LIGO-T890058-00-R

#92

List of 5/23/90

September 27, 1989

To: R. E. Vogt, Director, LIGO Project

From: Yekta Gürsel

Subject: The report of the 40 meter prototype conceptual design team

Design Team:

Scientists: A. Abramovici, R. W. P. Drever, Y. Gürsel, F. J. Raab, R. Spero, M. Zucker

Engineers: F. Assiri, L. Jones, B. Moore

I. Abstract

Section II describes the upgrade conceptual design. In section III, the overall estimated cost of such a system broken down in a coarse fashion is given. In section IV, a finer breakdown of the costs are presented. Section V contains a very short description of the figures which are included in this report.

II. Introduction

The prototype conceptual design team has decided on a concept for the upgrade of the Caltech 40 meter prototype vacuum system. The main elements of the concept are:

(1) There are 4 test mass chambers. Each chamber is 4 feet in diameter and 6 feet high. Each has one main seismic isolation stack.

(2) There is a separate beam splitter chamber. This chamber is also 4 feet in diameter and 6 feet high. This chamber also has one main seismic isolation stack.

(3) The end test mass chambers are connected to the central test mass chambers along an arm of the interferometer with a beam pipe which is 2 feet in diameter and approximately 132 feet (40 meters) long.

(4) The central test mass chambers are connected to the beam splitter chamber with short pipes and bellows which are 2 feet in diameter.

(5) There are no large (2 feet aperture) gate-valves in the system. A place holder for them (a short piece of pipe with two flanges) will be supplied in case need for them arises.

(6) There is a 2 feet aperture, compensated bellow assembly on each arm of the interferometer.

(7) The input optics chain is contained in seven tanks which are 18 inches in diameter and about 3 feet high (with a bell jar). These tanks are connected to each other by a pipe which is 8 inches in diameter. The input chain is connected to the beam splitter tank through a 1 foot aperture with a bellows assembly. The total length of the input chain is about 67 feet (20 meters) including the laser and the initial injection optics which is in air.

(8) The output optics chain is contained in three tanks which are 18 inches in diameter and about 3 feet high (with a bell-jar). These tanks are also connected to each other by a pipe which is 8 inches in diameter. Th output chain is connected to the beam splitter tank through a 1 foot aperture with a bellows assembly. The total length of the output chain is about 50 feet (15 meters) including the photodetectors which are in air.

(9) The various bellows assemblies mentioned above are necessary to be able to take the system apart for easy access.

This vacuum system is designed to accommodate 10 kilogram test masses which are 8 inches in diameter and about 7 inches long. Each test mass chamber also contains a recoil mass identical to the test mass. The vacuum requirements of this system are:

(1) The pumping speed should be sufficient to bring the total pressure in the system below 10^{-2} Torr 2 hours after the pumping initiation. This is necessary in a test system with a reasonably short turn-around time.

(2) To be able to demonstrate the same noise equivalent displacement as required in initial LIGO, the minimum acceptable ultimate pressures are:

(i) The Nitrogen pressure: 3×10^{-6} Torr.

(ii) The Hydrogen pressure: 4×10^{-5} Torr.

(iii) The Water pressure: 4×10^{-6} Torr.

(3) To reach the quantum limit for 10 kilogram masses, i.e. to eliminate the residual gas noise entirely, the desired acceptable ultimate pressures are:

(i) The Nitrogen pressure: 6×10^{-10} Torr.

(ii) The Hydrogen pressure: 1×10^{-8} Torr.

(iii) The Water pressure: 1×10^{-9} Torr.

III. The Cost of the Upgrade

The cost estimates given in this section is for the vacuum system, the internal support structures of the tanks and the seismic isolation stacks. They do not include the cost of any of the optics, test masses, mirrors and coatings, position sensors, the electronics and the wiring needed to support the whole test system. Our past experience indicates that the cost of these required to support one vacuum tank is about the same as the cost of the vacuum chamber itself. The same "rule of thumb" seems to hold for the chamber internals (mechanical) as well. In the following, we assume that all five 4-feet-diameter chambers are of comparable construction. We made use of the parts of the present 40 meter system whenever possible. The 8 inch diameter pipe and 6 of the 10 chambers in the input-output system are parts of the present 40 meter system. We counted these as no cost items. However, the internals of these small chambers have to be redesigned for all 10 chambers since the old ones from the present 40 meter system will not be usable. The pumping system is designed to achieve an ultimate pressure somewhere between the desired acceptable ultimate pressure and the minimum acceptable ultimate pressure closer to the minimum level. It also makes use of the existing pumps in the 40 meter prototype. We also would like to indicate that not all of the details of the implementation of this upgrade has been worked out. It is possible that there may be some minor modifications to the laboratory, like reinforcing some parts of the laboratory floor or hoist replacement on the present cranes. All costs are in 1989 U.S. dollars.

Component	Amount or Number Needed	Unit Cost	Total Cost
4 feet diameter chamber	5	60,000	300,000
Chamber Internals	5	70,000	350,000
Pipe	300 feet	150/foot	45,000
Bellows, Flanges, Welding, Cleaning, Pipe support			45,000
Pumping System	1		78,000
18 inch diameter chamber	4	5,000	20,000
18 inch chamber internals	10	4,000	40,000
Lab Civil Engineering, Contingency			20,000

The total cost of the "mechanical" part of the upgrade is $898,000.

IV. Detailed Breakdown of the Cost of the Upgrade

The following is the detailed cost breakdown of the pumping system. This costing is supplied by Boude Moore.

Component	Amount or Number Needed	Unit Cost	Total Cost
Mechanical pump	1	6,230	6,230
Blower	1	7,110	7,110
Turbo Pump	1	11,245	11,245
Ion Pumps	3	11,887	35,661
Gages, Controllers	2	2,500	5,000
Shipping, sales tax			5,220
Installation, labor, material			6,525

The total for the pumping system is $77,512. A rounded figure of $78,000 is carried into the overall costing in section II.

A detailed cost breakdown of the 4 feet diameter chambers is not available. These were costed by L. Jones as a whole. The detailed breakdown of the cost of the internals of the 4 feet diameter chambers are as follows:

Component	Amount or Number Needed	Unit Cost	Total Cost
Isolation Stack Masses	4	2,500	10,000
Top support	1	1,500	1,500
Bottom support	1	3,000	3,000
"Optical Table"	1	3,000	3,000
Stack Canisters	20	2,000	40,000
Leg Assembly, Braces	4	3,125	12,500

The total for the internals of the 4 feet diameter chamber is $70,000 per chamber.

The price for the 18 inch diameter chambers are obtained from the recent order of two chambers to the machine shop for the beam splitter break-up. The cost of the internals of the 18 inch diameter tanks is an estimate as the detailed accounting from the machine shop is not yet available.

V. Figure Captions

The figures are:

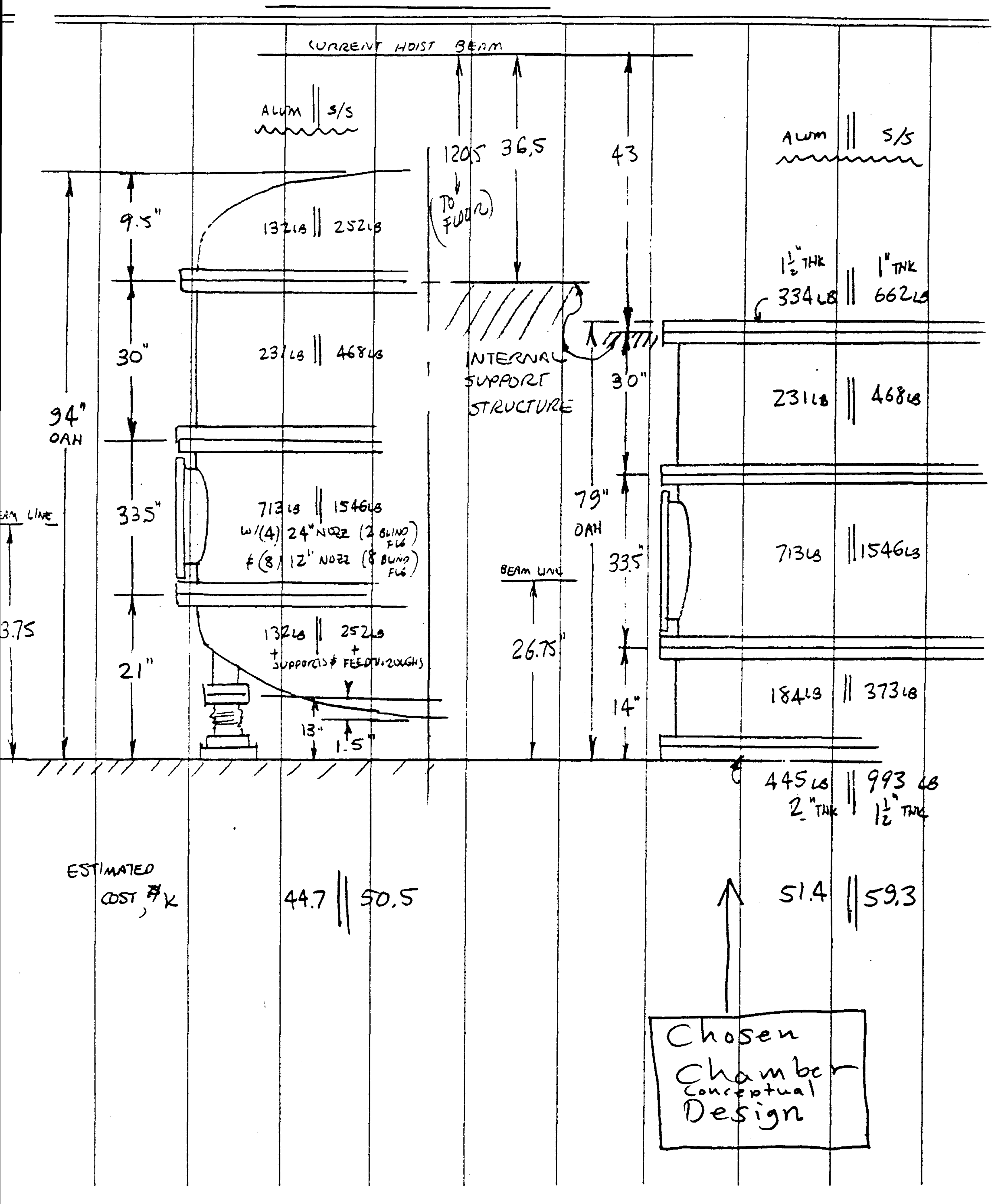
(1) The 4 feet diameter chamber concept (Drawing by L. Jones)

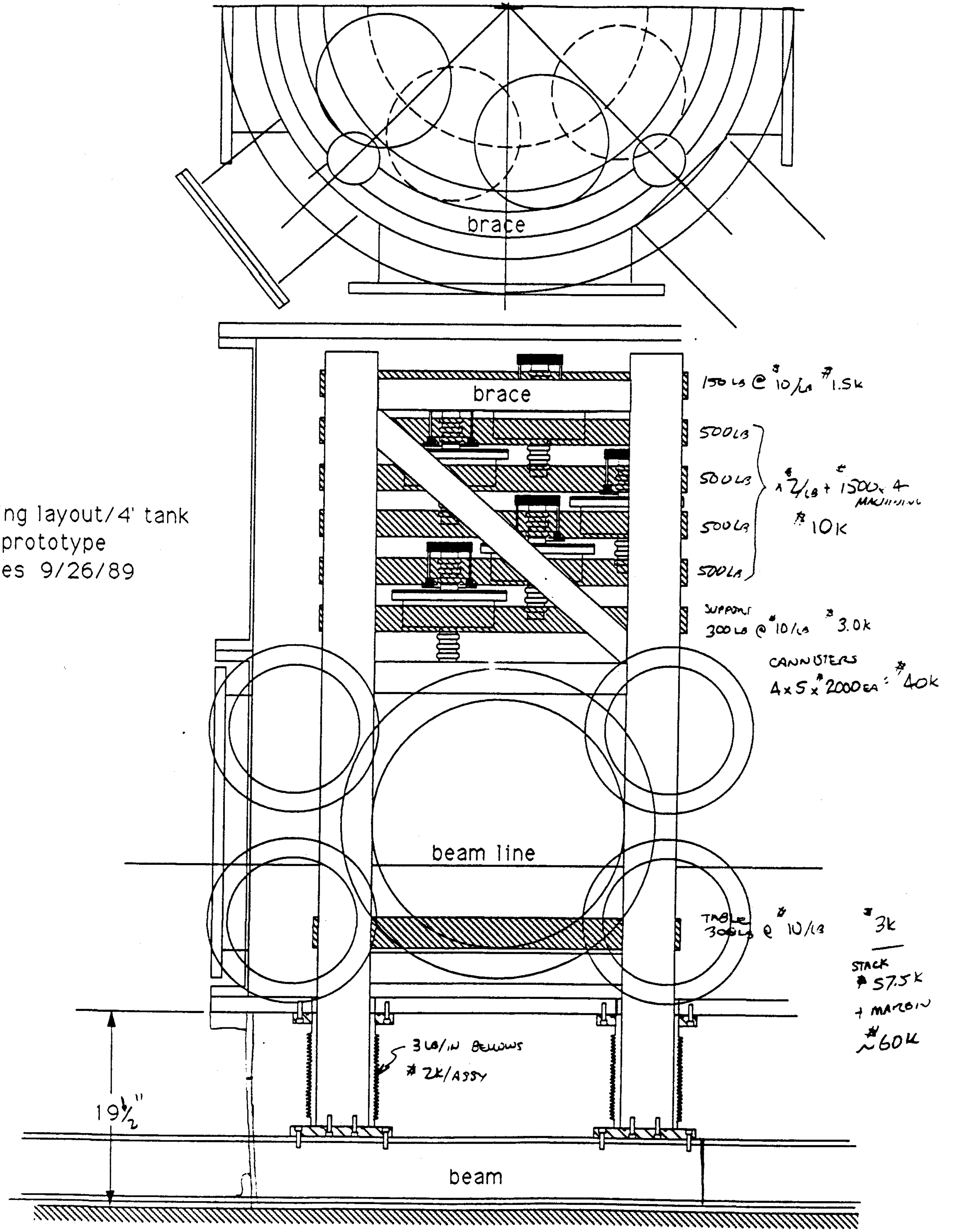
(2) The internals of the 4 feet diameter chamber (Drawing by L. Jones)

(3) The Floor plans and some detail of the upgraded lab (Drawings by A. Abramovici)

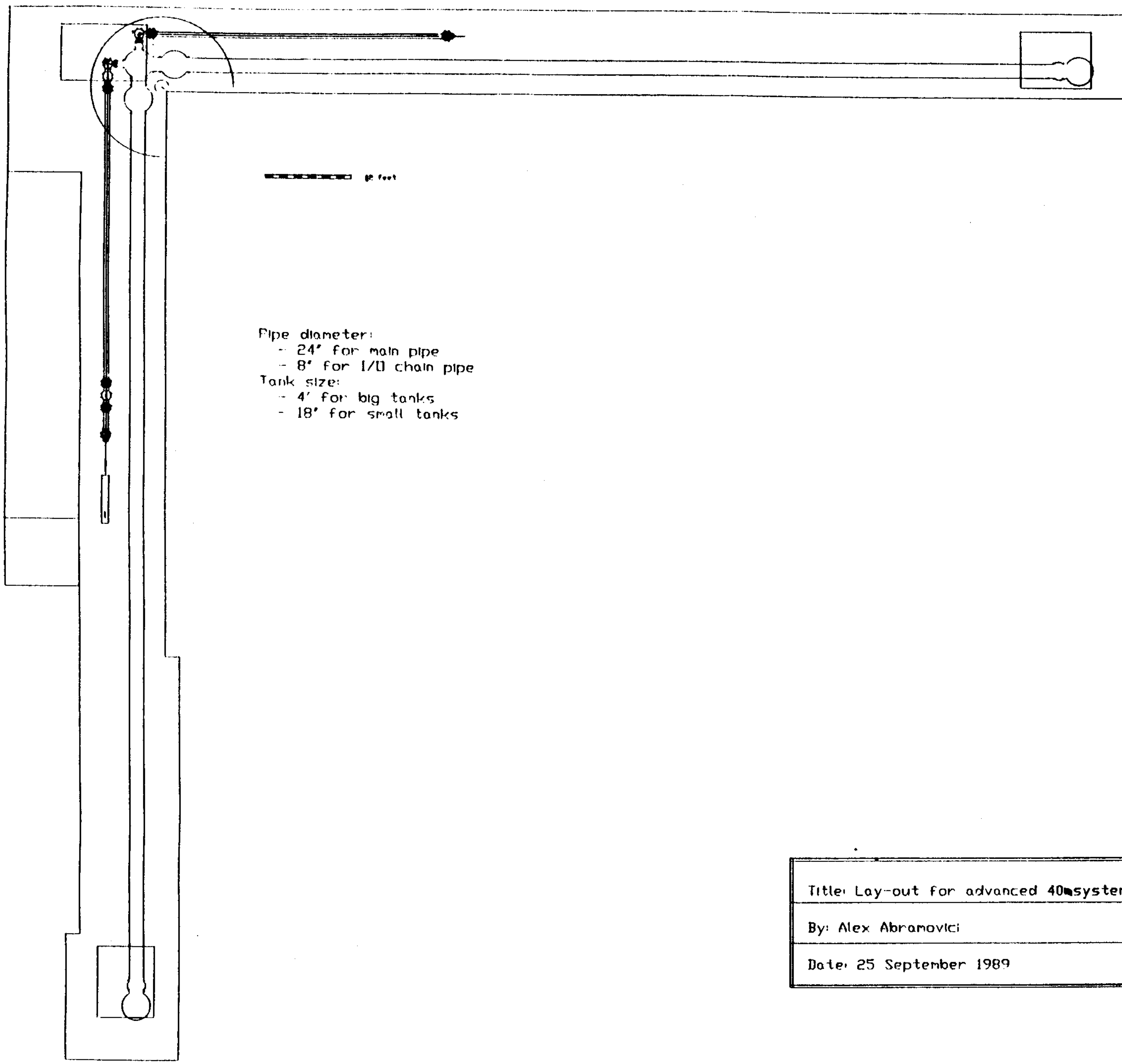
40 M PROTOTYPE UPGRADE: 4' ϕ TANK OPTIONS

9-22-8

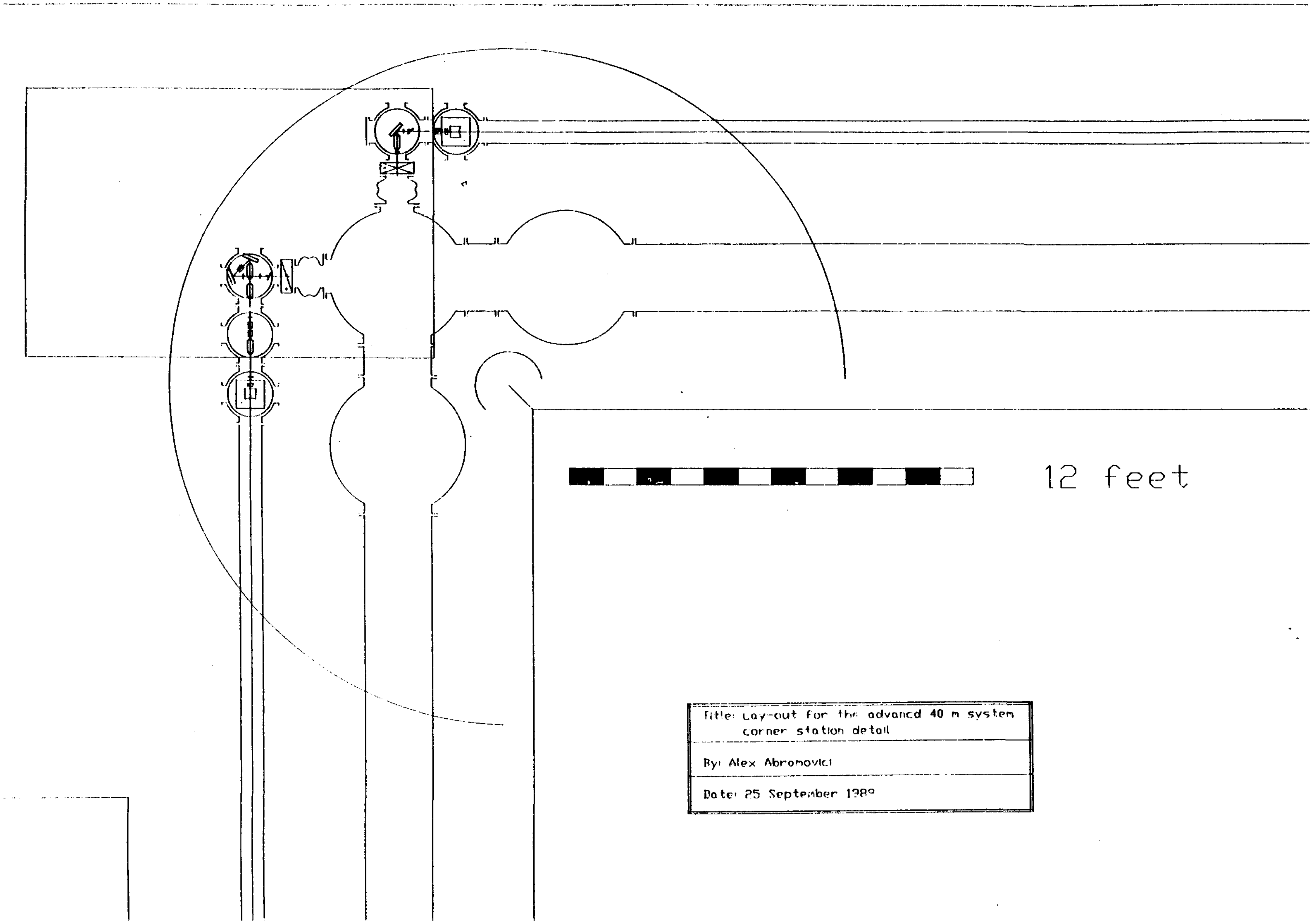




working layout/4' tank
40 m prototype
L. Jones 9/26/89

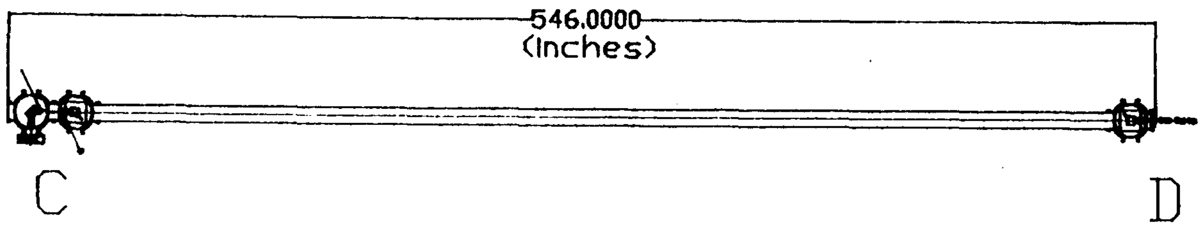


Title: Lay-out for advanced 40m system
By: Alex Abramovici
Date: 25 September 1989

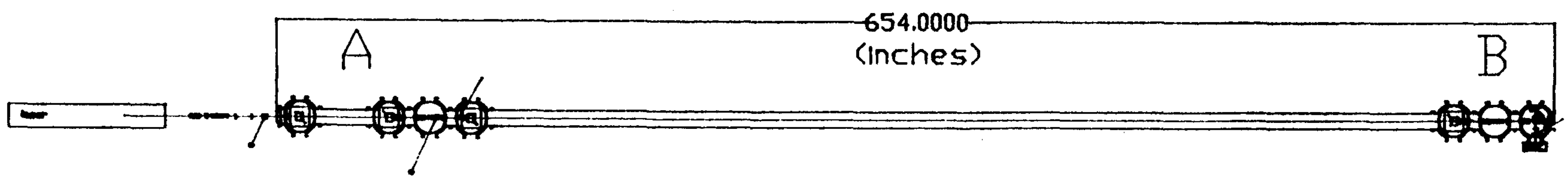

12 feet
Title: Lay-out for the advancd 40 m system
corner station detail
By: Alex Abromovici
Date: 25 September 1989

Title: Overall view of I/O chain vacuum enclosure
By: Alex Abramovici
Date: 25 September 1989

Vacuum enclosure for output optics



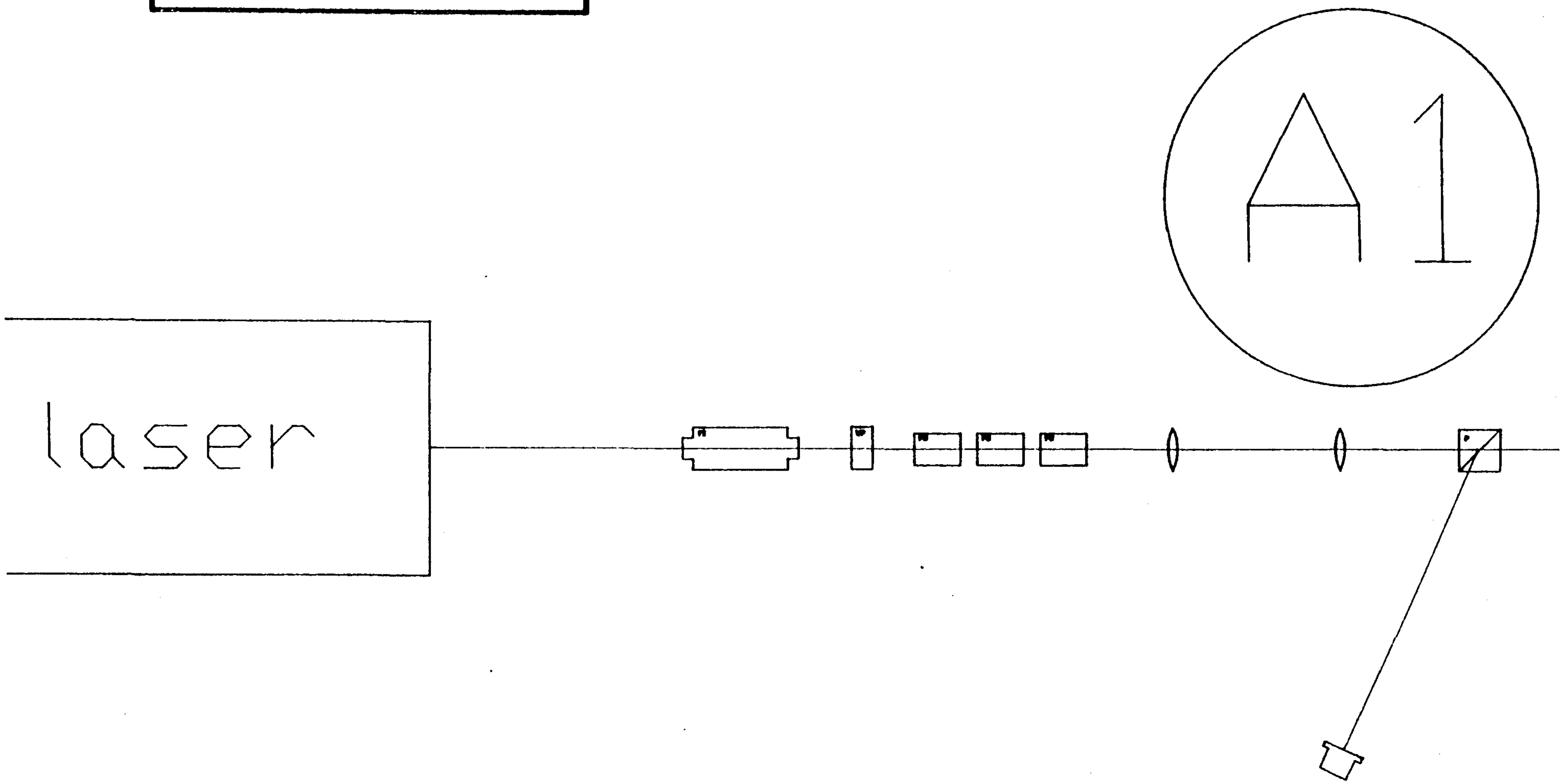
Vacuum enclosure for input optics



Title: Input chain detail, section A2

By: Alex Abramovici

Date: 25 September 1989



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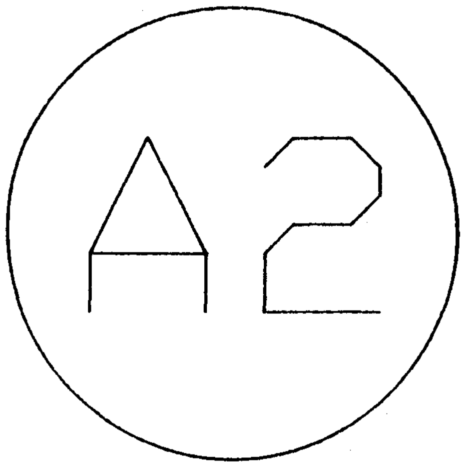

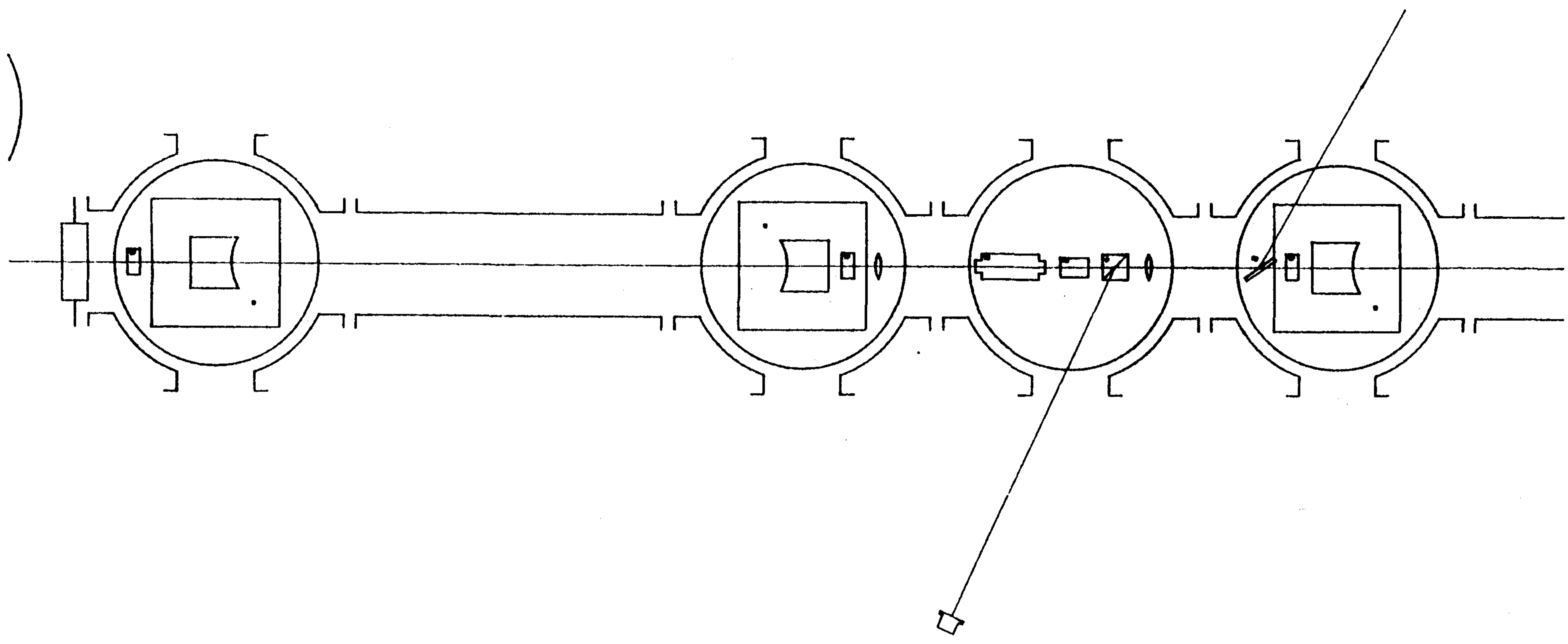

Title: Input chain detail, section B
By: Alex Abramovici
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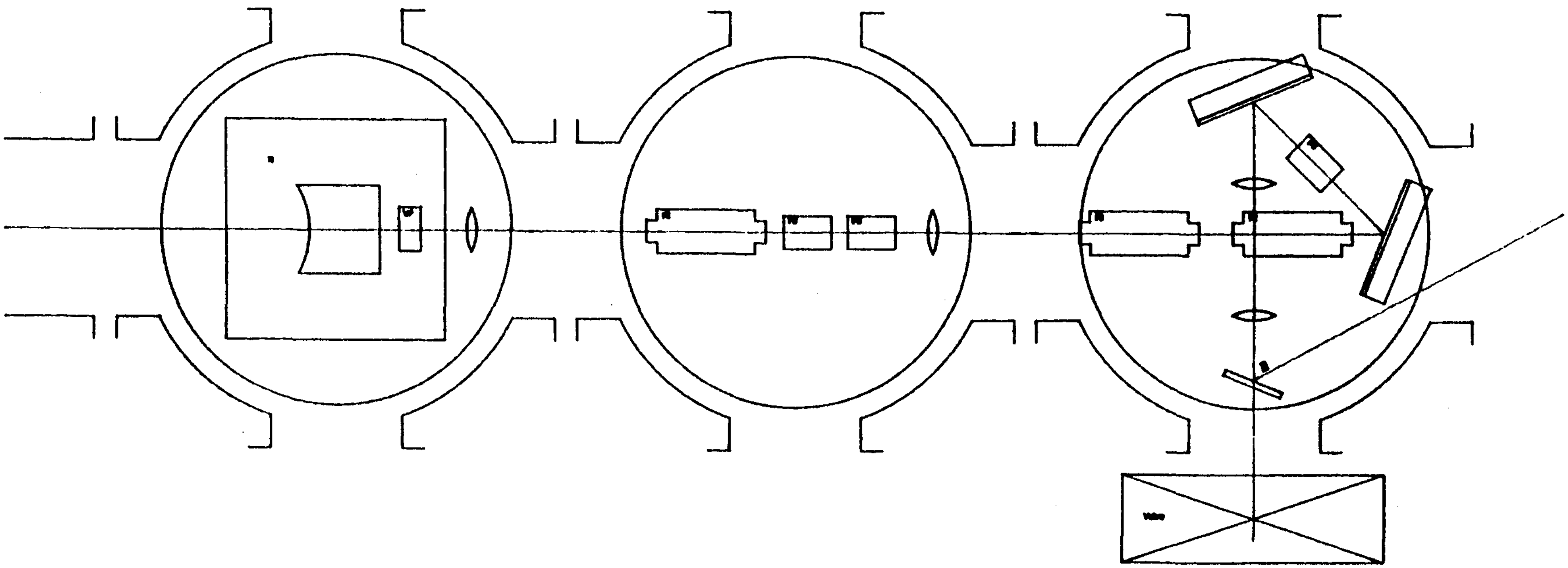
B



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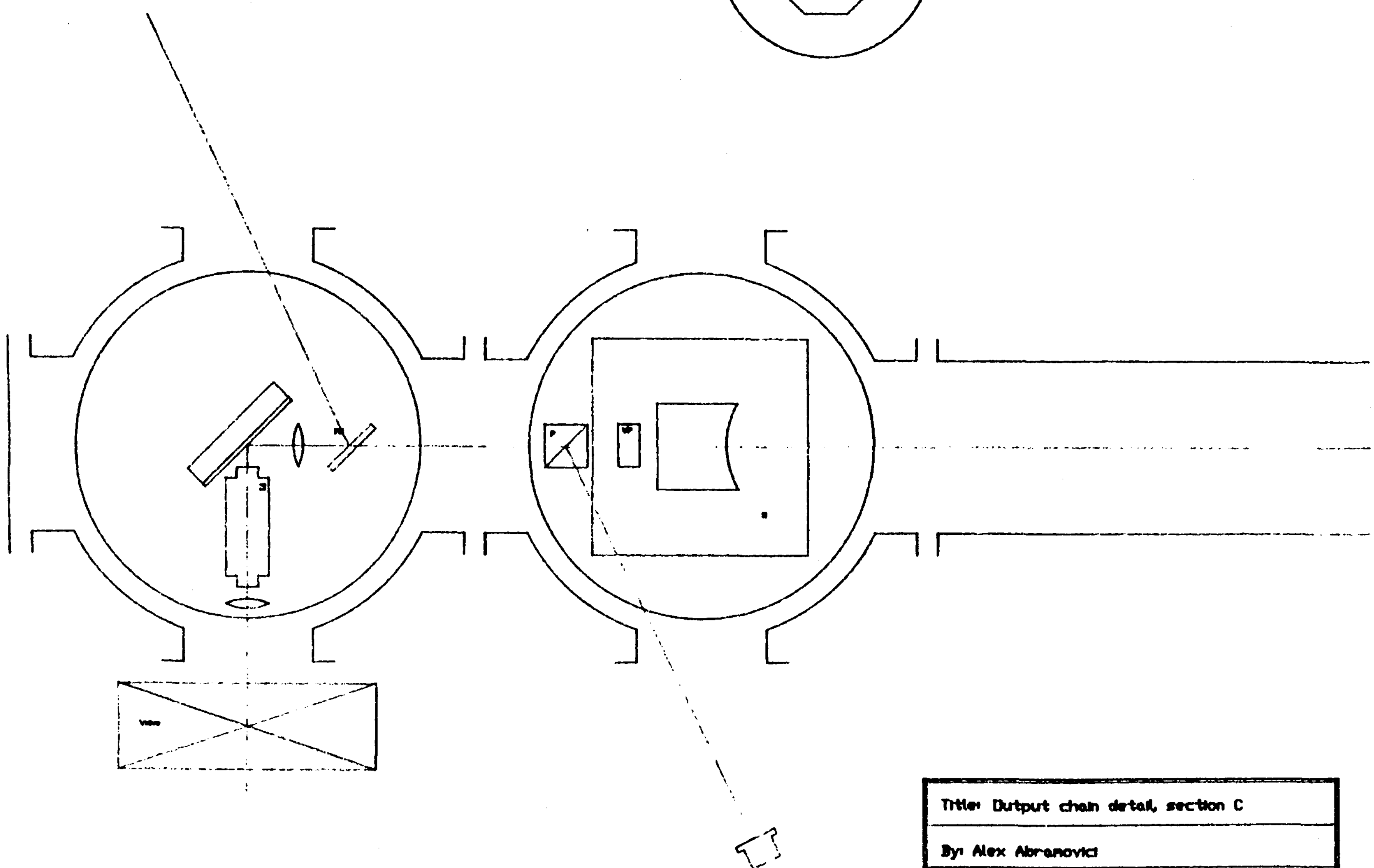

Title: Output chain detail, section C

By: Alex Abramovici

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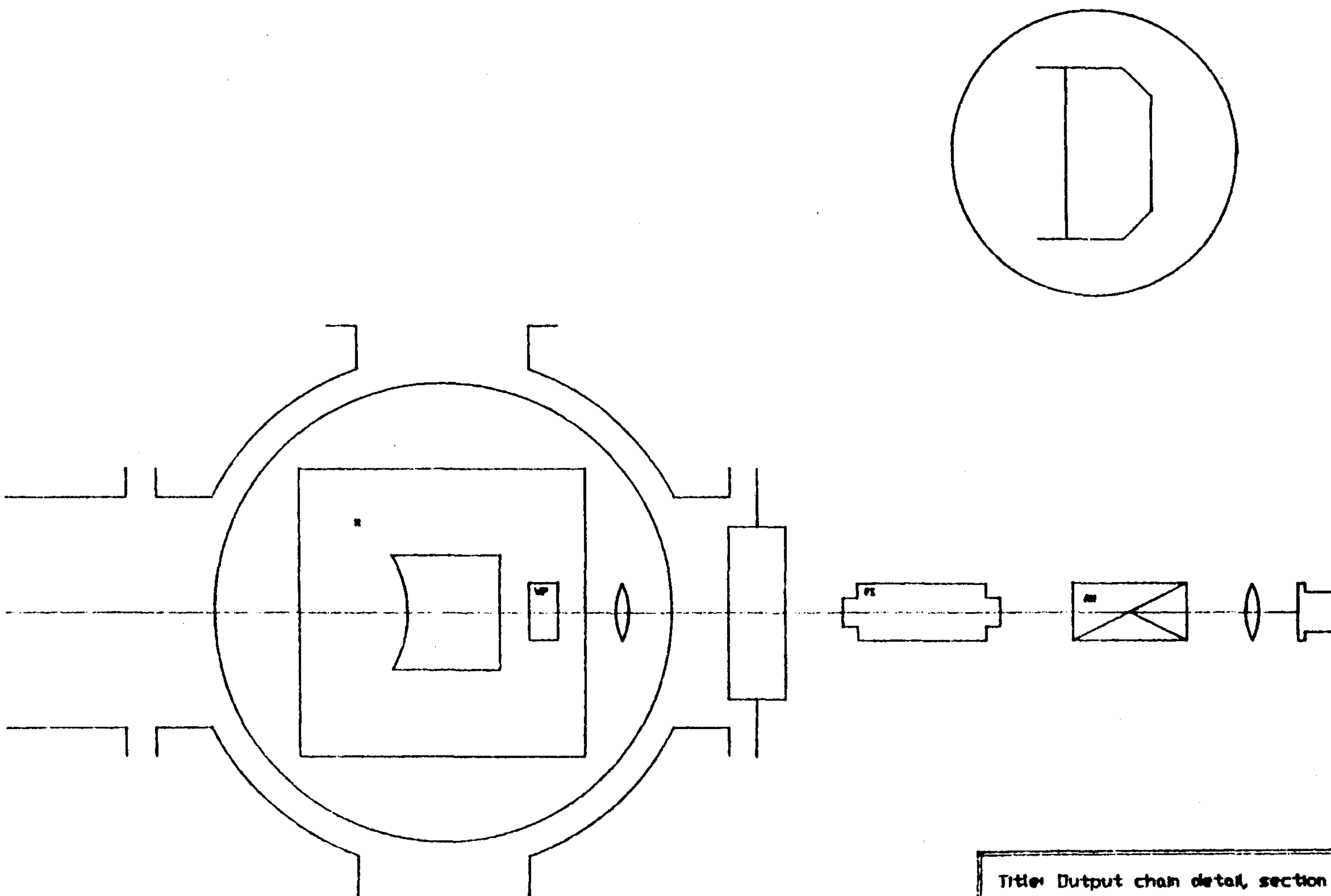

Title: Output chain detail, section D

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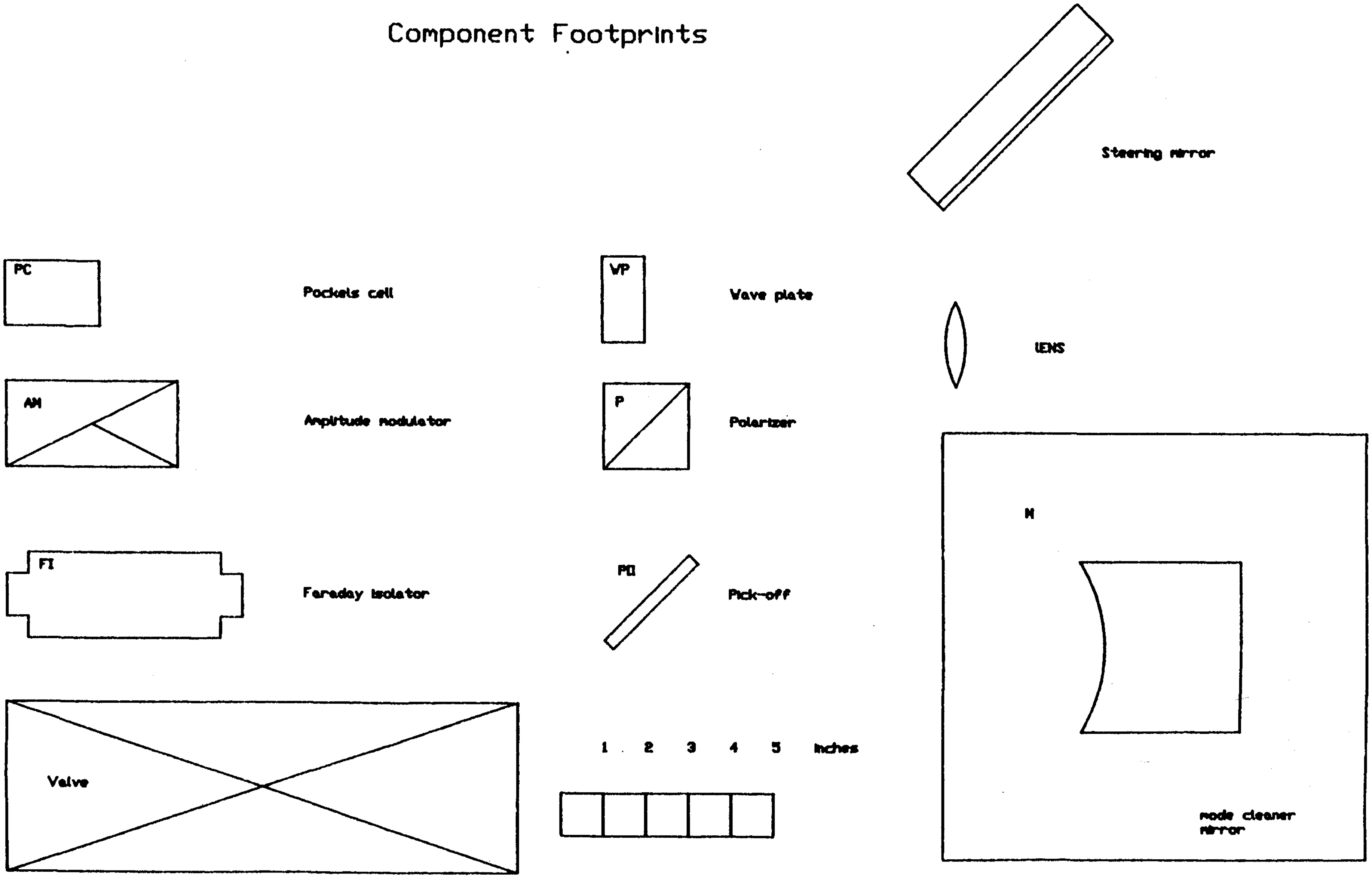
Component Footprints



Component tank outline