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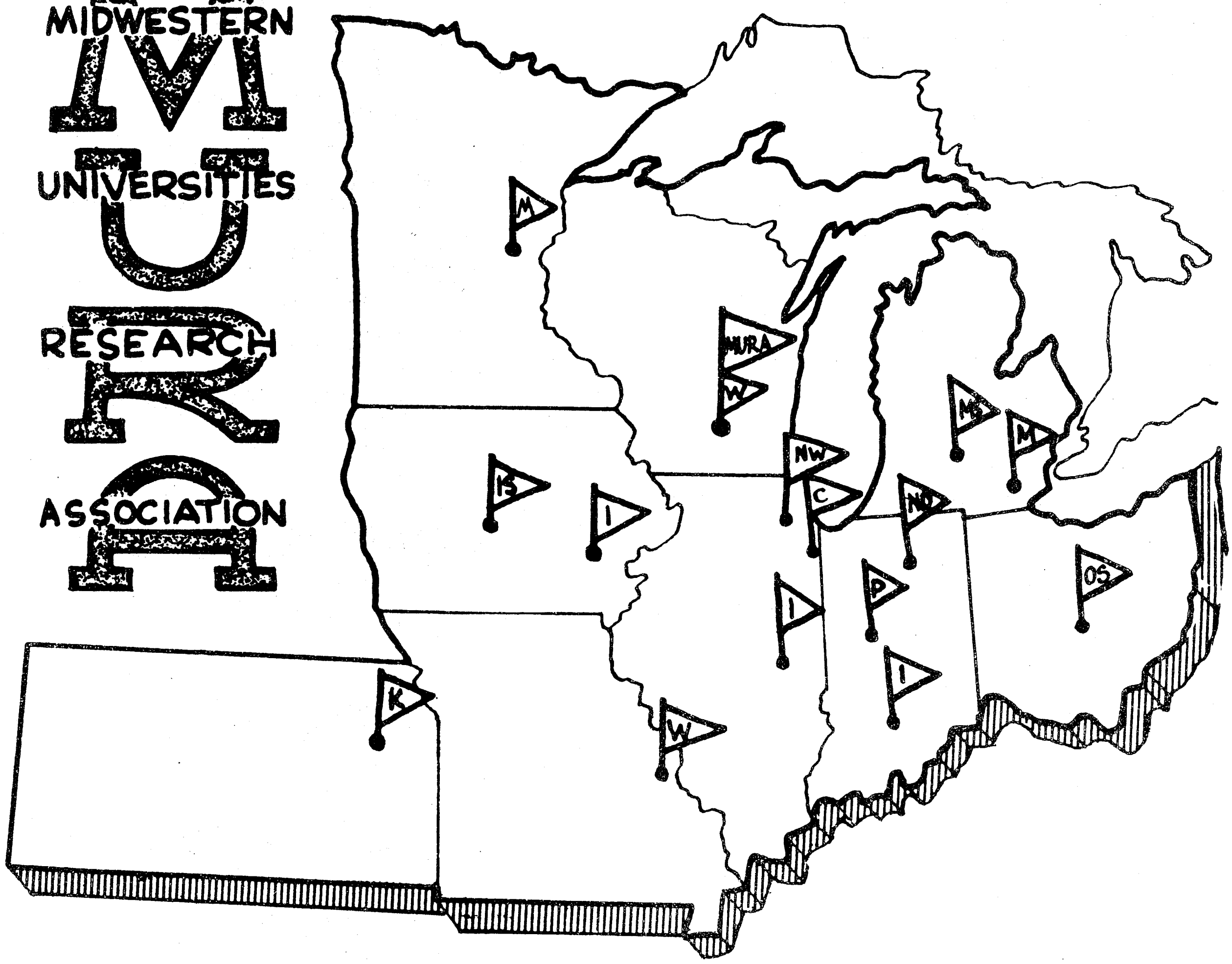


# PRELIMINARY DESIGN DEVELOPMENT OF A VACUUM CHAMBER FOR THE ARGONNE ZGS

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P.O. Box 6, Stoughton, Wisconsin

# PRELIMINARY DESIGN DEVELOPMENT OF A VACUUM CHAMBER FOR THE ARGONNE ZGS

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March 1, 1965

## ABSTRACT

There is a need for a new vacuum chamber for the Argonne Zero Gradient Synchrotron. The chamber must have the following design features: withstanding full atmospheric load without suffering permanent deformation, operating in a region of high radiation without loss of vacuum or structural integrity, and operating in a pulsing magnetic field with a minimum of eddy current effects. This report gives the development of one possible design.

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In mid February 1964 a work project was proposed by Argonne engineers for the purpose of designing a vacuum chamber for the ZGS with the following features:

A. To be capable of withstanding full internal or external atmospheric-to-vacuum loads without permanent damage to the chamber.

B. To be capable of assembly into the ZGS with a minimum of magnet disassembly--possibly by opening the straight sections only.

C. To reduce the eddy current effects by a factor of 2.

The design would be based on a criteria of full 5-1/4 aperture at a maximum outer vacuum chamber pressure of 1 millimeter. Greater pressures would reduce this aperture.

The reasons for this improved chamber design are as follows:

A. With the known limited life of the plastics of the present vacuum chamber under a radiation environment, it is necessary to be able to replace vacuum chambers from time to time.[1] Easy replacement of the chambers will require much less down time of the machine.

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1 See Reference.

B. Until the vacuum pumping system has been proved 100% reliable, it is necessary that the chamber be capable of withstanding greater momentary loads than at present.

C. Higher beam intensities in the future will cause higher radiation levels. If the chamber cannot be readily replaced it must be capable of withstanding the higher radiation levels.

The above mentioned work project was authorized, and, as recorded in a March 23 Progress Report, five designs were being actively pursued.

1. A brazed and welded panel of ceramic and titanium alloy.
2. An all-welded titanium alloy space metal panel.
3. An all-welded titanium alloy continuous bellows.
4. Titanium alloy fused to glass.
5. Titanium alloy bag-type design.

In April 1964 a cooperative effort between Argonne and MURA engineers was initiated, and on April 20, W. R. Winter of MURA met with W. B. Hanson at Argonne.

At this meeting the above five designs were discussed, and because of the additional design criteria listed below it was decided that only designs 1 and 2 remained feasible.

1 - Pole face windings are to be provided (permitting thicker metal in the tank walls).

2 - A 4-1/2" inside vertical aperture is all that is required. (allowing more room for support members)

3 - The magnet yoke could be used for supporting the air load on the chamber.

It was further decided that MURA would pursue design 2 and Argonne - design 1.

In investigating the feasibility of an all-welded structure, MURA analyzed four "space metal" configurations, with respect to their strength, and equivalent solid sheet thickness.[2] It became readily apparent that any space metal configuration would require external support to carry an atmospheric load. Investigation was then made into the possibility of mechanically fastening a space metal structure to the magnet yoke. All methods that were considered, were incompatible with a convenient magnet assembly.

Because of the difficulties encountered with the "space metal" type of construction, MURA's efforts were then devoted to a completely self-supporting chamber (full atmospheric load) that would not require an outer vacuum system, and further would be fabricated using only inorganic materials,

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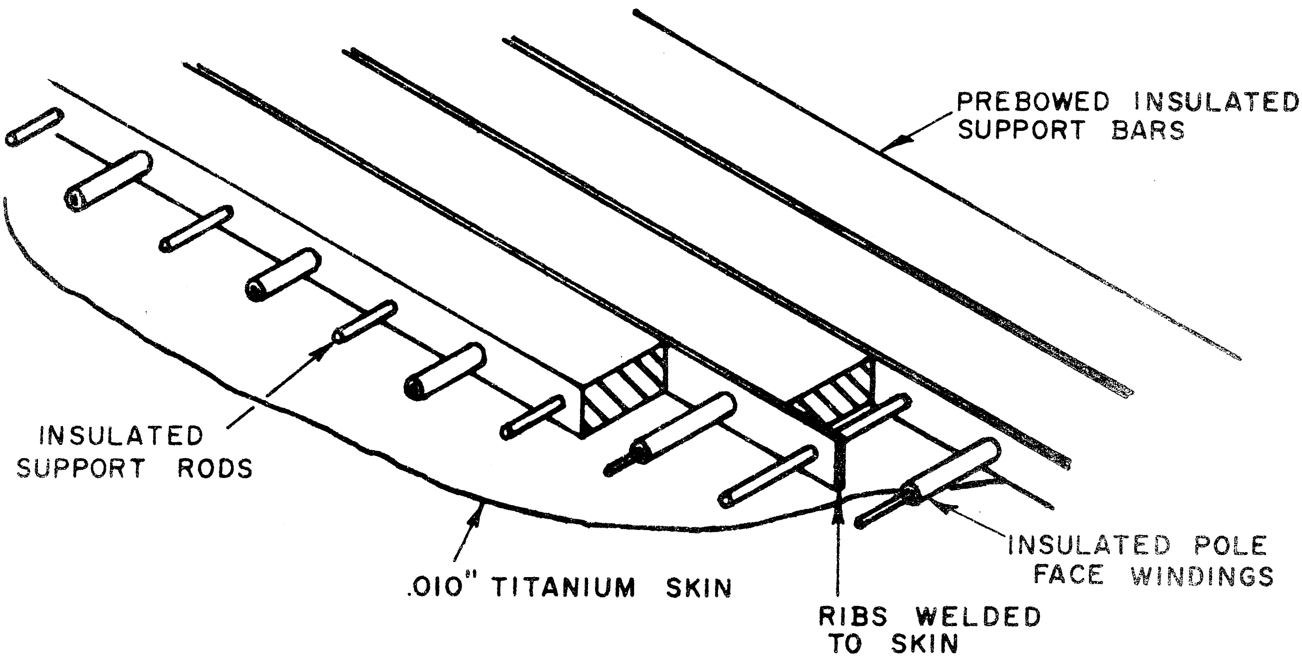
[2] See Appendix.

thus, removing the concern of radiation damage. This design approach did not look promising at first, because of the eddy current restrictions on the amount of metal that could be used for structural purposes.

In early May, J. O'Meara of MURA and W. Hanson of Argonne visited Coor's Porcelain Corporation for the purpose of discussing the use of ceramic in the construction of the chamber. A number of design possibilities were discussed; including an all-ceramic chamber, and a ceramic-brazed-to-metal chamber. Although Coor's engineers felt that both of these methods were possible, they considered that they would be heroic undertakings and would require a considerable amount of research and development. However, at this meeting the idea was brought forth that if the ceramic could somehow be mechanically fastened to a vacuum-tight metal envelope the fabrication could be rather straightforward.

With this idea, a completely self-supporting chamber became a distinct possibility. In analyzing this type of design, it was determined that one-half an inch was the material thickness required if high strength stainless steel or titanium could be used; with ceramic this would be marginal; plus, ceramic, although strong, is a brittle material and stress concentrations would be a problem. MURA then devised a method of combining the strength properties of a metal structure and the insulating properties of the ceramic. As shown below, this design consists of a vacuum-tight, all-welded titanium envelope to which vertical titanium ribs are welded. These ribs are perforated to accept pole face windings and support rods; these rods transfer the load from the




vacuum envelope to the support bars. The support bars themselves are metal, but are ceramic coated so that an eddy current path is contained completely within each individual bar and it is not a continuous path around or along the chamber. These bars should preferably be made of stainless steel; although it does not have the strength of titanium it has a higher modulus of elasticity, therefore, smaller deflections. In either case, deflections of the structure that would reduce the vertical aperture could be minimized by prebowing the support bars, thus, under load the chamber walls would be flat.

This design approach is now being actively pursued by Argonne.

# REFERENCES

1 W. Hanson, AVS Report.

# APPENDIX

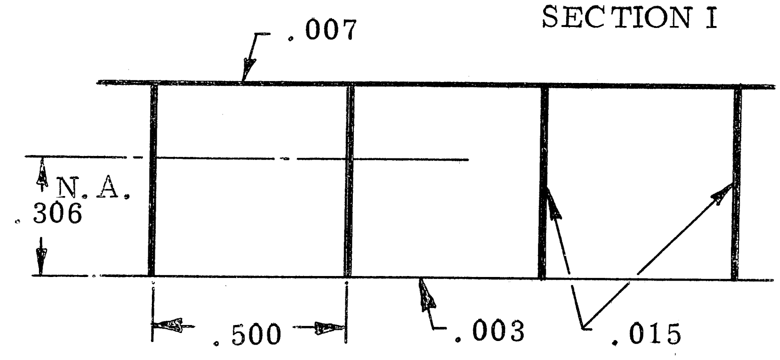
TN-473
By: Glenn Lee
Date: 4/30/64

## ARGONNE ZGS VACUUM CHAMBER CONSIDERATIONS

It is desired to build a vacuum chamber for the ZGS that can support a full air load. The four following sections were considered for comparison purposes. To check deflection between supports, the moment of inertia was calculated for each section and the equivalent solid sheet thickness calculated for that moment of inertia.

Several titanium alloys could be considered for resistivity, weldability, and availability. Three of them are: Ti-13V-11CR-3AL, Ti-6AL-4V, and Ti-8AL-1Mo-1V.

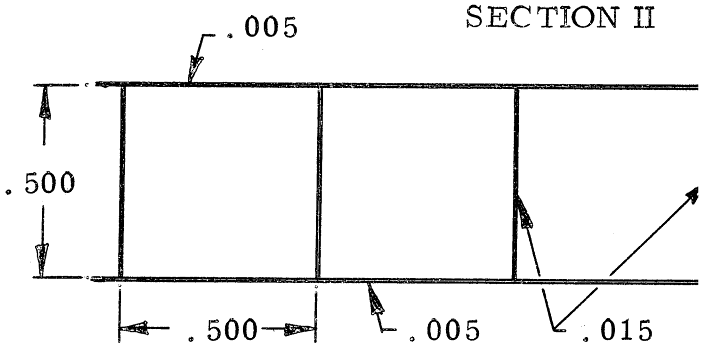
SECTION I




$I_{N.A.}$ = .0007/inch width

Equivalent to .203 Sheet

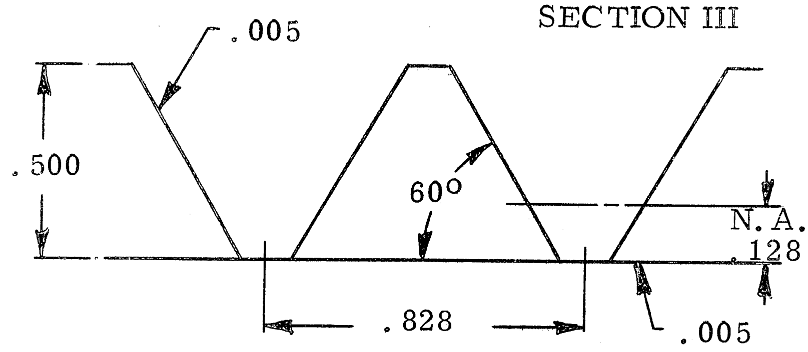
SECTION II




$I_{N.A.}$ = .0009/inch width

Equivalent to .221 sheet

SECTION III

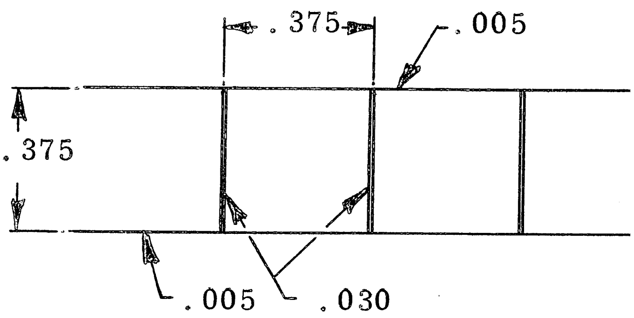



$I_{N.A.}$ = .000264/ .828 Width

= .00032/inch width

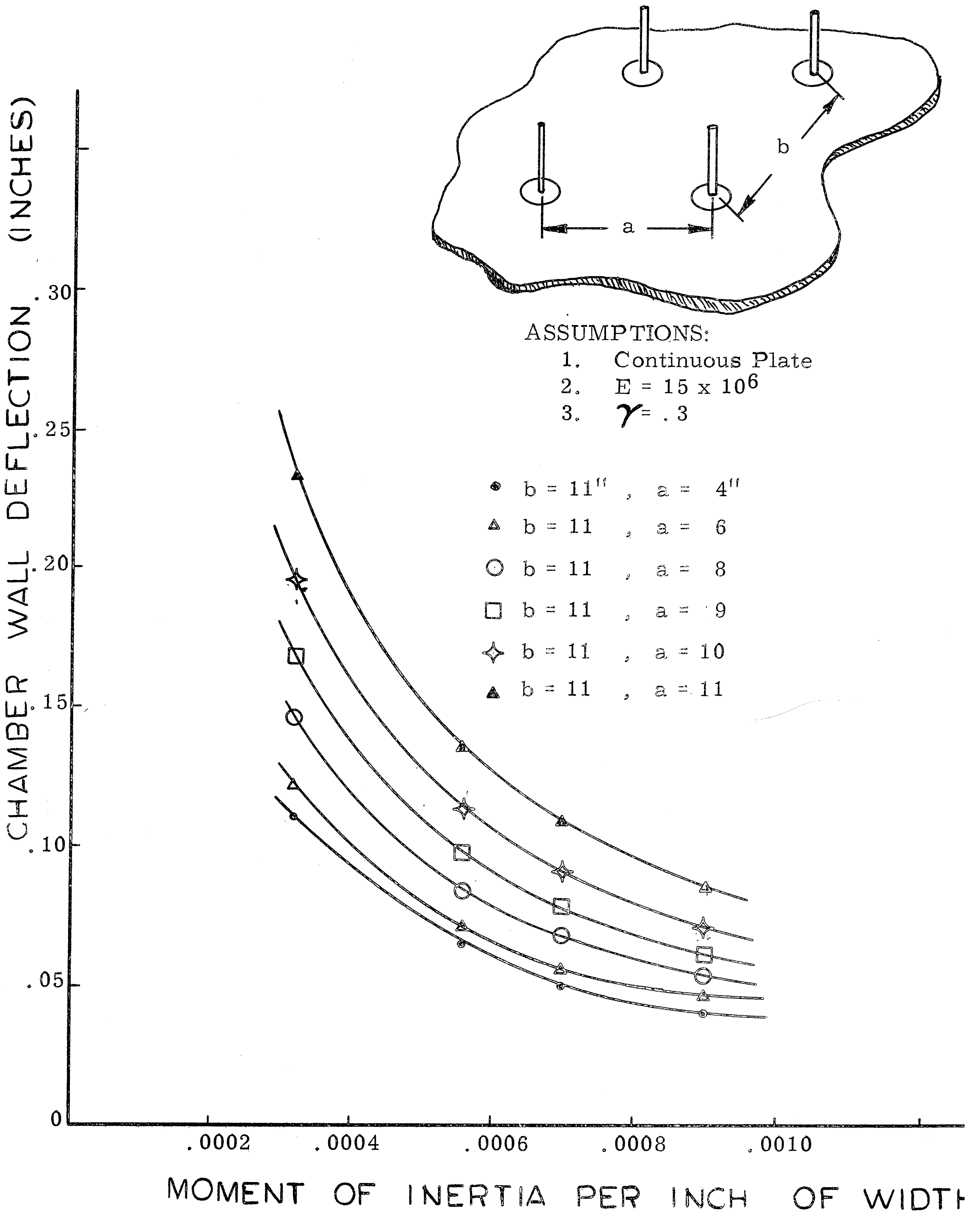
Equivalent to .157 Sheet

SECTION IV




$I_{N.A.}$ = .00056/inch width

Equivalent to .188 Sheet



b
a
ASSUMPTIONS:
1. Continuous Plate
2. E = 15 x 10^6
3. γ = .3
b = 11", a = 4"
b = 11, a = 6
b = 11, a = 8
b = 11, a = 9
b = 11, a = 10
b = 11, a = 11
CHAMBER WALL DEFLECTION (INCHES)
.30
.25
.20
.15
.10
.05
0
.0002
.0004
.0006
.0008
.0010
MOMENT OF INERTIA PER INCH OF WIDTH