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THE AGS STRETCHER WITH ROOM TEMPERATURE MAGNETS

Y. Y. Lee

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Collider Accelerator Department
Brookhaven National Laboratory

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Accelerator Division
Alternating Gradient Synchrotron Department
BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York 11973

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THE AGS STRETCHER WITH ROOM-TEMPERATURE MAGNETS

Y.Y. Lee and G.T. Danby

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Introduction

The need and potential benefit of a stretcher ring specifically designed for high extraction efficiency and low operating cost has been suggested in the report of the AGS Task Force.[1] Its desirable features are outlined in the AGS-NSLS study group report of conceptual design for the stretcher installed inside the present AGS tunnel.[2] Also, the possibility to construct a superconducting stretcher has been studied.[3] This report is to study another possibility; namely, a normal magnet installed outside of the AGS tunnel, and to try to make a preliminary, educated guess of the cost.

The following criteria are used for this stretcher design:

1. The ring is located in such a way that the present SEB experimental area and its facilities are intact, i.e., the extraction line merges directly into the present SEB line.
2. Minimum interruption to the AGS program.
3. The polarized proton program is left intact. The inside the AGS ring stretcher[2] does not preserve the polarization, while the superconducting ring[3] does.
4. The ring has enough earth cover to handle the proton beam flux of 5×10^{13} protons per second, i.e., a minimum of 23 feet of earth over the entire ring.[3]

Location

The proposed location of the stretcher is shown in Figure 1. The ring encircles the Cosmotron complex. The topological map shows that the minimum height of the complex is over 90 feet from sea level. If we place the top of the tunnel to below 67 feet from sea level, the ring can be safely placed in the area. The only area that needs additional earth berm is around the old southwest area. Since the water table in this area is below 55 feet, we do not expect any problem placing the ring. The length of the transfer line is over 200 meters in each direction; however, the long transfer line enables one to separate the horizontal and vertical bend thus preserving the polarization. The long transfer line also means the requirement of the bend is less than a few degrees.

Ring Lattice

For ease of beam transfer and operation, the circumference of the ring is chosen to be the same as the AGS. The superconducting stretcher ring has a circumference of 13/24 of the AGS and the beam transfer between the two machines is very tricky and difficult.

There are four 60 meter long straight sections and four 141.75 meter long arcs. Each of the arc segments consists of 10 FODO cells with 60° phase advance per cell. The maximum beta function of this section is 24.5 meters and the minimum, 8.2 meters. The dispersion function maximum and minimum are 2.8 and 1.7 meters respectively.

The beta function maximum determines the aperture requirement of the dipole magnets. Compared to the "inside the ring" stretcher, the vertical beta maximum is almost identical (24.5 vs 25.8) and horizontal beta function and dispersion functions are somewhat smaller than the "inside the ring" stretcher. Rather than going through complicated analysis, we are going to assume the same aperture for the arc part of the ring with the "inside the ring" stretcher.[2] They are 30 x 105 mm for the dipoles and 10 cm diameter for the quadrupoles.

The straight section insertion consists of three cells of 120° phase advance each, which makes 2π insertion. The lattice function around the straight section is given in Figure 2. One notices the large vertical beta function of 114 meters. The large beta function is advantageous to the efficient slow extraction from the stretcher. The parameters for the stretcher are given in Table I.

Table I. Stretcher Parameters

Magnetic Rigidity (T-m)	100
Ring Circumference (m)	807
ARC	
Length	567 m
Number of Cells	40
Number of Dipoles	80
Dipole Field	1.5 T
Phase Advance per Cell	60°
Beta Max./Min.	24.55/8.18 m
Xp Max./Min.	2.78/1.67
INSERTION	
Length	60 x 4 m
Number of Cells per Insertion	3
Phase Advance per Cell	120°
Beta Max. Horizontal/Vertical	63/114 m
Qx/Qy	10-2/3
APERTURE	
Dipole	30 x 105 mm
Quadrupole Diameter	100 mm

Extraction

Third integer vertical resonance extraction is proposed. There are six 9 meter long free spaces in each of the insertions. A vertical 8 meter long electrostatic septum is placed in the fourth straight section of the insertion. A static field of 60 kV/cm will produce 1.6 milli-radian of deflection. Such a deflection produces 14 mm of space between the circulating and extracted beam at the upstream end of the last section of the insertion where one places a 3 meter long Lambertson septum magnet with an 8.5 kG field. The septum is tilted 10° to give both horizontal and vertical bends. A vertical deflection is necessary in order to compensate vertical deflection by the last focusing quadrupole. It will compensate geometrically as well as partially compensate for the spin precession produced by the quadrupole. Because of the spin precession, the beam loses about one percent of the spin. The rest of the section is filled with 5 meter long Lambertson septum magnets deflecting in the horizontal direction, which will produce enough clearance to pass the downstream quadrupoles. Figure 3 shows vertical separation of the phase space at the upstream and downstream ends of the Lambertson septa.

Cost Estimate

Since the depth of the tunnel from the surface is similar, the conventional construction cost is scaled from the superconducting ring by the ratio of the tunnel length. We took the ring magnet and power supply cost to be the same with the "in the ring" estimate, and the transfer equipment is scaled from the superconducting estimate where all the trnasfer and extraction equipment are normal magnets. The rest of the systems should all be similar to each other. Table II shows the comparison of each system.

Table II. Cost Comparison

	In Ring	Superconducting	This Proposal
Ring Mag. + P.S.	13,541	7,810.38	13,541
Cryo. System	---	4,641	---
Conv. Fac.	466	5,802	9,590
Trans. + Ext.	6,271	6,598.70	3,823
Vacuum System	2,689	2,648	2,689
Instrumentation	1,813	1,813	1,913
Controls	3,122	3,122	3,122
RF System	--	1,000	--
Acc. Phy.	630	630	630
SUBTOTAL	29,039	34,015.08	35,208
20% Contingency	5,761	6,803.16	7,042
GRAND TOTAL	34,800	40,818.24	42,250

Power Requirement

10 x 10 cm conductor dimension for the dipoles and 5 x 10 cm for the quadrupoles are assumed to calculate the power requirement. The d.c. power required is 1500 KW for the dipoles and 950 KW for the quadrupoles. Combined power of 2450 KW is much less than the power required to flattop the AGS.

References

1. Report of the AGS II Task Force, February 1984.
2. AGS Stretcher, BNL-37752.
3. AGS Superconducting Stretcher Ring, BNL-39142.

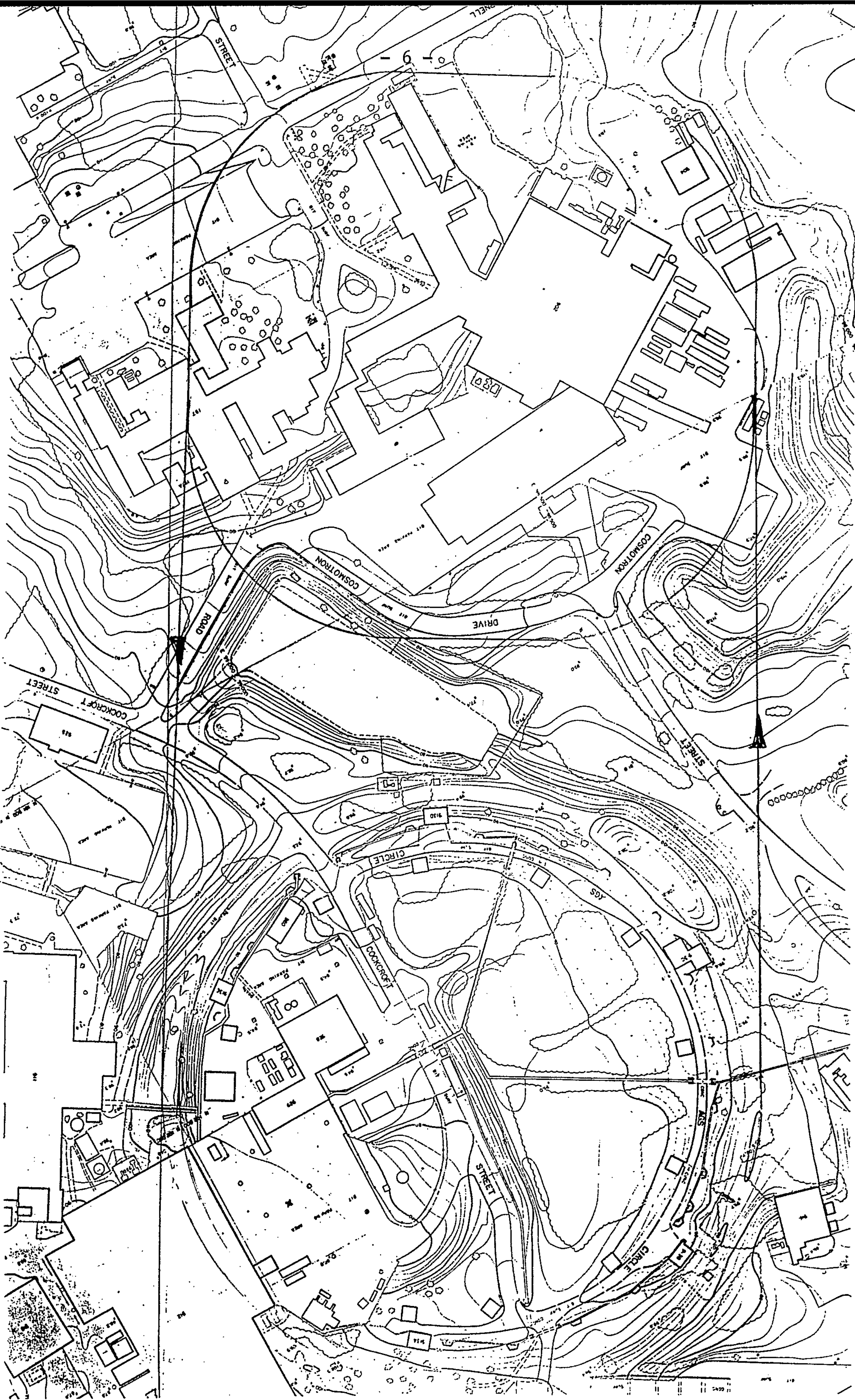

COSMOTRON
DRIVE
COSMOTRON
STREET
ROAD
COCKCROFT
STREET
CIRCLE
AGS
COCKCROFT
STREET
AGS
CIRCLE
STREET
RNELL

Figure 1

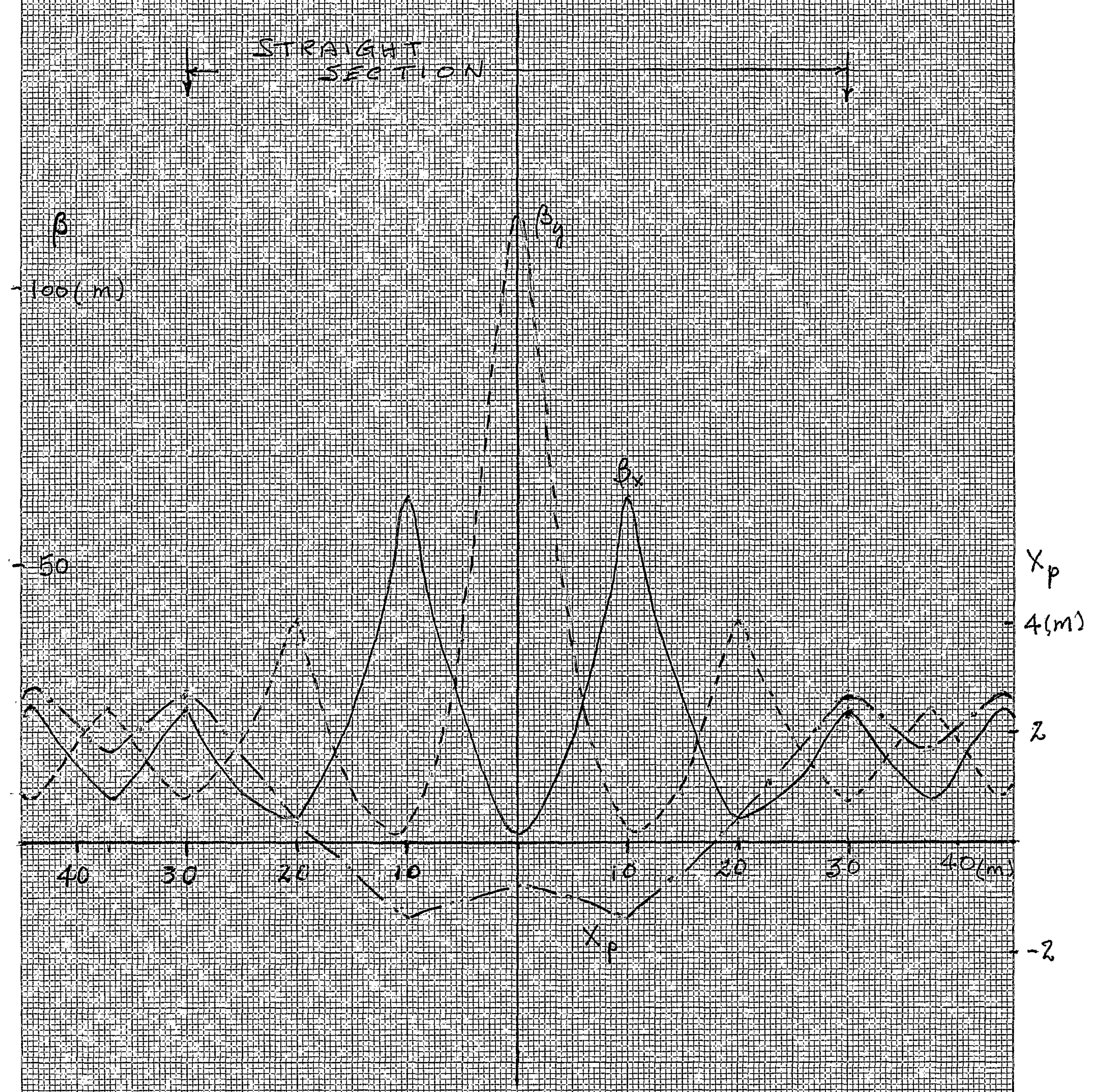
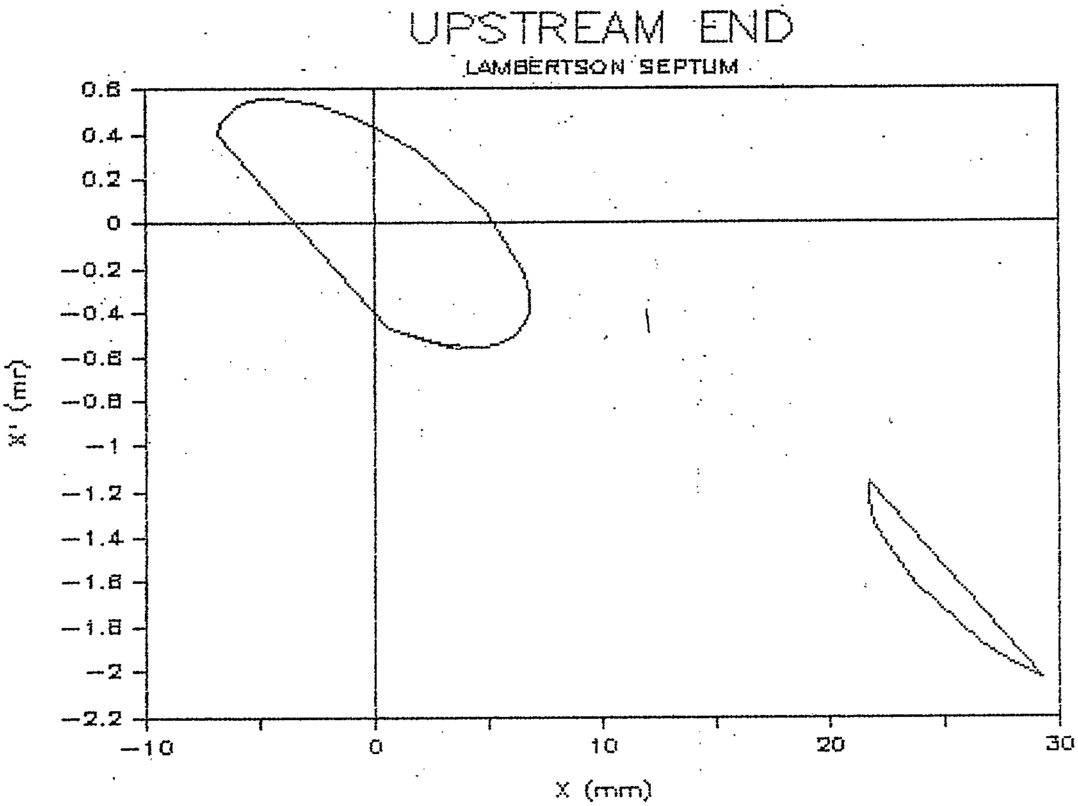

STRAIGHT SECTION
β
100 (m)
50
β_y
β_x
X_p
4 (m)
2
-2
40
30
20
10
10
20
30
40 (m)
X_p

Figure 2


UPSTREAM END
LAMBERTSON SEPTUM
X' (mr)
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.4
−1.6
−1.8
−2
−2.2
−10
0
10
20
30
X (mm)

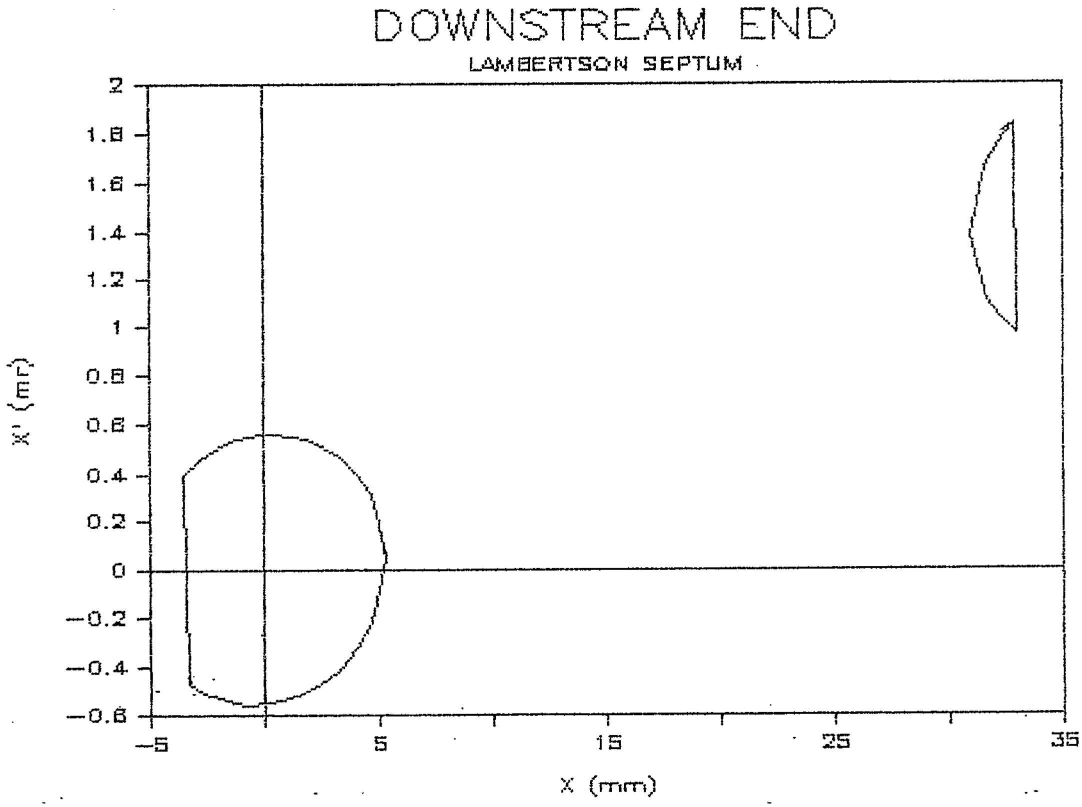

DOWNSTREAM END
LAMBERTSON SEPTUM
X' (mr)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−5
5
15
25
35
X (mm)

Figure 3