MECHANICAL DESIGN FEATURES OF THE NAL 200 MEV LINAC INJECTOR*

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Introduction

The National Accelerator Laboratory has been organized to design and build a 200 BeV accelerator, Figure 1. The present accelerator design includes a 750 kV Cockcroft-Walton preaccelerator and a 200 MeV linac. The physical design of the linac is similar to the linac being constructed at Brookhaven National Laboratory.[1] A very active exchange of design information has been pursued and this report will cover areas of differences that are considered desirable or necessary because of material availability, fabrication techniques or operation.

The present schedule is to complete the design and start fabrication of the first tank of 10 MeV before proceeding to the rest of the system. A building has been built at the Weston site, Figure 2, which will allow the preaccelerator and the 10 MeV linac cavity to be installed and operated. This will permit tune-up and testing of this section at the earliest possible time to allow design features to be investigated. This report will cover the mechanical features of the 10 MeV section.

Drift Tubes

The drift tube and cavity dimensions have been chosen using data from the MESSYMESH computer program.[2] The drift-tube table is the same as specified for the BNL linac for the AGS Improvement Program.

The drift-tube body consists of a brazed copper assembly without end caps. The support stem is brazed to the copper body to form a complete water system that can be pressure tested before assembling the quadrupole, Figure 3. The quadrupole is then positioned in the housing and located in relation to the stem and the magnetic axis. The quadrupoles for the first 10 MeV are being built as a joint project with Brookhaven National Laboratory.

The end cap of the drift tube is the same for both ends and is made from one-quarter inch thick annealed OFHC copper plate as shown in Figure 4. End caps for the drift tube are formed by cold pressing. In the first step the general outer contour of the piece is formed. In the second step the inner radius and the bore hole are formed. The formed part is then reannealed and a finish cut is made to size the outside. The amount of OFHC copper required by this method is minimal. Location of the end cap is achieved by a machined groove near the outer diameter and is concentric with the quadrupole magnetic center. Final closure of the drift tube is by electron-beam welding the end cap to the body and monel bore tube. These joints are made without filler metal.

The finished drift tube is shown in Figure 5, positioned in the tank. The rf contact from tank wall to drift-tube stem is a "D-spring" contact mounted in a copper insert, pressed in the tank. The "D-spring" has sufficient travel to allow alignment of the drift tube and maintain rf contact. This is a departure from the use of a bellows which must be clamped as a final step in alignment. The clamping of the bellows puts a force on the stem which may cause a deflection of the drift-tube center and a problem of realignment. The O-ring seal unit floats during alignment and is clamped to the tank by the welded studs after drift-tube alignment.

Alignment Fixture

A drift tube alignment fixture has been built, Figure 6, to position a drift tube. It is massive enough to allow movement with small stresses and deflections. This fixture is adjustable for all degrees of movement; each independent of any other. A spherical seat has been built in the unit with the center of curvature at the center of the drift-tube bore axis. Thus, after the drift-tube bore axis has been brought to coincide with the alignment axis, the drift tube can be rotated about this axis to orient the quadrupole without moving the center off axis.

The alignment fixture is positioned over a drift-tube stem and bolted to the tank. The drift-tube mounting block is then bolted to the alignment fixture and the drift tube positioned. When the drift tube is located in the final position, the nuts with spherical washers are torqued on the mounting block to transfer it to the tank through three welded studs. The alignment fixture is then released from the drift-tube mounting block.

It is planned to use a tooling laser to establish the alignment axis for all drift tubes. This will permit greater alignment accuracy over a number of tanks as compared with the conventional optical method.

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RF Cavity

The recent copper strike had made it impossible to predict delivery times for copper clad steel. As a result of this, we have designed the 10 MeV tank utilizing existing one-half inch thick copper-clad material. LRL released four sheets of 80 inches x 20 feet material for this use. The copper-cladding on this material is 0.050 inch thick. The radius of curvature of the tank is such that interior spot facing is impossible without breaking through to the steel. Another problem is the difficulty of making copper to copper welds on this thin material. These problems have made the pressed bushings and their associated "D-spring" contacts attractive. We have avoided any copper welding other than the longitudinal and girth welds required to fabricate the tank body. Figure 7 shows a tuner port and Figure 8 the rf input loop.

The twenty-five foot tank is to be made in one piece. This design approach eliminates the need for fabrication of intermediate flanges and spring ring contacts. As a result of using the thin copper clad material (one-half inch thick), it is necessary to use stiffening rings. The wall deflections are calculated to be less than .001 inch. This consideration is important in preventing the misalignment of quadrupoles.[3]

The vacuum-port slots are machined in the tank wall, Figure 9. Each port has 12 slots with a total calculated conductance of approximately 2500 liters/sec. The copper surface area for the rf current is slightly over 50% of that available in other parts of the cavity. Four vacuum ports are used on the tank to allow 1200 liters/sec ion pumps to be attached.

The tank has been extended on each end beyond the rf cavity end plates. At the high energy end a rectangular vacuum box will be attached. The low energy end has an eight inch extension to the tank walls. These extensions allow the rf cavity end wall positions to be unaffected during evacuation of the tank. The extensions have several ports so that various diagnostic devices can be inserted without dismantling any major portion of the cavity.

The copper end-plates are spring loaded to the cavity ends. This end plate with a tapered edge is similar to those developed at LASL in their two cell test cavity.[4] This approach eliminates the need for spring ring contacts and the associated copper insert ring on the end of the cavity, Figure 10.

The area where the drift-tube stem penetrates the cavity wall will be enclosed with a vacuum box. These boxes provide a "back stop" for any possible leaks in the drift tube and stem seals. Figure 11 is a cross section of the stem penetration area showing the stem, clamping block, water connections and quadrupole leads.

Welding studs will be used extensively in fabrication of tank ports. Tapped holes will be found only in certain areas where special considerations make them necessary.

References

1. P. Grand, "The Physical Design of a 200 MeV Linac Facility" Proceedings of 1967 Particle Accelerator Conference, pg. 860

2. B. Austin et. al. "The Design of Proton Linear Accelerators for Energies Up To 200 MeV" MURA Report No. 713 (1965) (unpublished) pg. 4

3. Ibid, pg. 97

4. E.D. Bush, Jr., J.R. Ruhe, E.J. Schneider, P.J. Stroik, LASL Report MP-3/EDB/JRR/ EJS/ PJS-1, "Two Cell 201.25 MHz Drift Tube Linac Power Model" (unpublished)

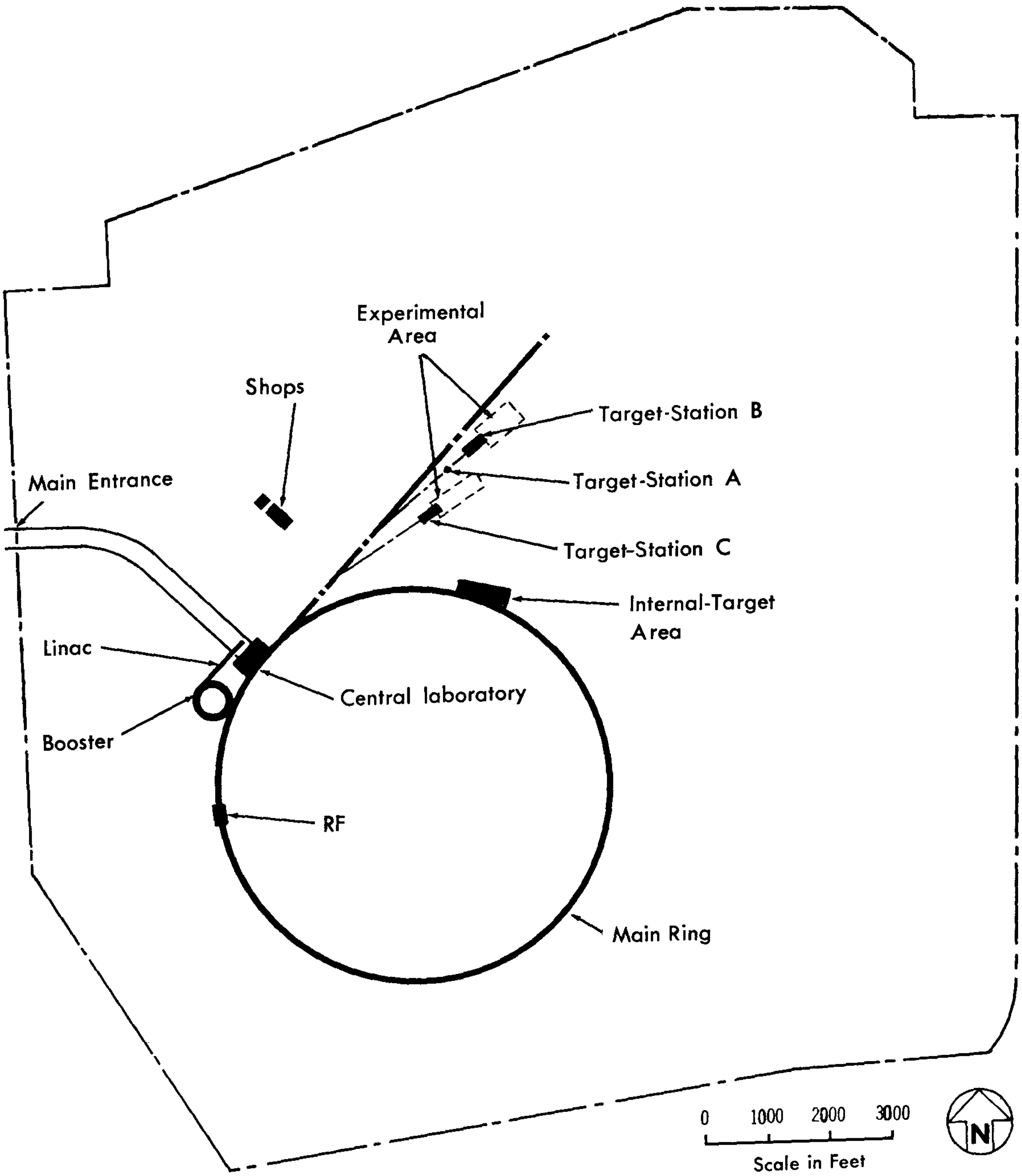

Fig. 1 NAL Site

Fig. 2 Linac Research Building - Weston

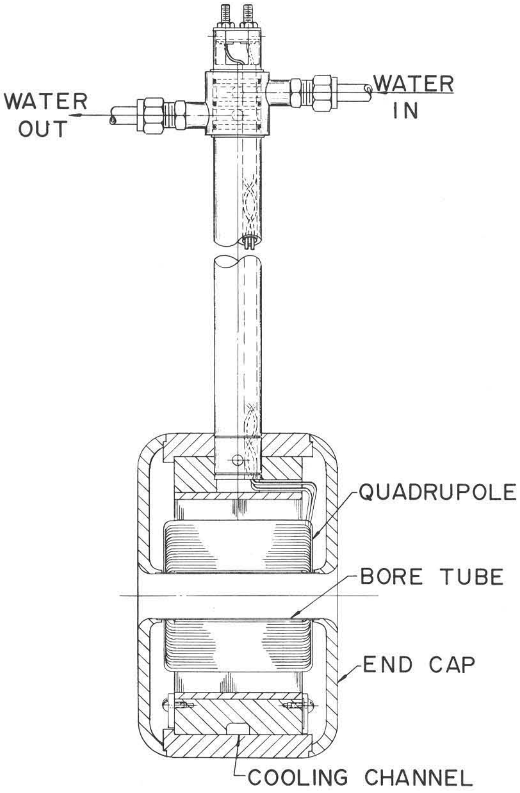

Fig. 3 Drift Tube Body

Fig. 4 Drift Tube End Cap

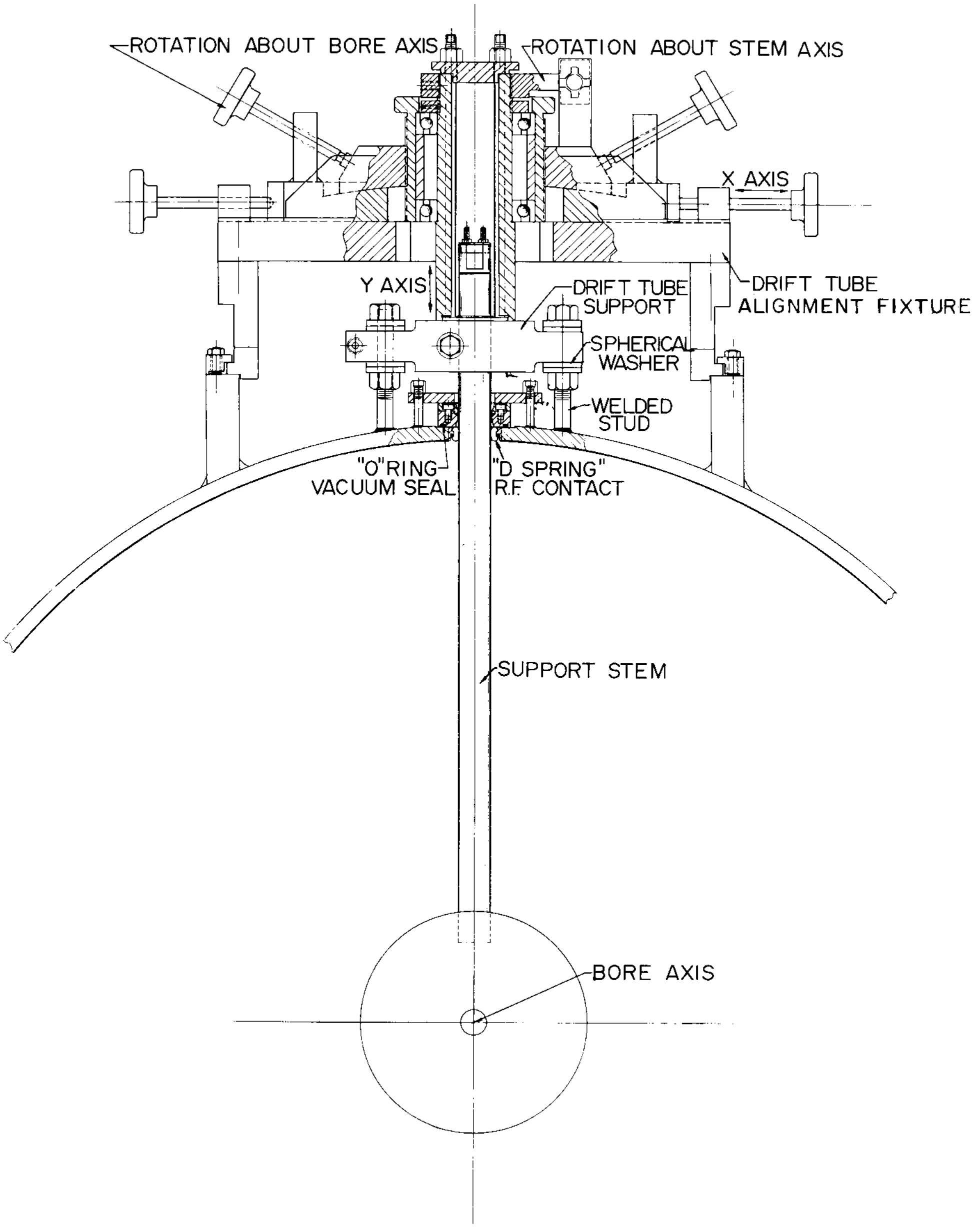

Fig. 5 Drift Tube in Tank

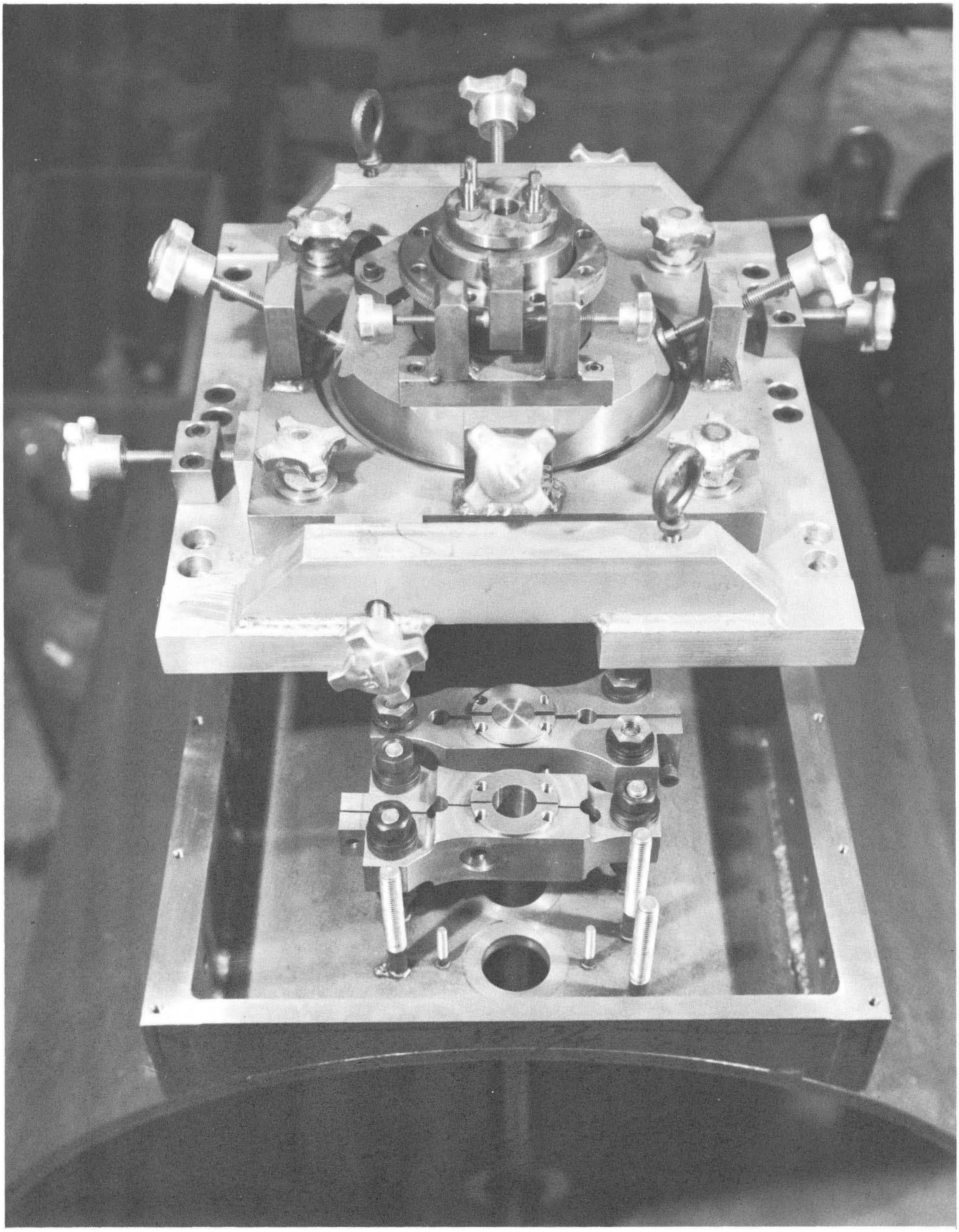

Fig. 6 Drift Tube Alignment Fixture

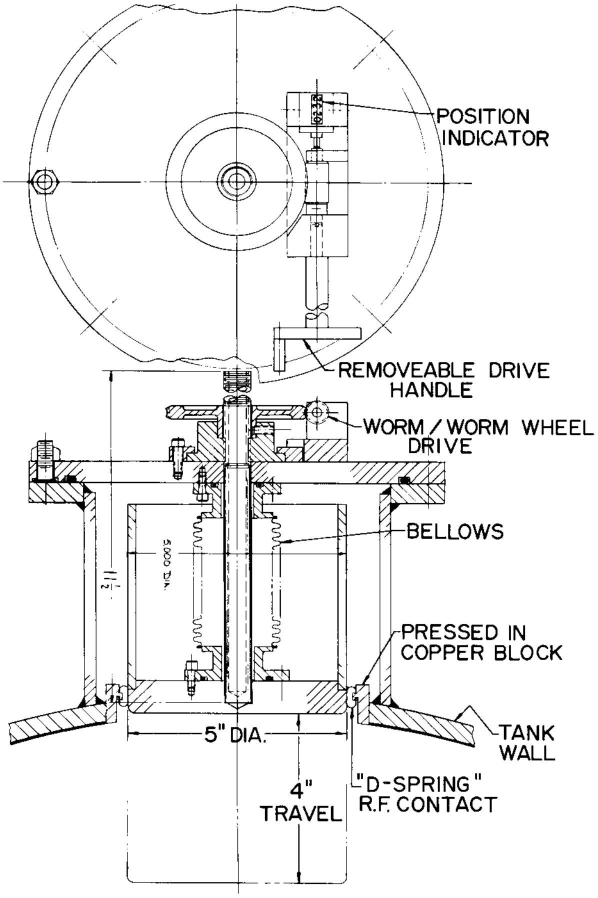

Fig. 7 Tuner Port

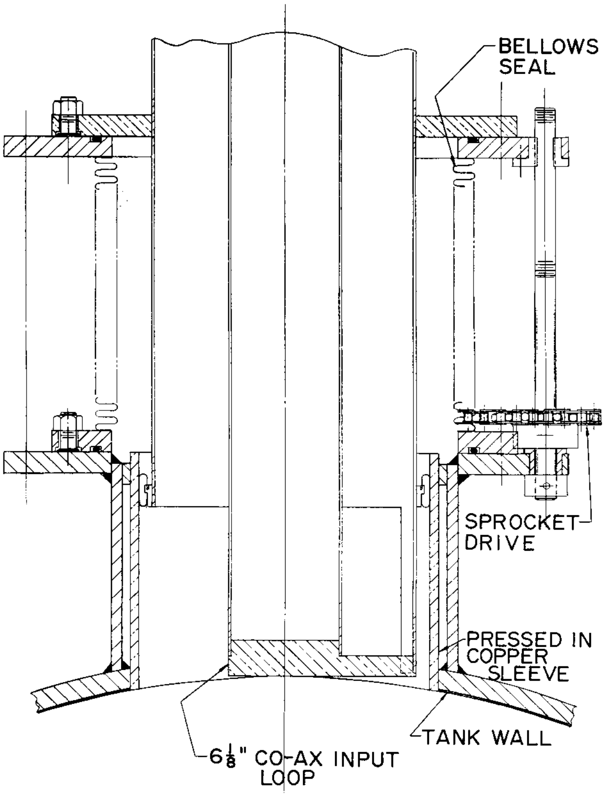

Fig. 8 RF Input Loop

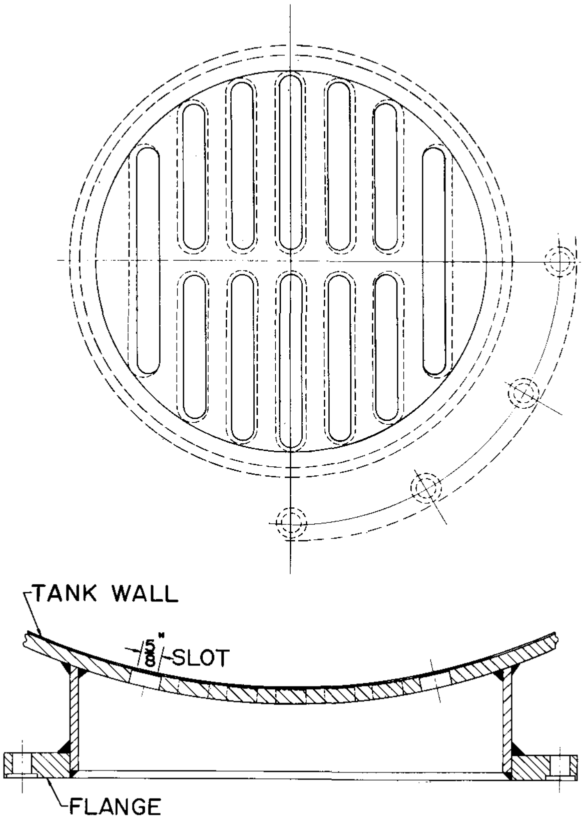

Fig. 9 Vacuum Pump Port

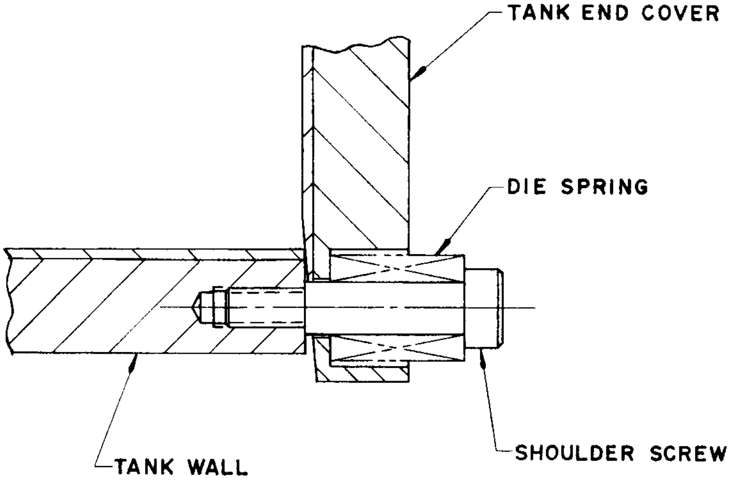

Fig. 10 Cavity End Cover

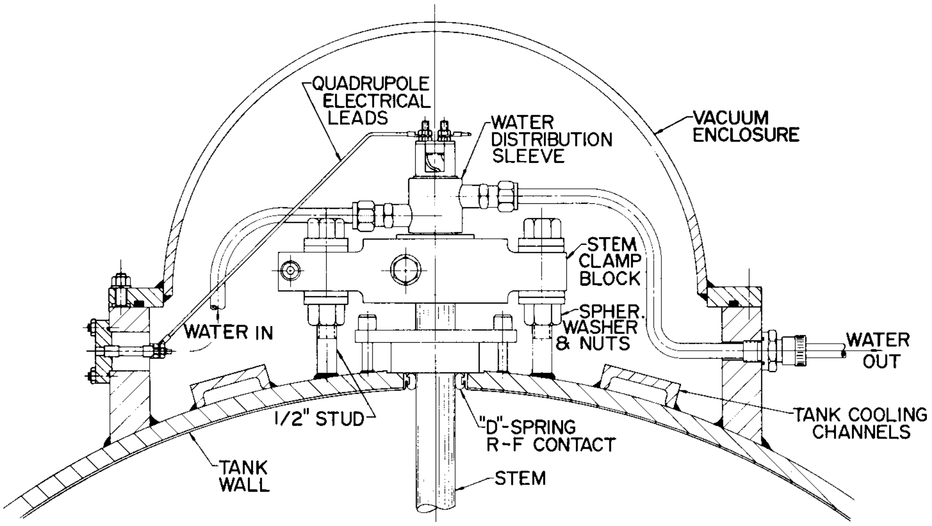

Fig. 11 Stem Box Section