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RADIATION PROJECT INTERNAL
REPORT NO. 11
CASINO Facility Mechanical Engineering
and Design Status Report
by

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Advanced Technology Branch
Plasma Physics Division

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CASINO FACILITY MECHANICAL ENGINEERING AND DESIGN STATUS REPORT

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INTRODUCTION

Engineering and design work has proceeded on this facility according to the GAMBLE I and CASINO flow chart as revised 30 December 1968.

The object of the present approach is to use an optimum number of coaxial pulser units in parallel, mounted in such a way that the flux beam of each diode focuses at the same point. To maximize the flux density incident on a target, the path length from the diode anode to the common focal point must be minimized. This requirement can best be met by arranging the pulser modules in a cluster with the long axes forming elements of a cone. The anode should be as close to the apex of this cone as the physical dimensions of the output end of the diode will permit. The design is based on a cluster of six pulse lines with cone angle of 110°. The cone angle is the angle between the long axes of opposing pairs of pulse lines. The success of the concept of modularizing coaxial pulse lines and focusing their beams within a few centimeters of the diode anode depends upon the ability to mount the diodes in precise relation to one another without at the same time having this precision extend to the mounting of the pulse line in general. The diodes must be easily and quickly removed and replaced with repeatability of position.

The high field strengths associated with the pulse former section and output end of the transformer section make it desirable to eliminate support structures through the field wherever possible.

Each pulse line will be charged by a 70 stage Marx pulse charger. The Marx will be similar to the one which is to drive the optimized GAMBLE I. Its capacity will be 175 kJ at 100 kV per stage or 125 kJ at 85 kV per stage. The outside dimensions of the pulse line will be the same as GAMBLE I.[1] The geometry of the diode envelope which is a function of the cluster cone angle and the pulse line outside diameter is thus determined.

DESCRIPTION

Fig. 1, an elevation view through the center of the facility shows two of the pulse lines mounted in the water dielectric tank at the 110° cone angle. Their output ends are bolted and indexed to the target chamber. The pulse line is mounted on rails attached to the tank structure. A flexible joint between pulse line and diode permits the position of the diode to be determined by the target chamber. The charging end of the pulse line is bolted to one end of a 145° elbow which is bolted and gasketed to a flange of the tank. The other end of the elbow is bolted and gasketed to the Marx. Two diaphragms are used, one between the Marx

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1 "Considerations Concerning the Optimization of GAMBLE I", by J.S. Shipman, Jr., (Internal Report).

and the elbow is an oil-to-oil diaphragm and the other one between the elbow and the pulse line is a water-to-water diaphragm. The use of two diaphragms instead of one as in GAMBLE I serves two purposes: (1) if the oil-oil diaphragm ruptures and the oil-water diaphragm does not, then only the water between the diaphragms enters the oil;[1] (2) the use of two diaphragms provides two reaction points from which the pulse former can be cantilever from the diaphragm with resulting forces acting in the plane of the diaphragms and producing tensile stresses only.

The structure in the center of the tank is a room for housing laser and photographic equipment for triggering and observing the spark gaps. The structure also serves as a base for mounting components and reduces the amount of water in the tank.

As shown in Fig. 1, the pulser modules are submerged in a common tank of water rather than making each a water tight vessel, containing its own water. This arrangement has the following advantages:

1. The joint between the diode and the pulse line does not need to be water tight.
2. Shock induced stresses in the outer conductor skin are reduced.

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1 "Considerations Concerning the Optimization of GAMBLE I", by J.S. Shipman, Jr., (Internal Report).

3. Diodes can be removed without lowering water level.

4. Repairs to tank ruptures will be simpler since water tightness is not required.

5. Radiation shielding required over 2π instead of 4π steradians.

6. Noise from spark gap is reduced.

Disadvantages are:

1. Dielectric water tank is required.
2. Larger water processing system is required.

Extra initial cost due to submergence:

Dielectric water tank	100 K
Storage tank	20 K
Extra deionization equipment	10 K
	130 K
Less savings due to simpler design of pulser	60 K
Total extra initial cost	180 K

This extra cost would be offset by quicker diode removal and replacement, simpler shielding, less noise, less probability of breakdown due to tank rupture, relative ease of repairing ruptures.

The second floor level coincides with the top of the water dielectric tank. It contains control room, screened room, laboratories and offices. A revolving electric hoist is provided for lifting components in and out of the tank and from first to second floor. The steps shown in Fig. 1 connect the second floor level with catwalks around the top of the Marx generators.

Fig. 2 shows arrangement of Marx generators and water and oil processing equipment on the first floor. Each pair of Marx generators is provided with a separate oil handling and filtering system. Three small tanks rather than one large tank are used to prevent contaminated oil due to a ruptured diaphragm from becoming mixed with a large volume of good oil. Demineralized water storage tanks are located inside the building so that stored water will remain at ambient room temperature to reduce bubble formation after transferring the water from storage to the main tank.

Fig. 3 shows the second floor arrangement. The area over each Marx generator and between each pair of Marx generators is left open to the roof to provide space for maneuvering when repairs are in progress. Areas over the pulsers are left open for the same reason. Not shown in Fig. 3, is a removable floor section to provide access to the target chamber. Walkways along the sides of the Marx generator tanks are reached by steps down from the main area.

FOCUSING

To insure that the six diode center lines converge at the required point, a sturdy jig is required. The jig must hold the diodes in the proper position, permit easy removal and replacement of any diode and provide for repeatability of position.

Fig. 4 shows, in the top view, the outline of the jig with the output end of two diodes in place. The bottom view shows, in elevation, a cross section of the jig and diode on the left side of the jig vertical center line and a full view on the right side. The focal point of the diodes falls at the center of the jig as shown so that the jig also serves as the target chamber. The method of bolting and indexing the diode to the jig does not show in the figure.

DIODE

As noted above, the diode envelope geometry is fixed by the cluster cone angle and the outside diameter of the pulse line. To maximize the incident flux density the cluster cone angle must be minimized. Two factors limit the acuteness of this angle: (1) as the cluster cone angle decreases, the diode taper decreases and since the diameter of the input end of the diode is fixed, the length of the diode increases; (2) if individual anode converter assemblies are used, the diameter of the target chamber at a point corresponding to the center of the assemblies must be large enough so that the circumference at this point is slightly larger than the sum of the diameters of the anode-converter assemblies. If a single anode-converter, common to all six diodes were used this limitation on the cluster cone angle would not exist. A common anode-converter is more expensive and since it is an expendable item the individual assemblies are desirable. Figs. 4 and 5 illustrate the problem. The present design is based on individual anode-converter assemblies which fixes the minimum cluster cone angle at 110°.

In order for the target chamber to be the controlling factor in positioning the diode some flexibility in the coupling mechanism between the pulse line and the diode is required. This is accomplished by making electrical contact between diode-cathode and inner conductor of the pulse line by spring loaded pins which contact a continuous ring, thus the quality of the electrical contact is independent of angular orientation or parallism between diode and pulse line. The ground connection between diode and pulse line is made by a quick acting clamp, continuous around the circumference, similar to the type used to attach tops to large steel drums. To facilitate removal and re-assembly the diode is hinged to the pulse line by a hinge with a removable pin. The hinge point is located so that the mating face of the diode swings clear of the face of the chamber.

Cathode tips and converters are replaceable through the target chamber which is above the water level.

WATER DIELECTRIC

When the system is operational the water dielectric tank is filled to a point just above the transformer leaving the diode output end projecting above the water level. Recirculated water direct from the deionizer and filter is pumped at the rate of 15-40 GPM directly into each pulse line, forcing return water out into the tank through suitable holes in the pulser skin. Water level is controlled by push button from a station on the second floor. Plumbing is sized to empty the tank in 53 minutes. This is deemed fast enough due to the fact that inspection or removal of diodes does not involve removal of water from the tank as in the case of GAMBLE I.

OIL DIELECTRIC

Three duplicate processing systems are used, each serving a pair of Marx generators. A system consists of storage tank, drain and fill pump, circulating pump and a combination filter and water separator. Fifteen minutes will be required to drain or fill each Marx. Three Marx generators can be filled in parallel.

VACUUM

Each diode is connected to a common manifold through a flexible line and equipped with vacuum gauges and isolation valves. A partial view of the manifold and plumbing to the diode is shown in Fig. 1. The system will be engineered when more data is available on vacuum requirements for the diode.

SUMMARY

The facility consists of six coaxial pulsers arranged in a conical cluster with their long axes converging at a common point inside of a target chamber. The cluster is mounted in a water tank containing deionized water which serves as the dielectric. Each pulser is driven by a 70-stage Marx pulse charger. Marx and pulser are connected by an elbow transition piece which penetrates the water tank wall. The building required to house the facility is a two story, slab on the ground structure roughly 105 ft square. Marx generators and water and oil processing equipment are on the first floor. Access to the target chamber is at the center of the second floor at floor level. All experimental operations would be conducted on the second floor. Overhead cranes are provided over Marx generators and pulsers.

Conceptual design is complete. The critical problems of mounting the diodes, pulse former, and transformer have been solved in detail and all other problems have been solved in principle.

A preliminary cost estimate indicates the following:

Cost of facility exclusive of Marx pulse chargers	927 K
Marx generators, 6 at $200 K	1200 K
Cost of building	636 K
TOTAL COST	2736 K

FIGURE CAPTIONS

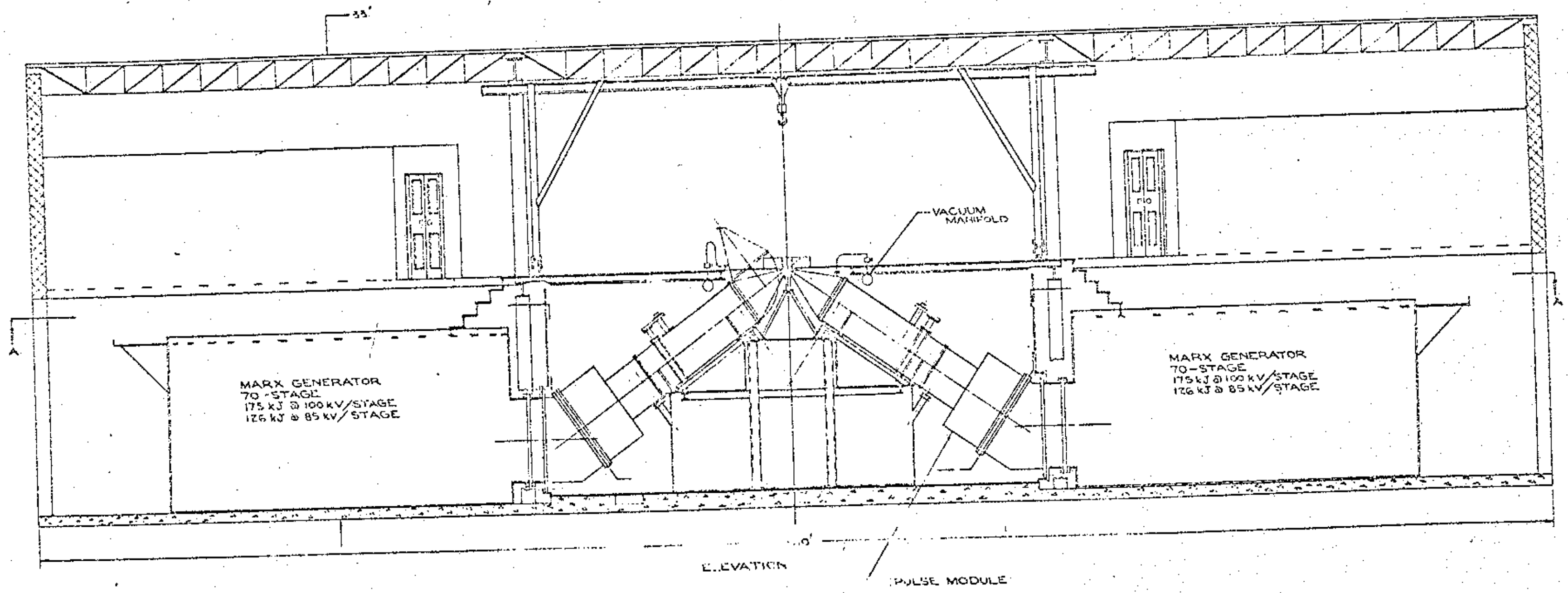
FIGURE 1. Elevation of Cross Section through Center of Facility

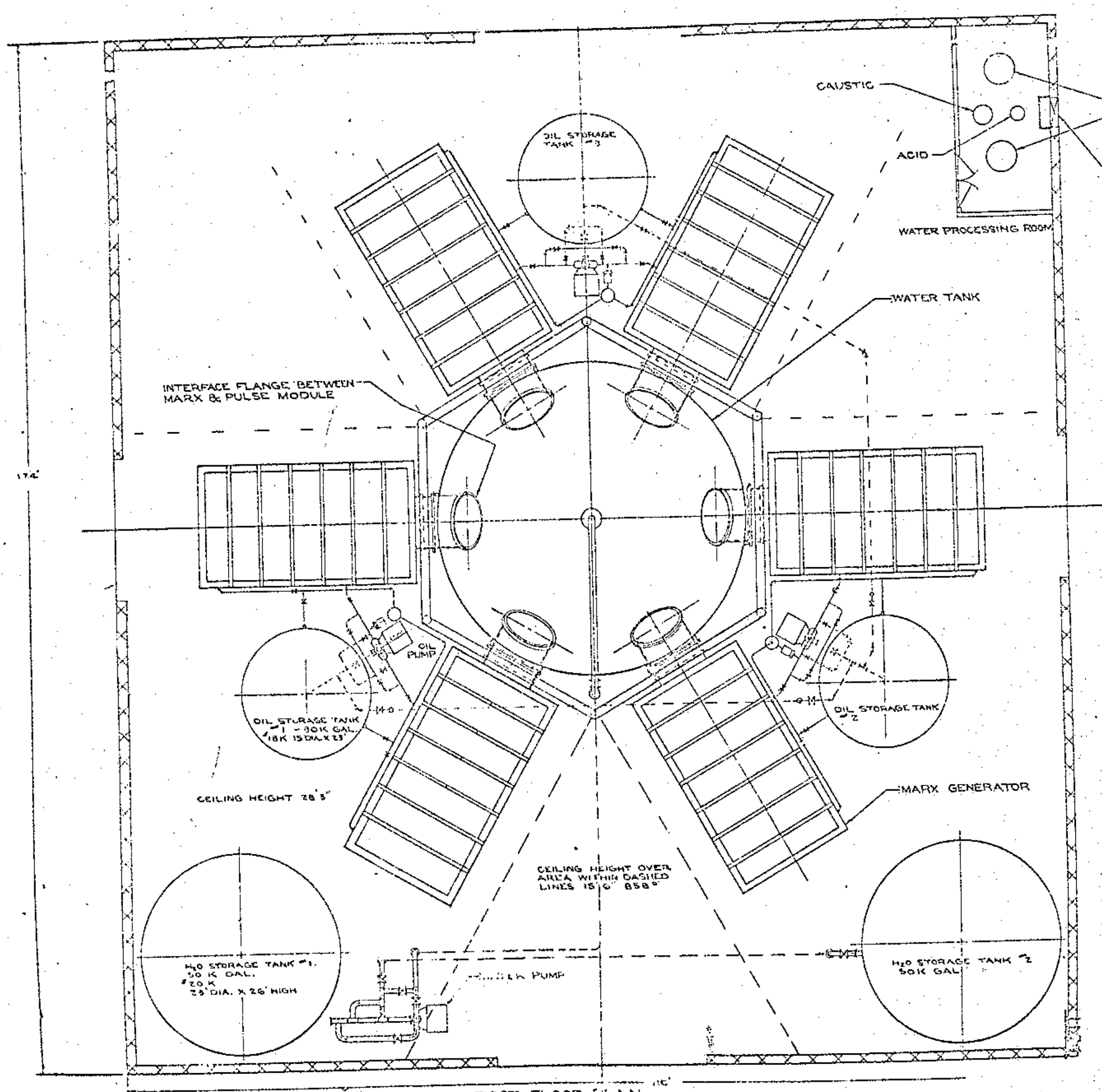
FIGURE 2. First Floor Plan

FIGURE 3. Second Floor Plan

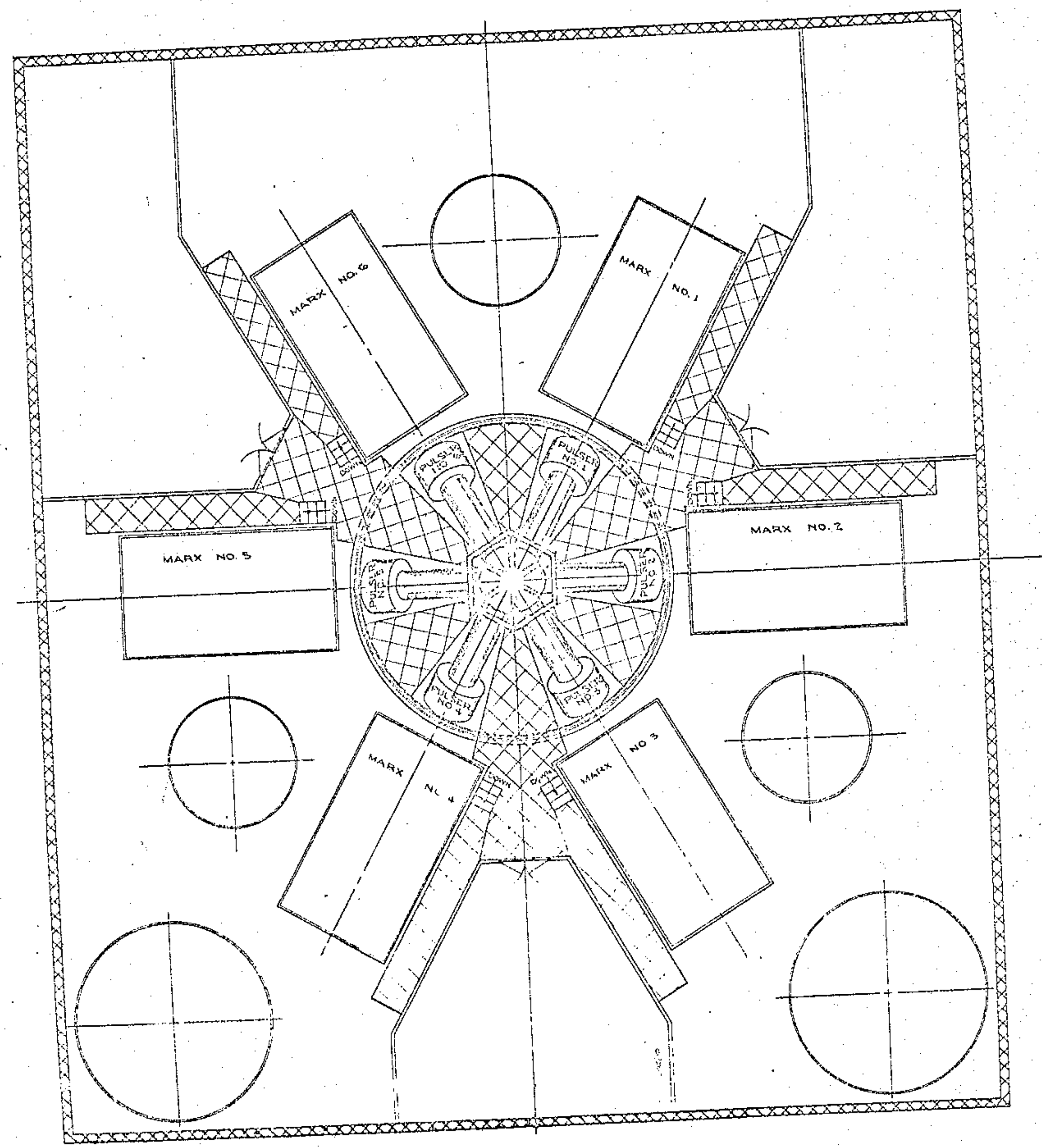
FIGURE 4. Diode-Target Chamber Junction

FIGURE 5. Diode Assembly

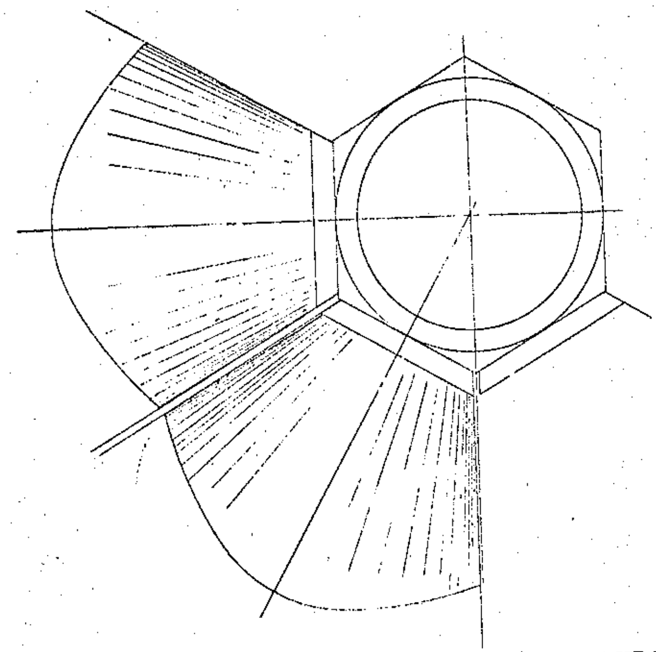

33'
VACUUM MANIFOLD
MARX GENERATOR
70-STAGE
175 kJ @ 100 kV/STAGE
126 kJ @ 85 kV/STAGE
MARX GENERATOR
70-STAGE
175 kJ @ 100 kV/STAGE
126 kJ @ 85 kV/STAGE
ELEVATION
PULSE MODULE

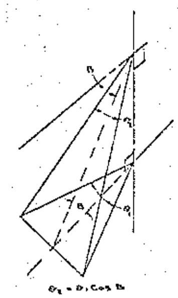


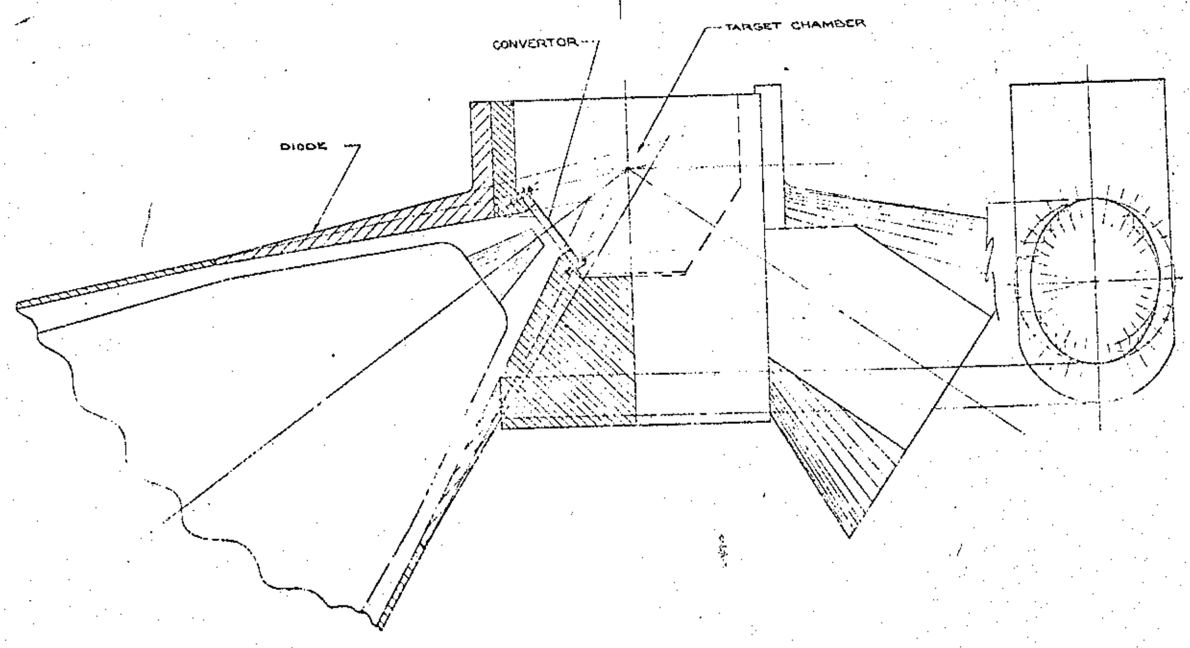
FIRST FLOOR PLAN
SECTION A-A
(PULSE MODULES NOT SHOWN)

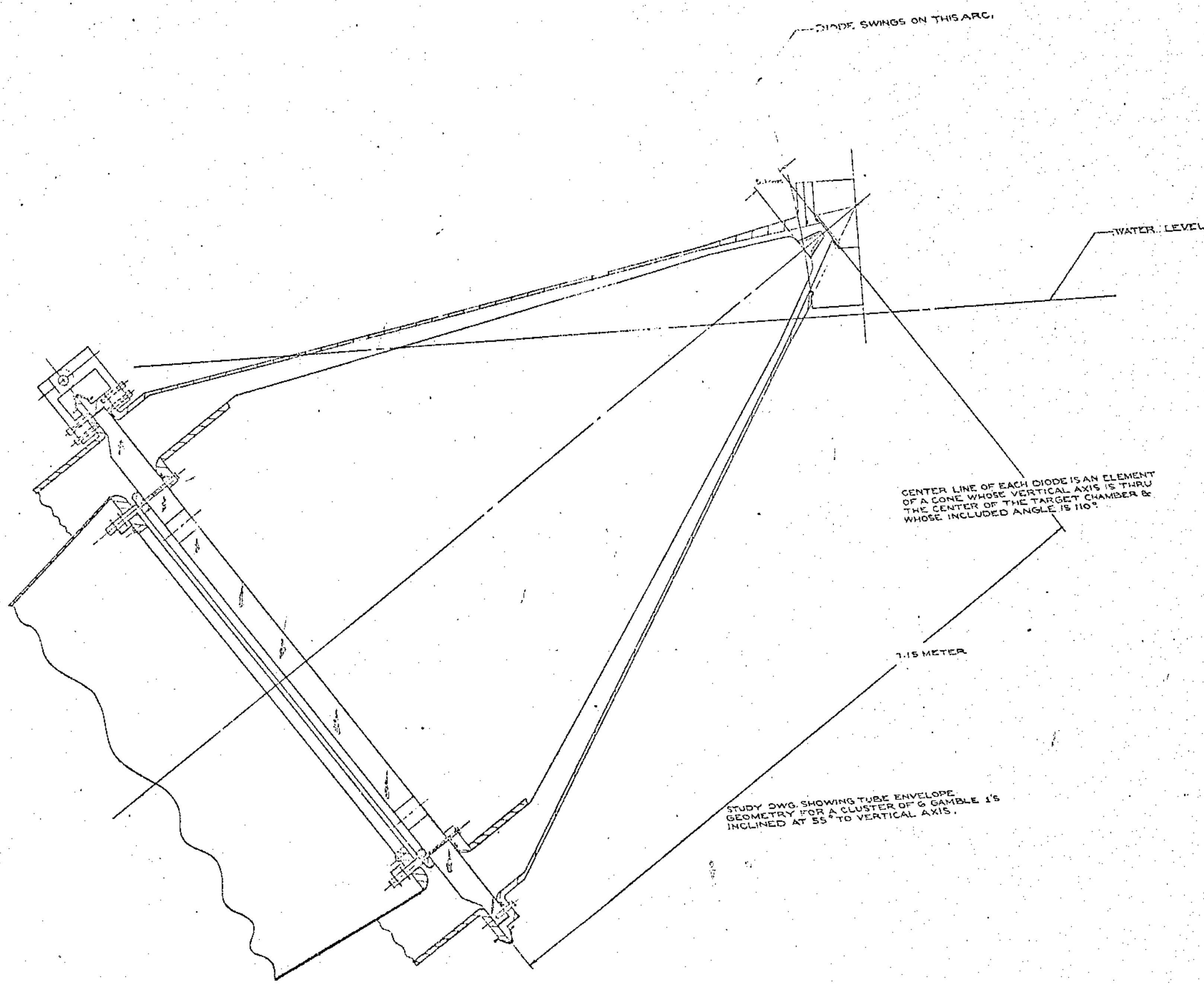


PLAN VIEW
SECOND FLOOR LEVEL






CONVERTOR
TARGET CHAMBER
DIODE


DIODE SWINGS ON THIS ARC.
WATER LEVEL
CENTER LINE OF EACH DIODE IS AN ELEMENT OF A CONE WHOSE VERTICAL AXIS IS THRU THE CENTER OF THE TARGET CHAMBER & WHOSE INCLUDED ANGLE IS 110°
1.15 METER
STUDY DWG. SHOWING TUBE ENVELOPE GEOMETRY FOR A CLUSTER OF 6 GAMBLE 1'S INCLINED AT 55° TO VERTICAL AXIS.