA
RF Structure	201.24	MHz
Bunch Length	0.208	ns
Pulse Length	50	μs
Max Particles Per Bunch	1.6	10^9
Max Particles Per Pulse	1.6	10^{13}
Max Beam Power	15.7	kW
Beam Emittance (95%)*	8	mm·mrad
σ_{max} (rms)	9	mm

* Since $\beta\gamma \approx 1$, normalized and unnormalized emittances are approximately equal.

The magnetic elements needed to produce this large beam require an unusually large aperture of at least 15 cm in radius just upstream of the device under test. (A similar aperture is needed downstream in order to refocus the beam onto the beam dump.) In addition, to avoid unacceptable beam losses on the beamline and test-stand components, tails will need to be scraped at $\pm 3\sigma$ on a primary collimator located upstream of the shielding wall that will separate the Linac enclosure from the Test Facility. A secondary collimator is recommended just after the shielding to shadow downstream components, in particular, the test stand. The secondary collimator represents a final safeguard against activation, thereby guaranteeing levels of residual radioactivity that allow hands-on-maintenance.

Table 2: Beam parameters proposed for the Linac Test Facility

Parameter	Minimum	Maximum	Unit
Beam Size ($\pm 3\sigma$) at D.U.T.*	1	30	cm
Beam Divergence† ($\pm 3\sigma$) at D.U.T.*	±0.5	±14	mr
Number of Pulses per Second		15	
Number of Protons per Pulse	1.6	16	10^{12}
Pulse Duration	5.0	50	μs

* D.U.T. = Device Under Test
†Min. divergence at max. size and vice versa.

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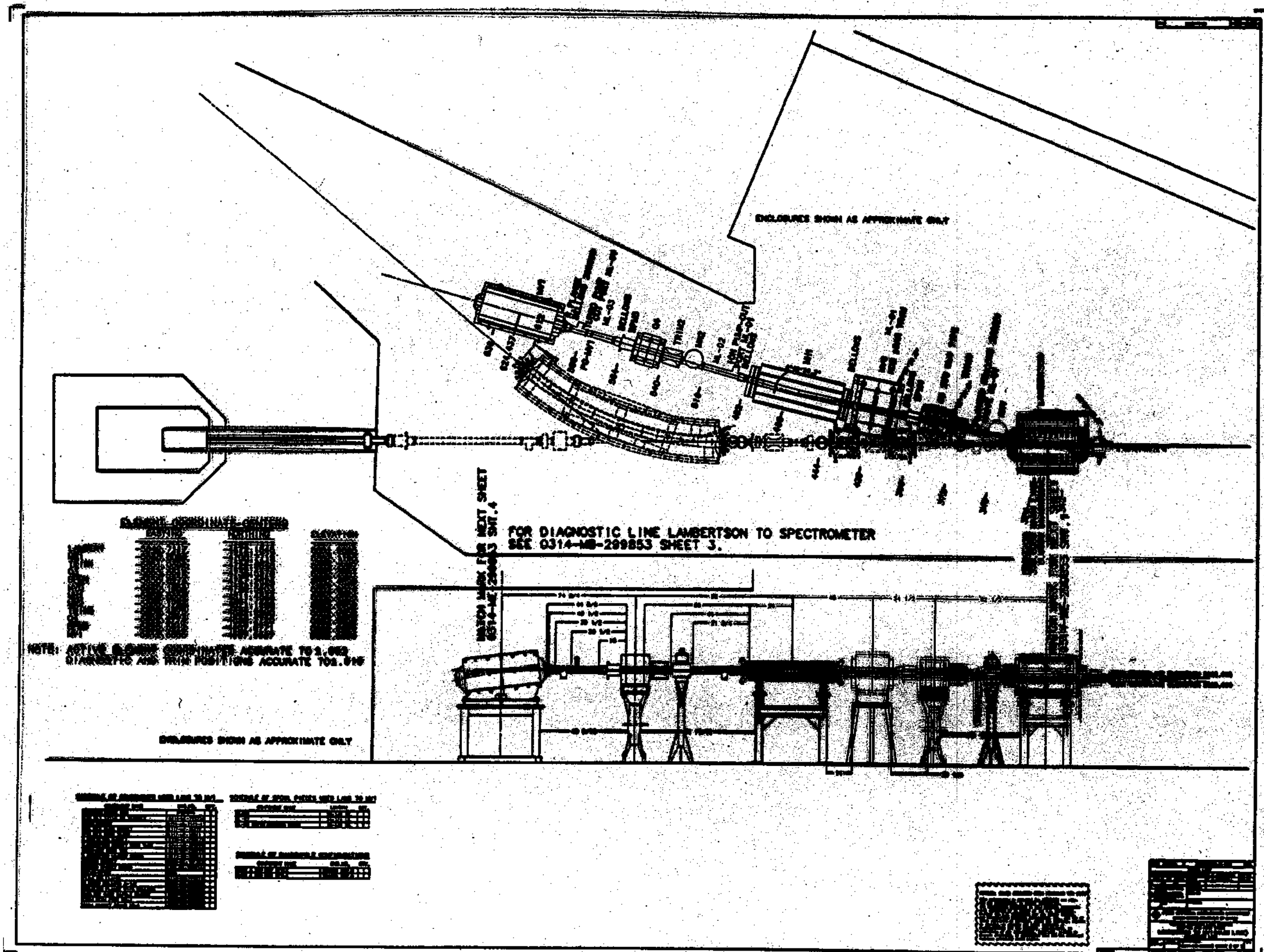
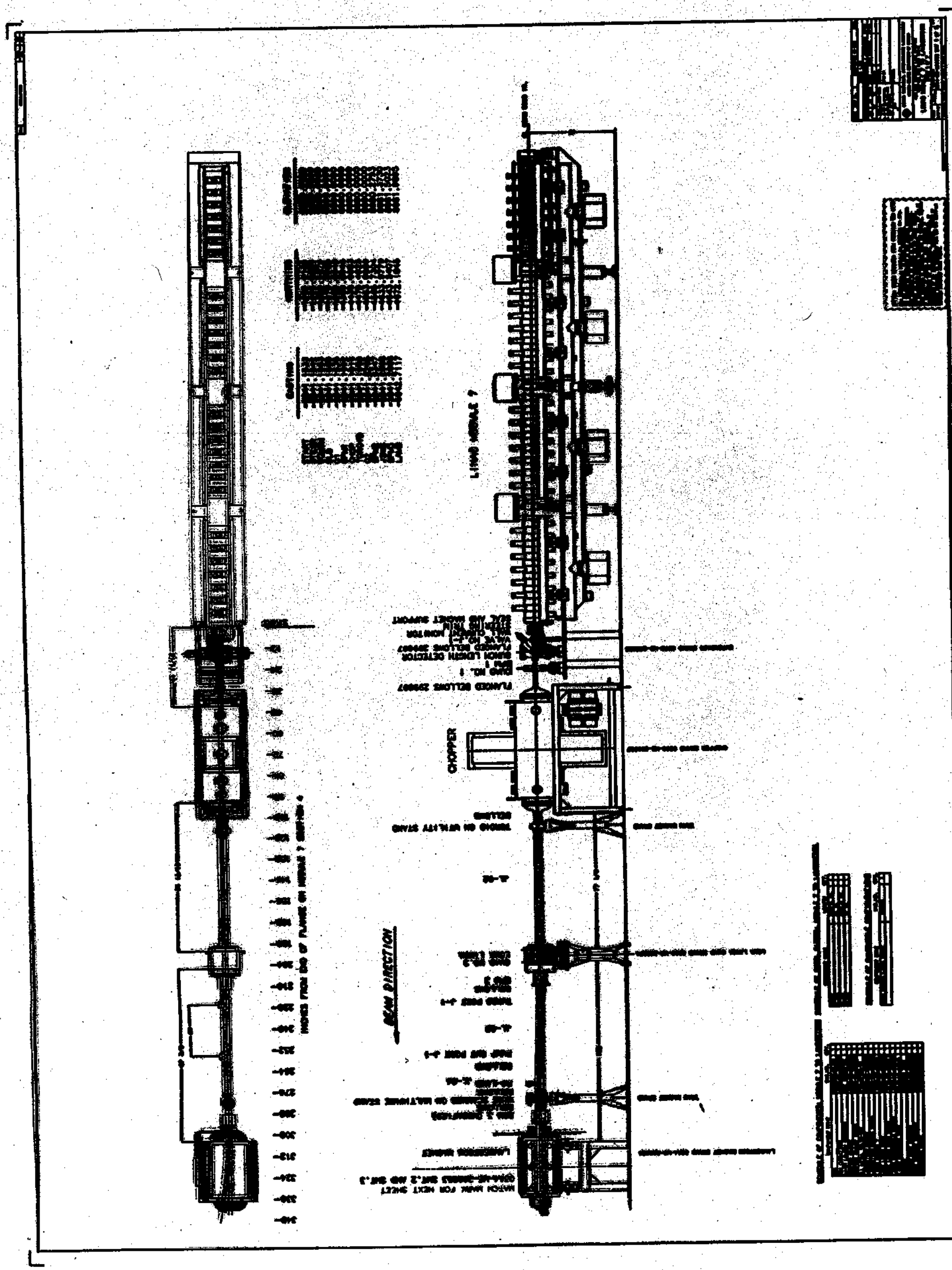
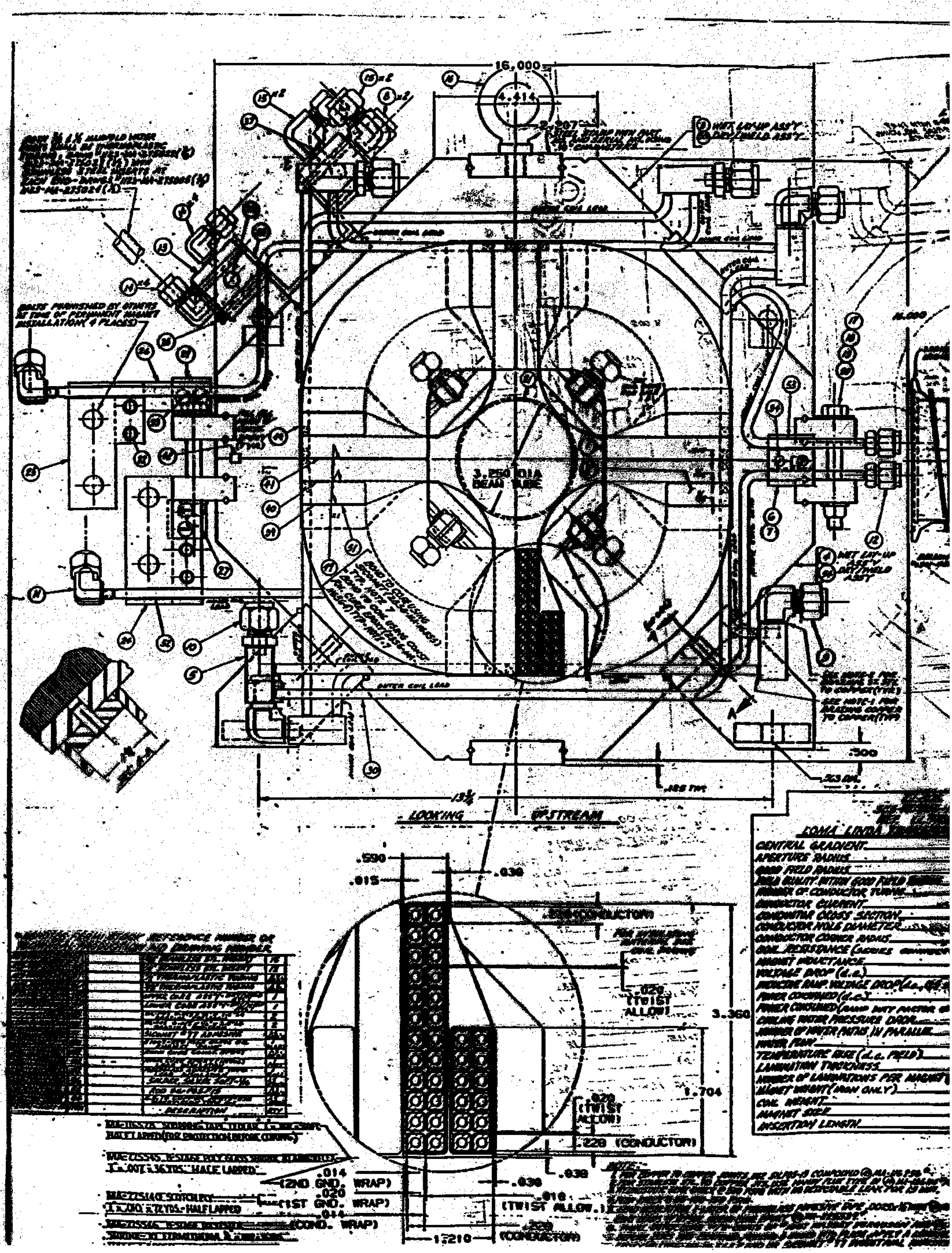
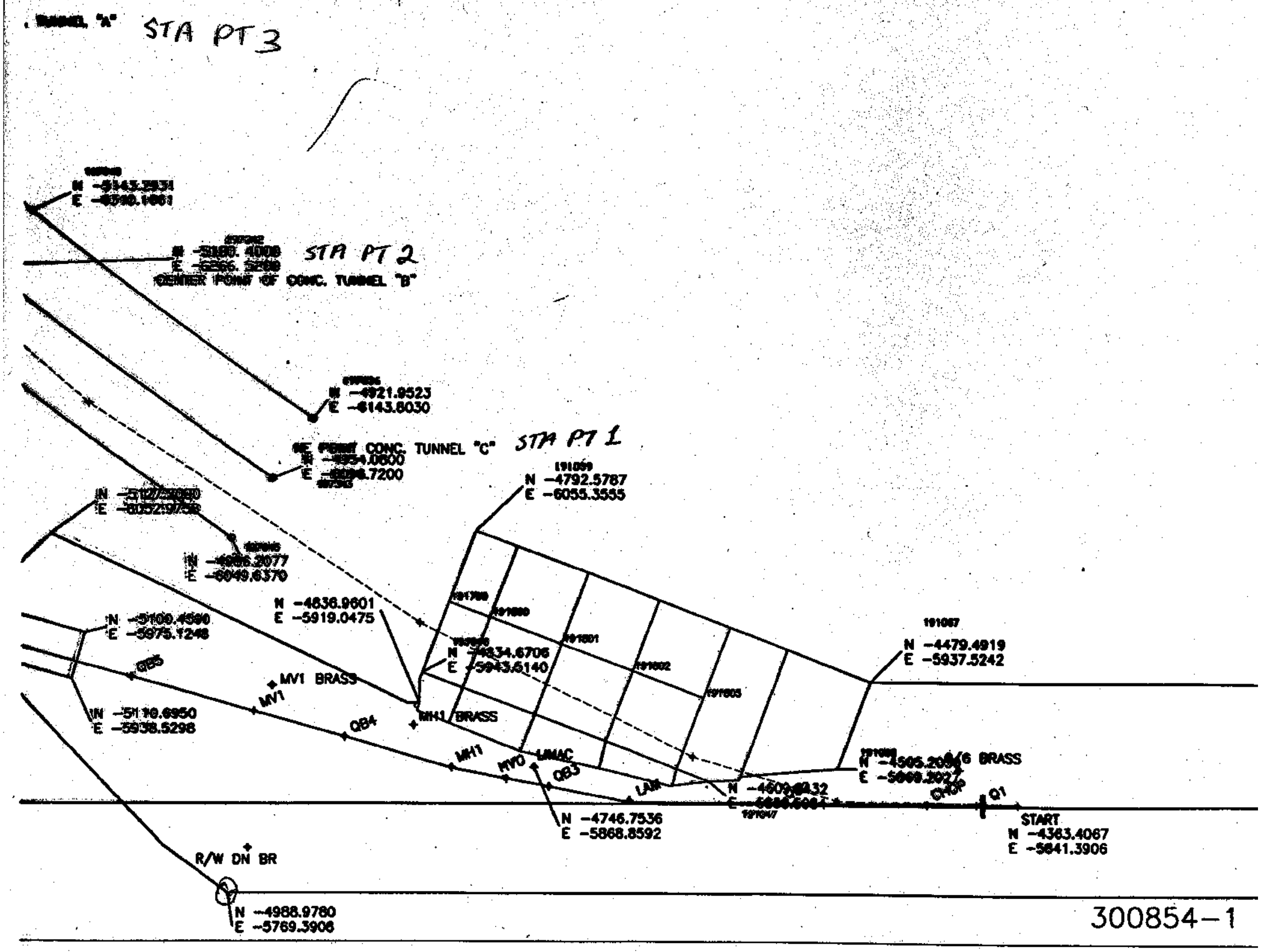

ENCLOSURES SHOWN AS APPROXIMATE ONLY
FOR DIAGNOSTIC LINE LAMBERTSON TO SPECTROMETER
SEE 0314-MB-299853 SHEET 3.
ENCLOSURES SHOWN AS APPROXIMATE ONLY


CHOPPER
BEAM DIRECTION


16,000
4.414
3.250 DIA
BEAM TUBE
13¾
LOOKING UPSTREAM
.300
.590
.015
.030
.020
(TWIST
ALLOW)
3.360
1.704
.220 (CONDUCTOR)
.038
.014
(2ND GND. WRAP)
.020
(1ST GND. WRAP)
.014
(COND. WRAP)
.010
(TWIST ALLOW.)
1.210
(CONDUCTOR)
LOMA LINDA
CENTRAL GRADIENT
APERTURE RADIUS
GOOD FIELD RADIUS
NUMBER OF CONDUCTOR TURNS
CONDUCTOR CURRENT
CONDUCTOR CROSS SECTION
CONDUCTOR HOLE DIAMETER
CONDUCTOR CORNER RADIUS
COIL RESISTANCE
MAGNET INDUCTANCE
VOLTAGE DROP (d.c.)
POWER CONSUMED (d.c.)
COOLING WATER PRESSURE DROP
NUMBER OF WATER PATHS IN PARALLEL
WATER FLOW
TEMPERATURE RISE (d.c. FIELD)
LAMINATION THICKNESS
NUMBER OF LAMINATIONS PER MAGNET
MAGNET WEIGHT (IRON ONLY)
COIL WEIGHT
MAGNET SIZE
INSERTION LENGTH
DESCRIPTION
NOTE:

NOTE:
The coordinates shown have been taken from numerous sources including: field as-founds, drawings from FESS and DXF files from AD/Mechanical. Other than the START point and the Linac beam azimuth of 179° 59' 41.79", do not rely on these coordinates to better than +/- 6 inches.

SCALE 1"=10'



To avoid stripping the H^- beam:

$B \lesssim 7\,kG$

To miss Linac enclosure wall $\theta \approx 19°$

To miss Q2 manifolding $\theta = 22°$

(remanifold) $\theta = 18.4°$

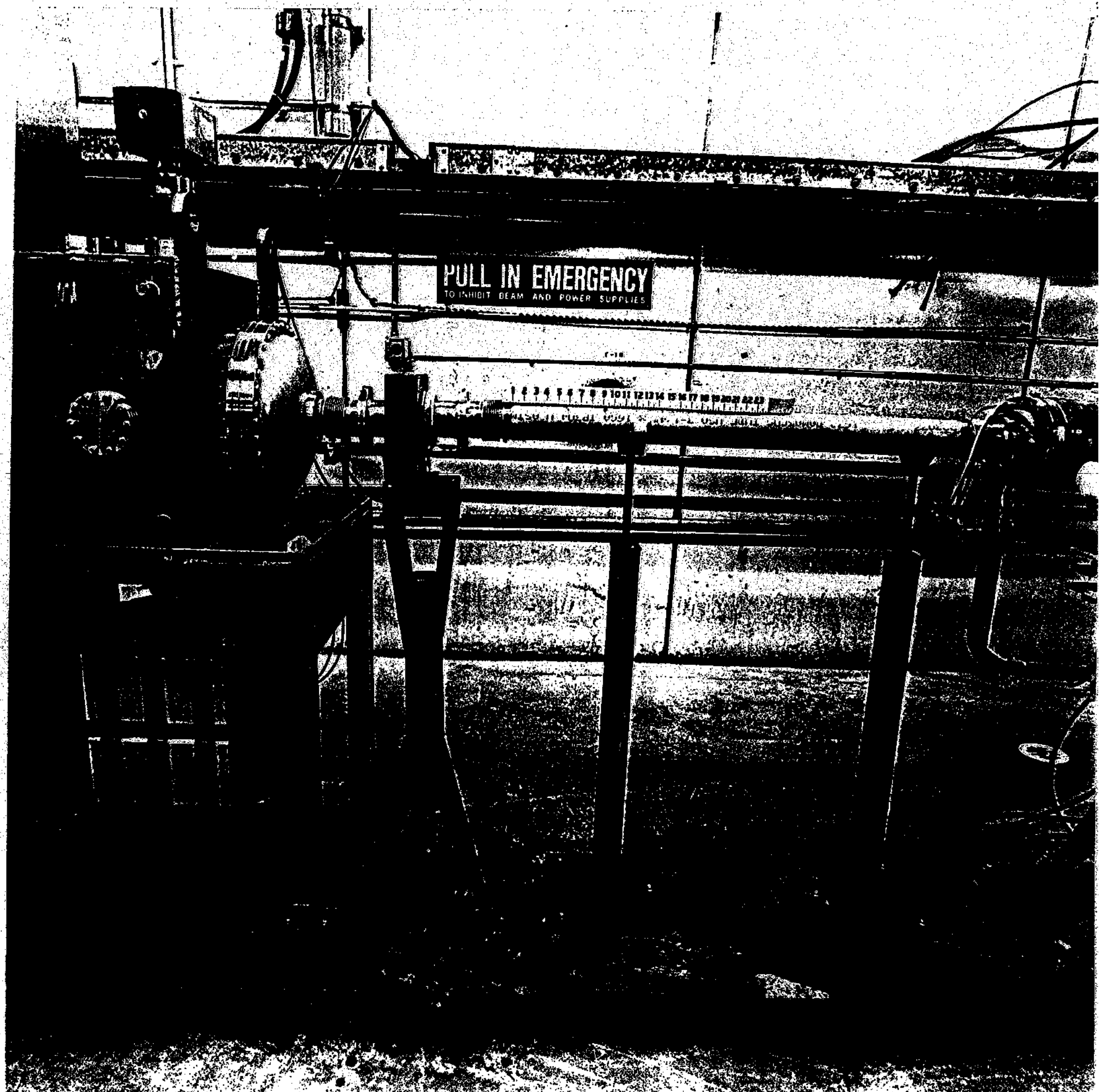
Available Between Chopper & Q2

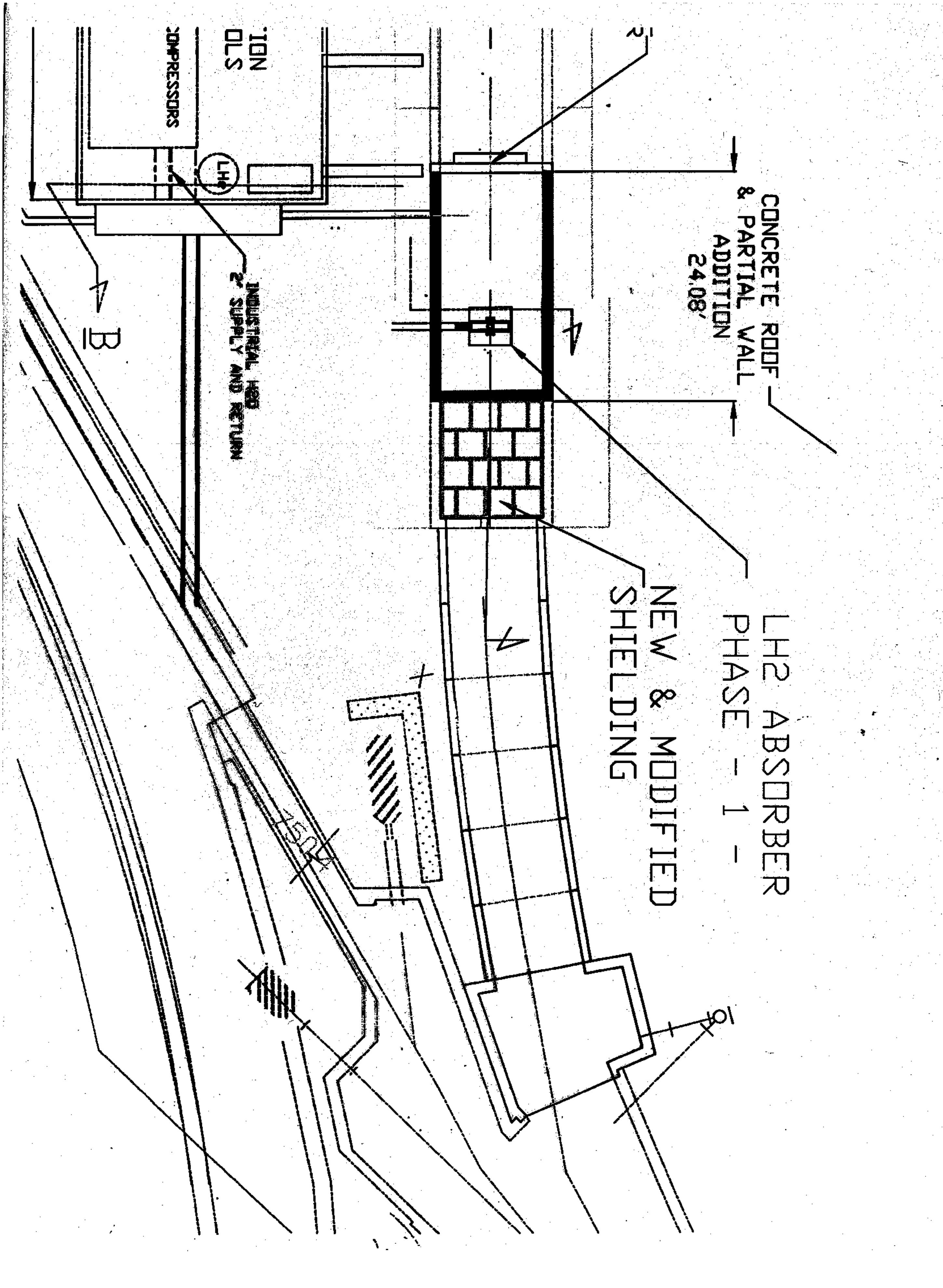
Flange to Flange: 45"
If toroid is removed 55"
Modify Q2's beampipe 65"

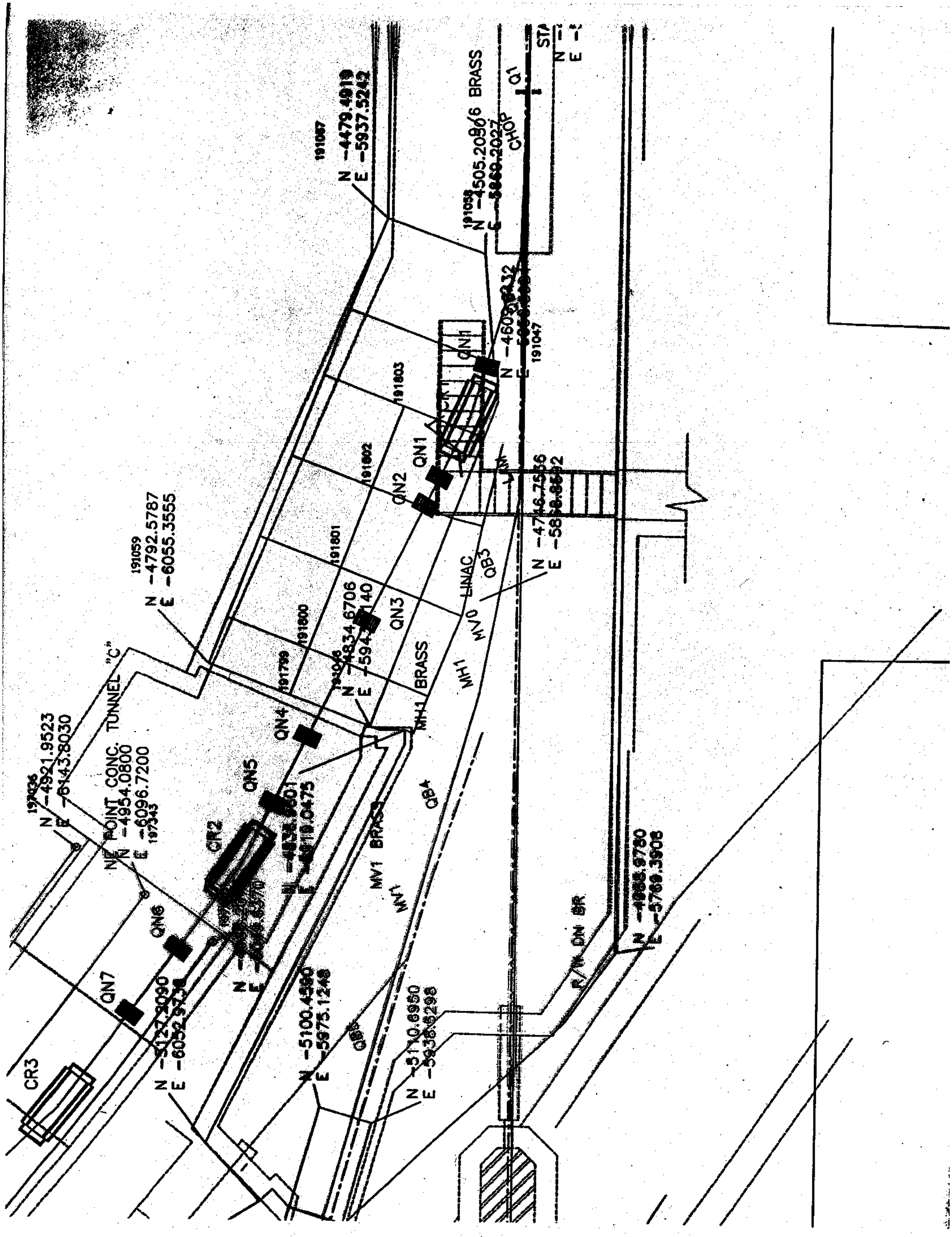
10" are required for flanges.

55" long dipole implies

$B_{min} = 7.5\,kG$


PULL IN EMERGENCY
TO INHIBIT BEAM AND POWER SUPPLIES


CONCRETE ROOF
& PARTIAL WALL
ADDITION
24.08'
LH2 ABSORBER
PHASE - 1 -
NEW & MODIFIED
SHIELDING
INDUSTRIAL H2O
2" SUPPLY AND RETURN
COMPRESSORS


TUNNEL "C"
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E -6096.7200
197343
N -4921.9523
E -6143.8030
191059
N -4792.5787
E -6055.3555
191067
N -4479.4919
E -5937.5242
BRASS
CHOP
Q1
191047
191803
191802
191801
191800
191799
QN1
QN2
QN3
QN4
QN5
QN6
QN7
CR2
CR3
LINAC
QB3
QB4
MV0
MH1
MV1 BRASS
MV1
R/W DN BR
N -4746.7536
N -5100.4580
E -5975.1248
N -5110.6950
E -5938.5298
N -5123.2090

Table 2
Typical magnet data and power levels.

Magnet	Type	Gap (m)	B (kG)	R (mΩ)	I (A)	P (kW)
QM01	14QE22	0.36	7.4	125	330	14
QM02	14QE22	0.36	7.4	125	260	8
BM01	C30X118	0.28	6.1	64	1000	64
QM03	12QE20	0.30	7.1	67	370	9
QM04	12QE20	0.30	7.1	67	220	3
BM02	C32X130	0.28	6.8	75	[illegible]	27
QM05	12QE20	0.30	7.1	67	[illegible]	5
QM06	12QE20	0.30	7.1	67	360	9
QM07	12QE20	0.30	7.1	67	[illegible]	9
QM08	12QE20	0.30	7.1	67	[illegible]	4.5
QM09	12Q15	0.30	9.2	102	[illegible]	7
QM10	12Q15	0.30	9.2	102	260	7
QM11	12Q15	0.30	9.2	102	260	7
QM12	12Q15	0.30	9.2	102	260	7
QM13	12Q15	0.30	9.2	102	280	8
QM14	12Q15	0.30	9.2	102	[illegible]	3.3
BM03	C32X130	0.28	6.8	102	760	43
QM15	12Q15	0.30	9.2	102	170	3
QM16	12QE20	0.30	7.1	67	[illegible]	3
QM17	12QE20	0.30	7.1	67	[illegible]	0.7
BM04	C32X130	0.28	6.8	75	720	42
QM18	12Q15	0.30	7.1	102	140	2
QM19	12Q15	0.30	7.1	102	140	2
QM20	16Q12	0.41	6.4	20	1000	20
QM21	12QE20	0.30	7.1	67	220	3
QM22	12Q15	0.30	7.1	102	140	2
QM23	12Q15	0.30	7.1	102	140	2
					Total	314.5

to multiple scattering for backward decay muon beams, with the results:

Muon Momentum (MeV/c)	Loss Helium	Loss Air
50	30%	~100%
100	<10%	40%

These results, which are also in agreement with a Monte Carlo calculation, indicate that for any momentum less than 50 MeV/c the losses become prohibitive. There are also practical difficulties with a helium system.

The entire beam line is contained within a stainless steel vacuum vessel, which has been shaped to fit within the magnet system. In the elliptical quadrupoles (QM01 through QM08) the vacuum tank is the cloverleaf shaped structure shown in fig. 2. Calculations indicate that this cloverleaf should transmit 2.5 times as much

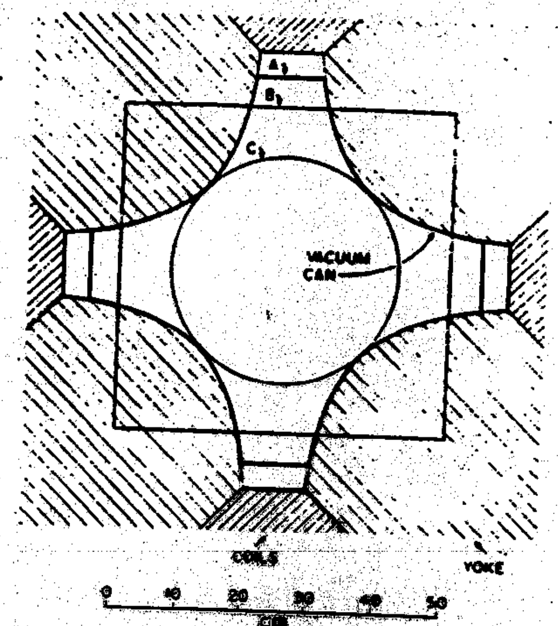
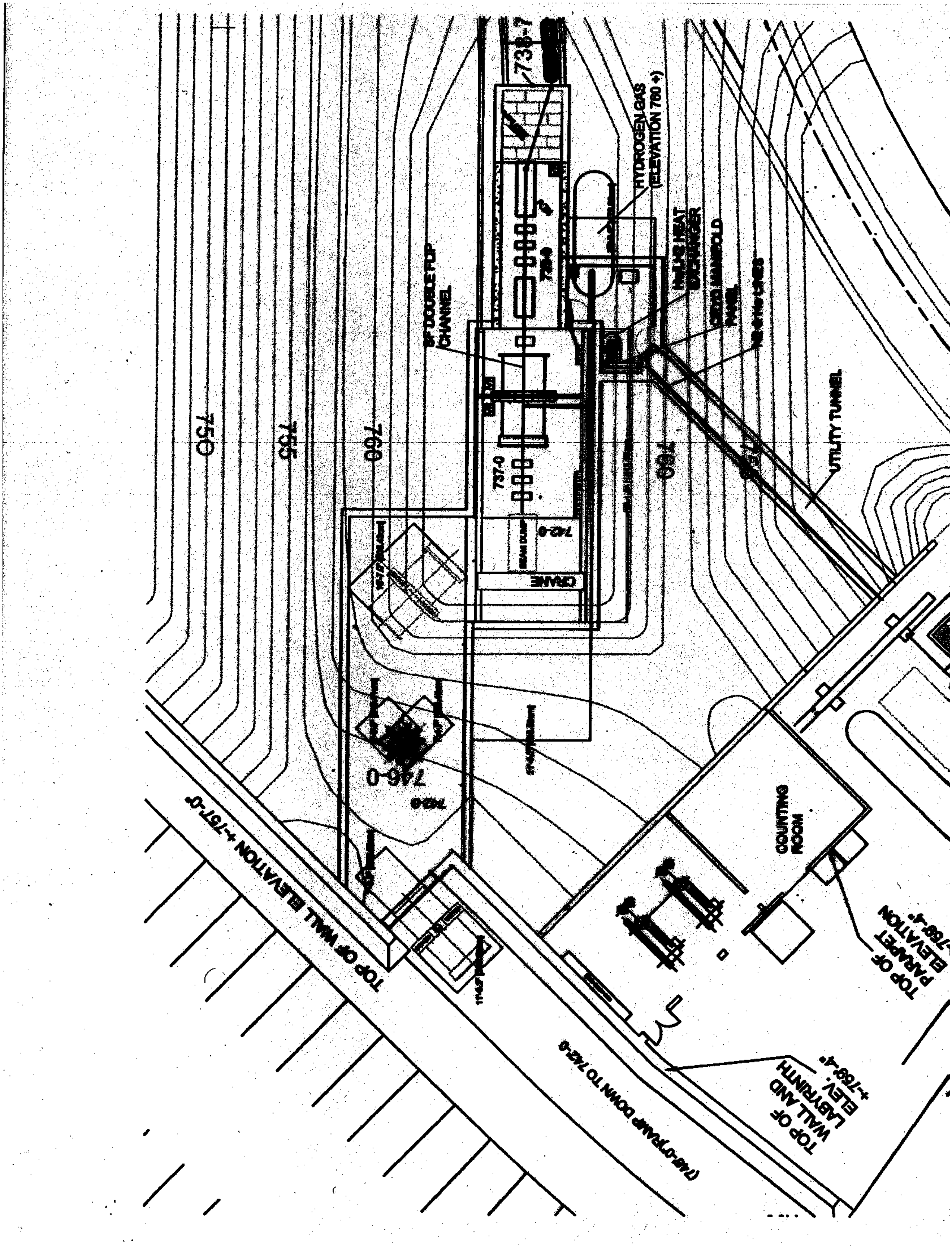


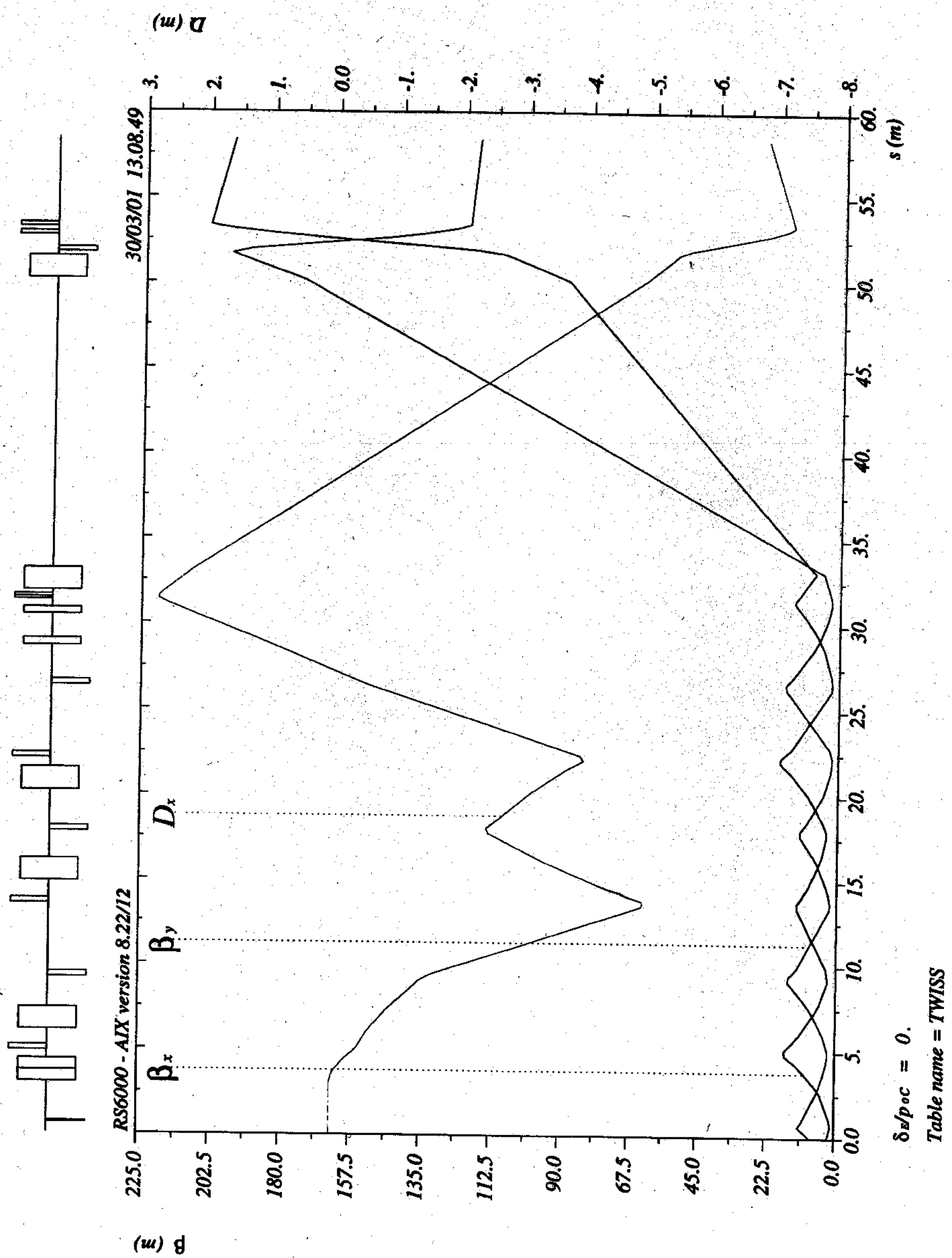
Fig. 2. Typical elliptic quadrupole for muon channel showing: A – the actual "cloverleaf" shaped vacuum can used; B – the square used in the calculations to approximate the vacuum can; and C – the circle representing the usable aperture if a round beam pipe were used.

beam as the simpler design of an inscribed circle. This large gain factor is observed in the measured beam. For the rest of the quadrupoles a round pipe matching the bore is used. In the bending magnets the vacuum tank is rectangular with a vertical opening of 25 cm. The main beam plug (which is just downstream of BM02) and the plugs for the West and South caves (just downstream from BM04) are contained within the vacuum tank. There is a valve after QM14 to provide isolation, otherwise the vacuum system is an integral part of that for the primary proton beam line. The only windows are at the ends of the beam legs; thicknesses used are 0.013 cm Kapton (Dupont Chemical Co.) for diameters less than 15 cm and 0.013 cm Al for larger diameters. The entire channel is pumped by a Rootes blower system located at BM03 to a pressure of about 3 m torr.

2.3. Proton target

The proton target is a rotating wheel of pyrolytic graphite (density 1.7 g/cm³). The thickness along the beam direction is 6 cm. Thicker targets would increase the muon flux but this target seems the best compromise between the use of the muon


HYDROGEN GAS
(ELEVATION 760 +)
CHANNEL
UTILITY TUNNEL
CRANE
COUNTING ROOM
750
755
760
738-7
737-0
742-0
746-0
TOP OF WALL ELEVATION +-757'-0"
(748-0"RAMP DOWN TO 742-0
TOP OF WALL AND LABYRINTH ELEV. +-759'-4"
TOP OF PARAPET ELEVATION +-759'-4"


RS6000 - AIX version 8.22/12
30/03/01 13.08.49
β_x
β_y
D_x
β (m)
D (m)
s (m)
δ_E/p_0c = 0.
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