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FLIGHT MODEL CESIUM ION SOURCE FOR ELECTRIC
FIELD MEASURING INSTRUMENT

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FOREWORD

This study was conducted by Northrop Corporate Laboratories, Hawthorne, California, in accordance with contract NAS2-4143, "Flight Model Cesium Ion Source for Electric Field Measuring Instrument," covering a program to develop a cesium ion source for incorporation with a flight prototype instrument to measure the electric field intensity in space. It is a follow-on effort to Phase I and Phase II of this contract. This report is the final engineering report for this task and has been assigned NCL 68-2 as a company report number. Dr. William I. Linlor, Chief, Electrodynamics Branch, NASA/Ames Research Center was the Contract Monitor. Mr. Mark A. Greene was the Contracting Officer.

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SECTION I

INTRODUCTION

The purpose of this program was to develop a cesium ion source suitable for incorporation into a flight prototype instrument for the measurement of the electric field intensity in space. This program is a continuation of an experimental effort conducted under NASA/Ames contract NAS2-4143, "Study of an Electric Field Measuring Instrument," and an earlier analytical study conducted under NASA/Ames contract NAS2-2895-2 titled, "Radioactive Sources to Measure the Electric Field Intensity in Space."

The conclusions drawn from the analytical study were that a cesium ion beam source instrument could measure electric fields $\cong 10^{-2}$ volts/meter in magnetic fields 500 times greater than those in which electron beam devices can perform. These results were proven in the subsequent experimental program conducted for this purpose during which two cesium ion beam sources were constructed and tested. In particular, the second source tested provided excellent results, producing a clean symmetrical ion beam. The experience gained in studying these sources has been utilized to completely design a flight prototype instrument for the measurement of the electric field intensity in space. Except for the electrical connections and a few components, the prototype source has been constructed and assembled in the laboratory.

This report describes the design and construction of the cesium ion source as it pertains to this effort.

SECTION II

SOURCE DESIGN AND CONSTRUCTION

The prototype cesium ion source contains four modules, the source assembly, the spacer assembly, the lens assembly, and the deflector assembly as shown in Figures 1 through 4. The four assemblies are stacked one on top of another with the source assembly at the bottom followed by the spacer assembly, the lens assembly, and the deflector assembly in that order. All four modules are enclosed and secured in a hermetic enclosure shown in Figure 5. A schematic of the complete design is shown in Figure 6.

Source Assembly

The source assembly consists of an ionizer, cesium reservoir, cesium feed tube, filament, accelerator, counter electrode, heat shields and supports. Cesium vapor passes through the reservoir through the cesium feed tube to the ionizer from which cesium ions are evaporated. The accelerator extracts the cesium ion beam from the ionizer and accelerates the ions toward the other assemblies. The counter electrode is both a heat shield and an electrode which repels the electrons toward the ionizer.

The ionizer tube and the cesium feed tube are of chemical vapor-deposited tantalum. Tantalum is used because it is the most ductile refractory and has excellent welding properties. This material is produced by vapor-deposition because this is the most satisfactory method for making small-bore thin-wall tantalum tubing.

Tungsten 3% rhenium is used for the electron emitting filament. The rhenium content prevents the low temperature embrittlement problems of unalloyed tungsten. The filament support is made of TZM (molybdenum, 0.5% titanium, 0.5% titanium, 0.1% zirconium) selected because of its

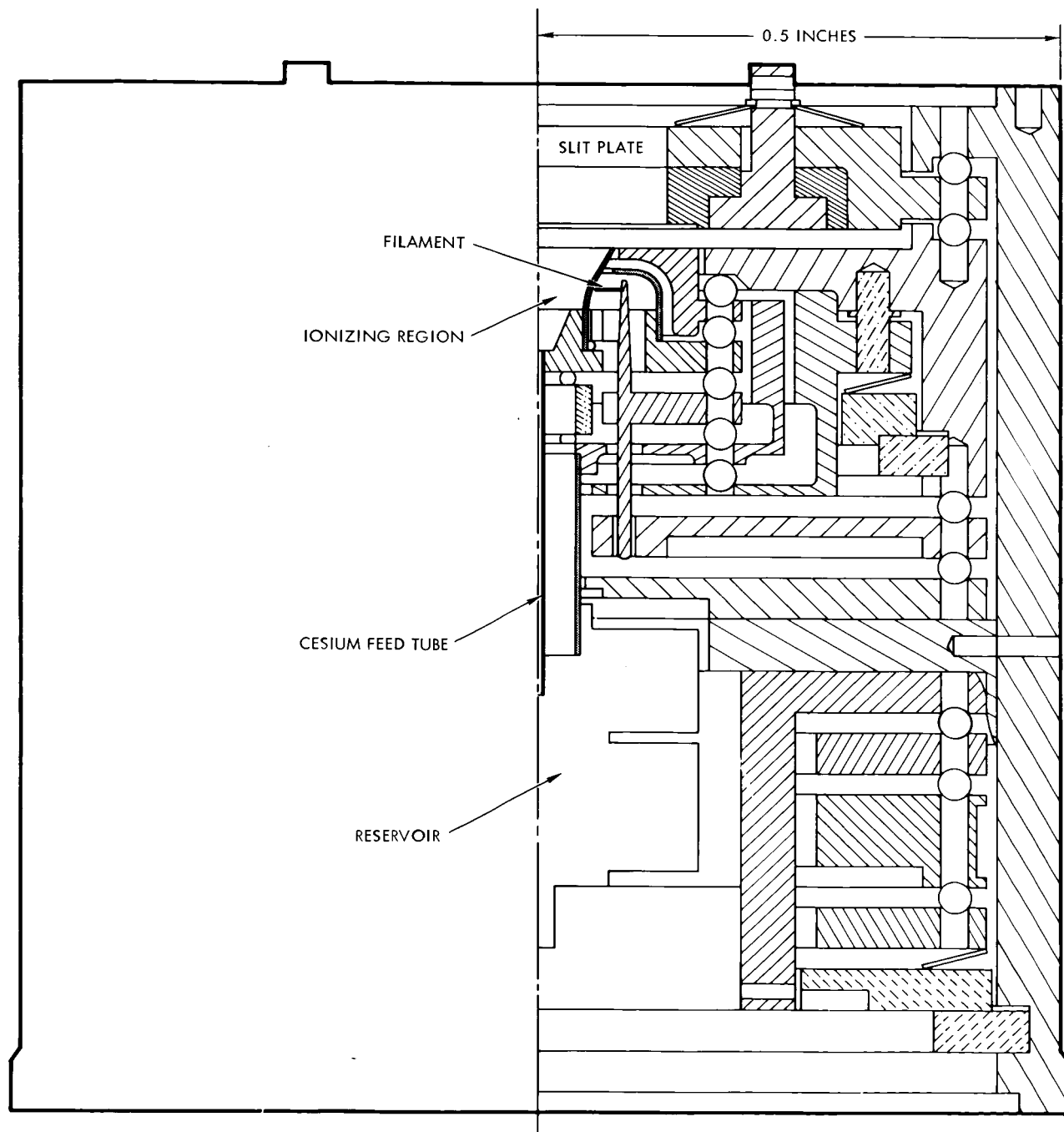
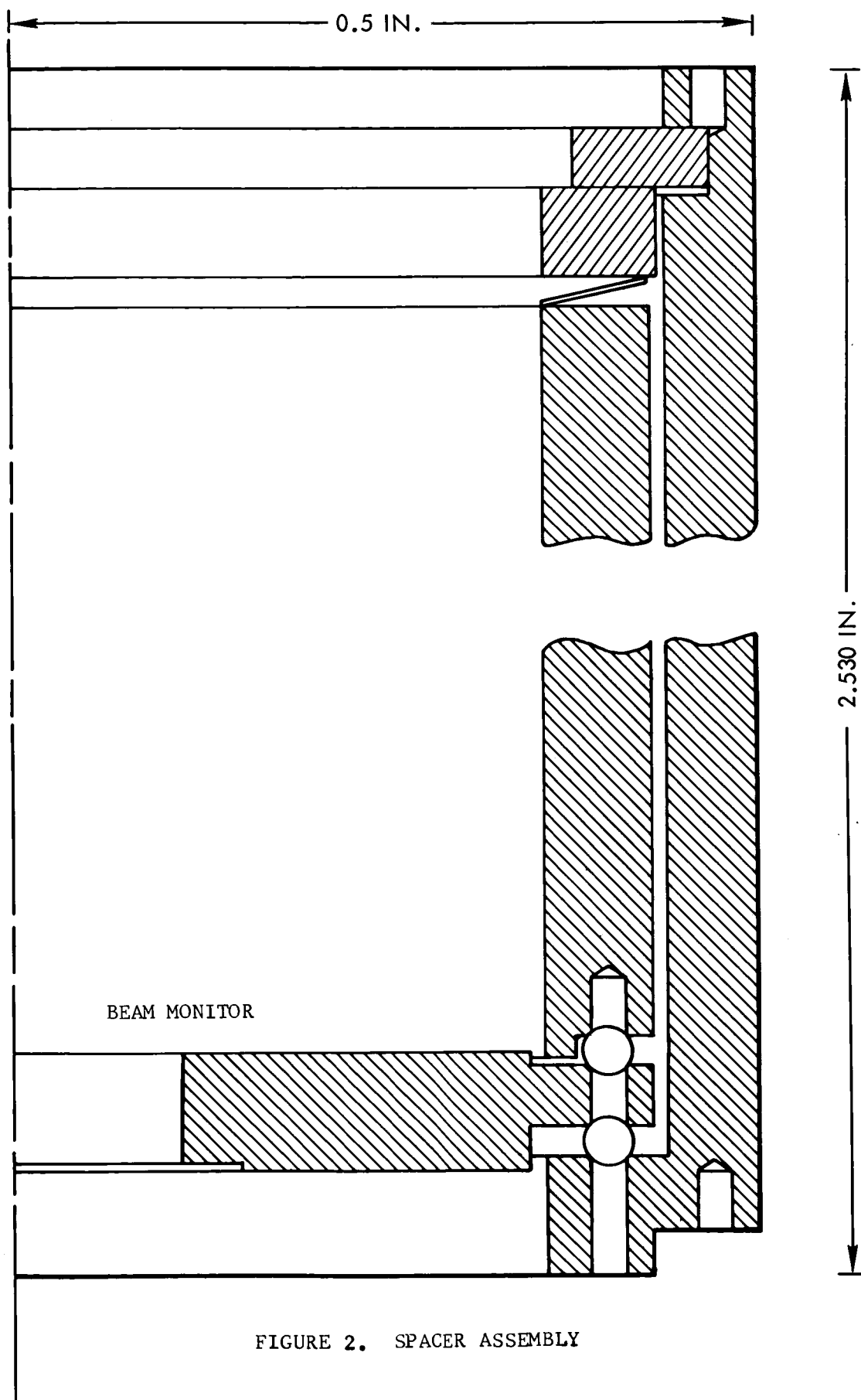


FIGURE 1. FLIGHT PROTOTYPE CESIUM ION SOURCE



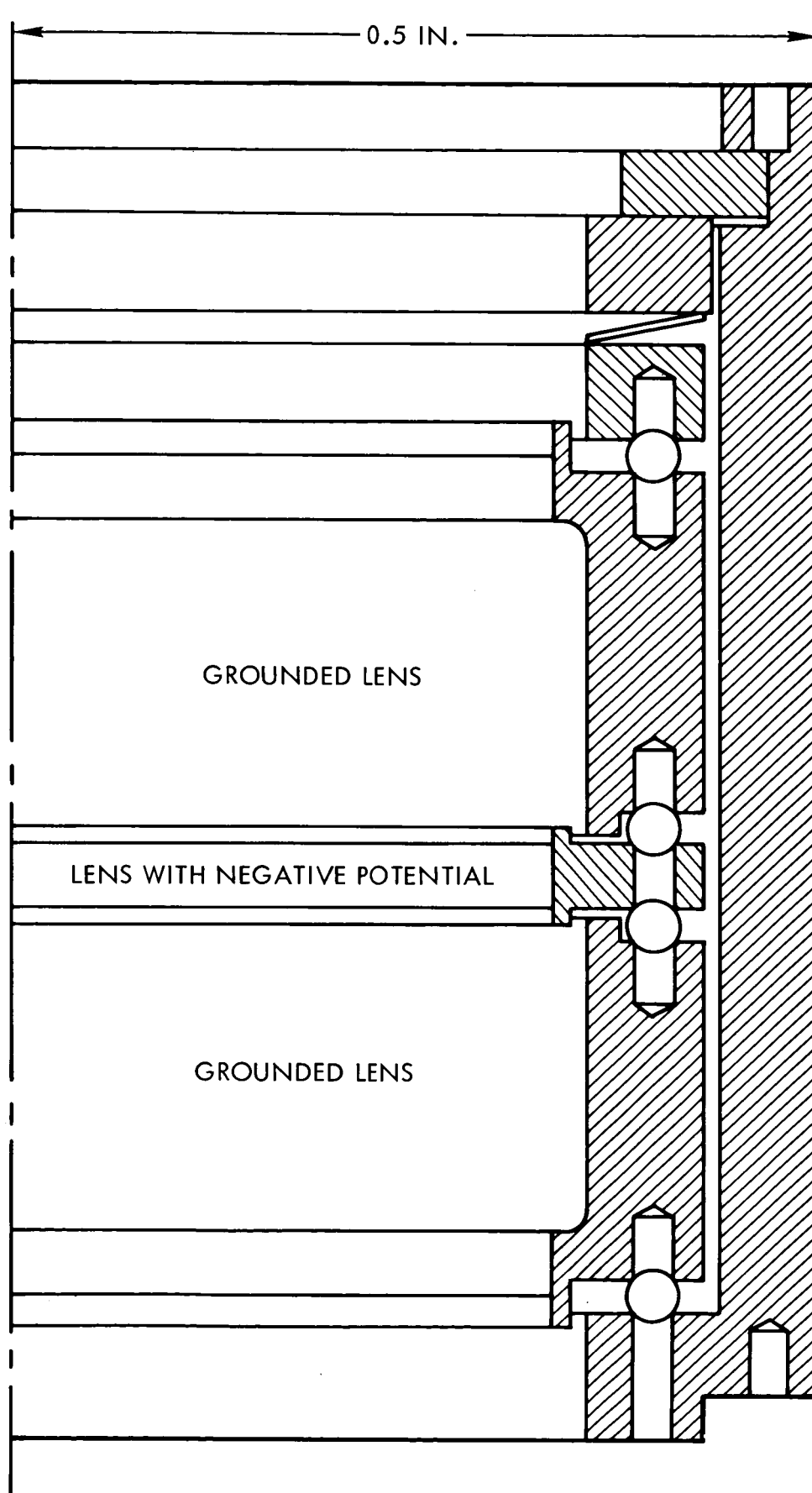
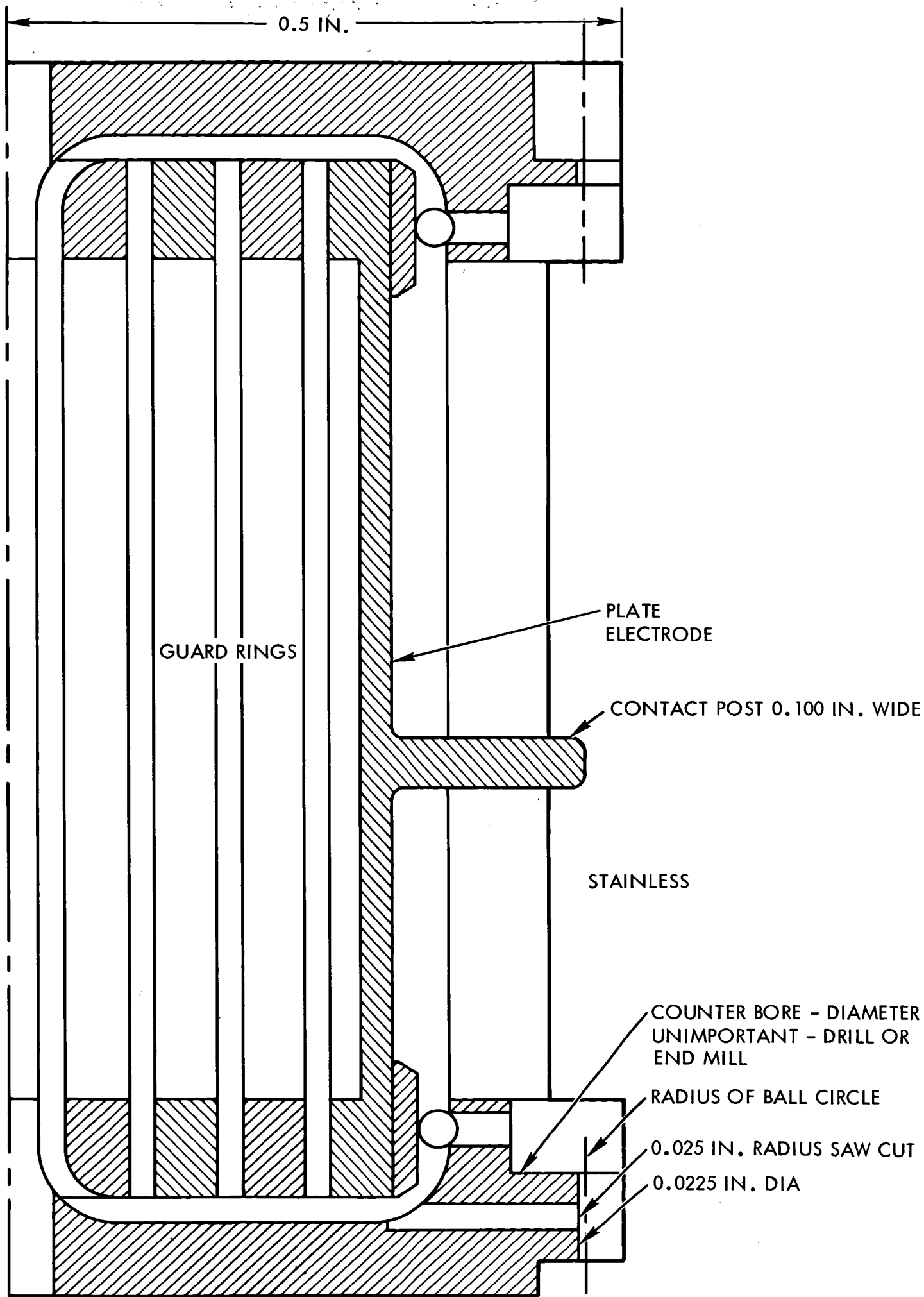


FIGURE 3. LENS ASSEMBLY



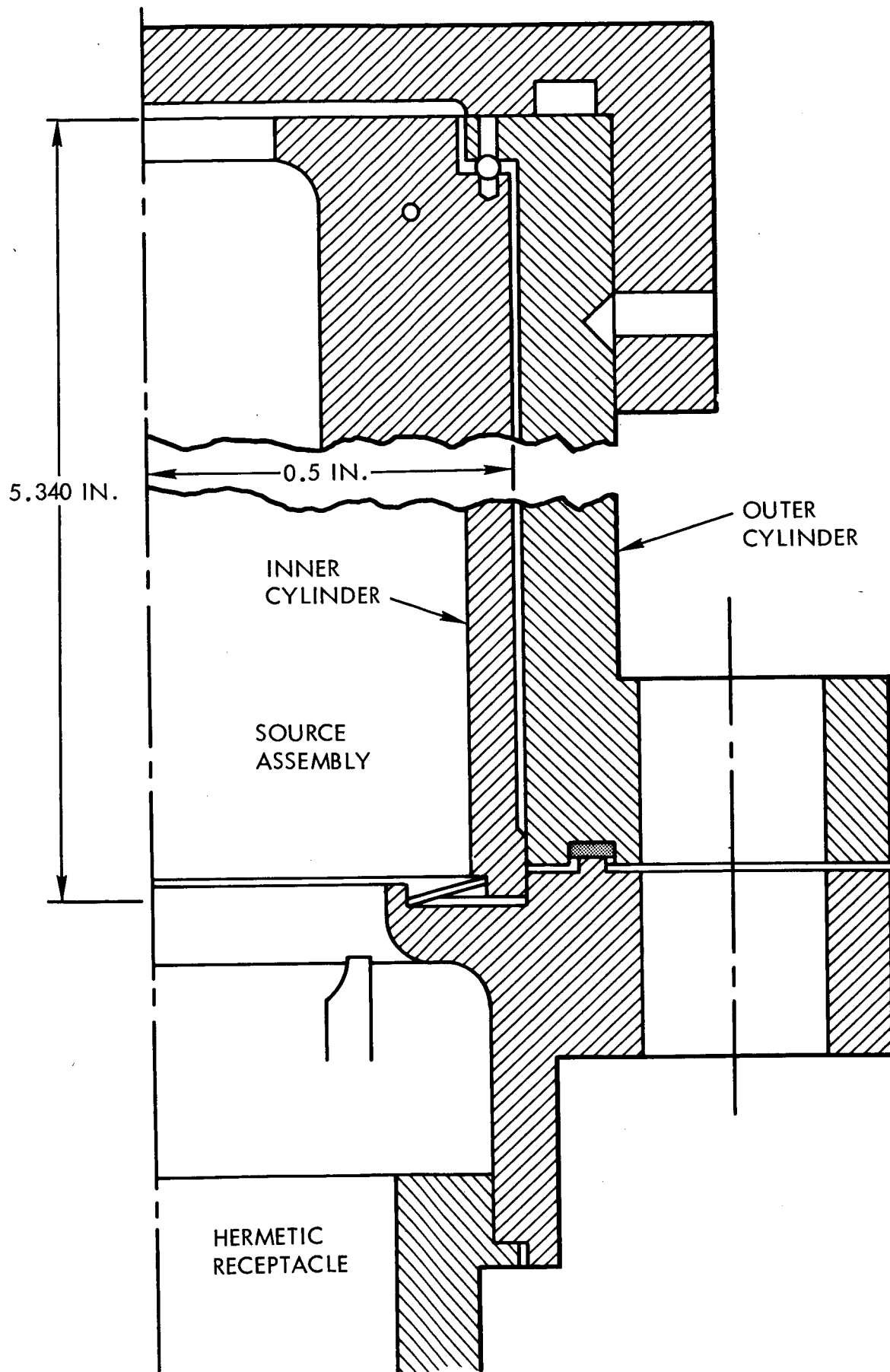
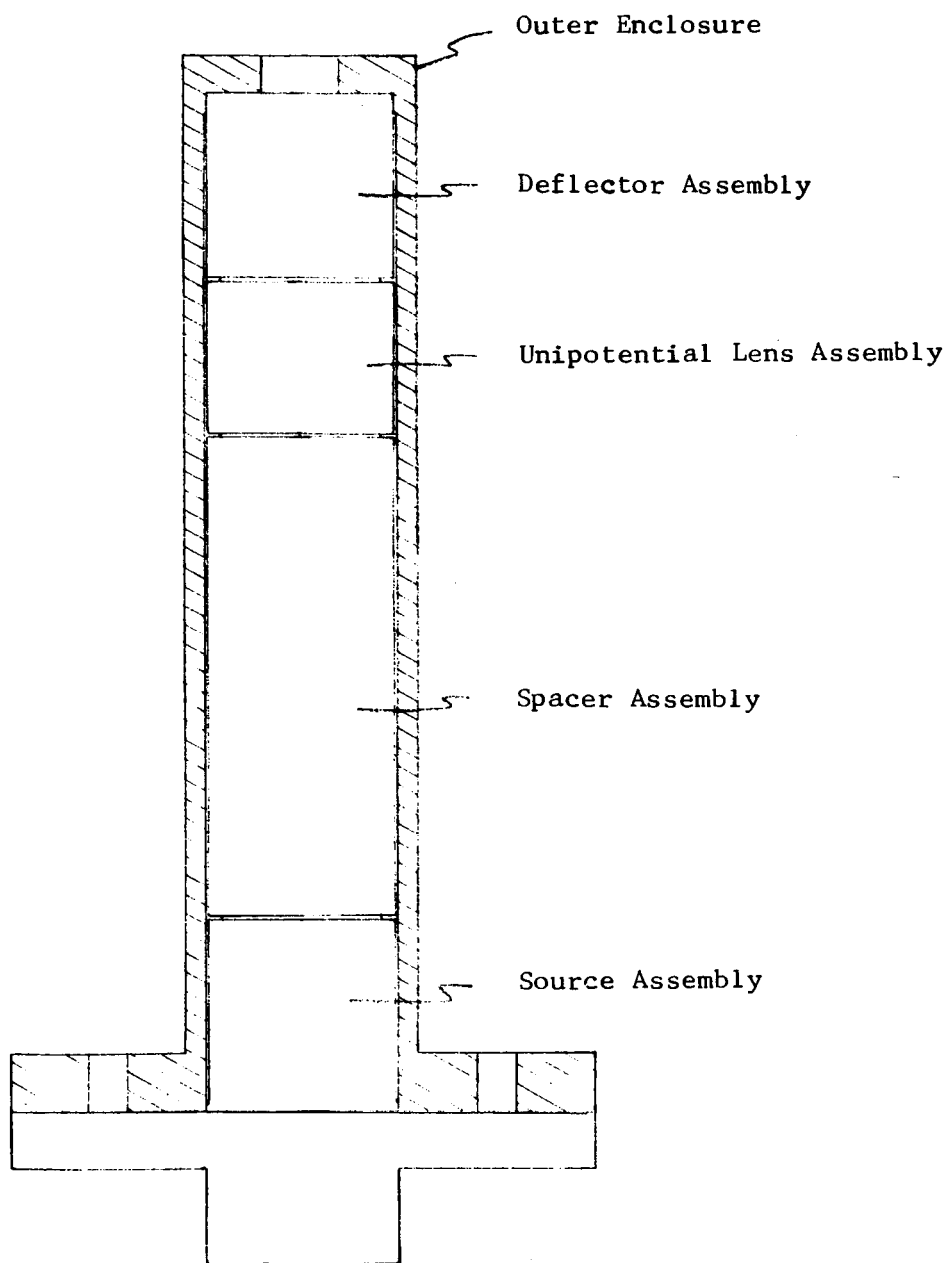


FIGURE 5. HERMETIC ENCLOSURE



Full Size

FIGURE 6. ASSEMBLED CESIUM ION SOURCE

high ratio of flexural rigidity to thermal conductivity. Because of TZM's low thermal distortion behavior, it is the material used for other parts in moderate temperature regions where distortion is to be minimized. Slit plates and Belleville springs are of unalloyed sheet molybdenum.

Synthetic sapphire balls are used for thermal and electric insulation and to assure permanence of mechanical alignment. Sapphire was selected because of its high compressive strength, reasonable thermal and electrical resistance, and low cost. Other metallic parts are made of stainless steel.

This module has been designed for ease of assembly and alignment. The accelerator slits are mounted on a movable assembly which can be moved laterally and rotated for alignment with the ionizer slit. A special slit ring has been designed into the connector between the adapter feed tube and reservoir to facilitate loading of cesium. A thin copper spider plate connects the reservoir to the housing which acts as a heat sink. A thermocouple is placed through the center of the copper plate to the bottom of the reservoir in a special receptacle for monitoring the reservoir temperature.

Spacer Assembly

A spacer is used to locate the lens an appropriate distance from the ion source. A beam monitor is incorporated in this assembly. The aperture in the monitor electrode is sized slightly larger than the limiting aperture of the system referred to the plane of the monitor electrode. By this means, a sizeable monitor current is collected without decreasing the net beam current.

Lens Assembly

A three-plate equipotential lens is used to focus the ion beam. The middle plate is connected to a negative potential and the outer plates are grounded.

Deflector Assembly

The uniform electric field required to deflect the ion beam is realized by two plate electrodes and seven guard rings. The guard rings

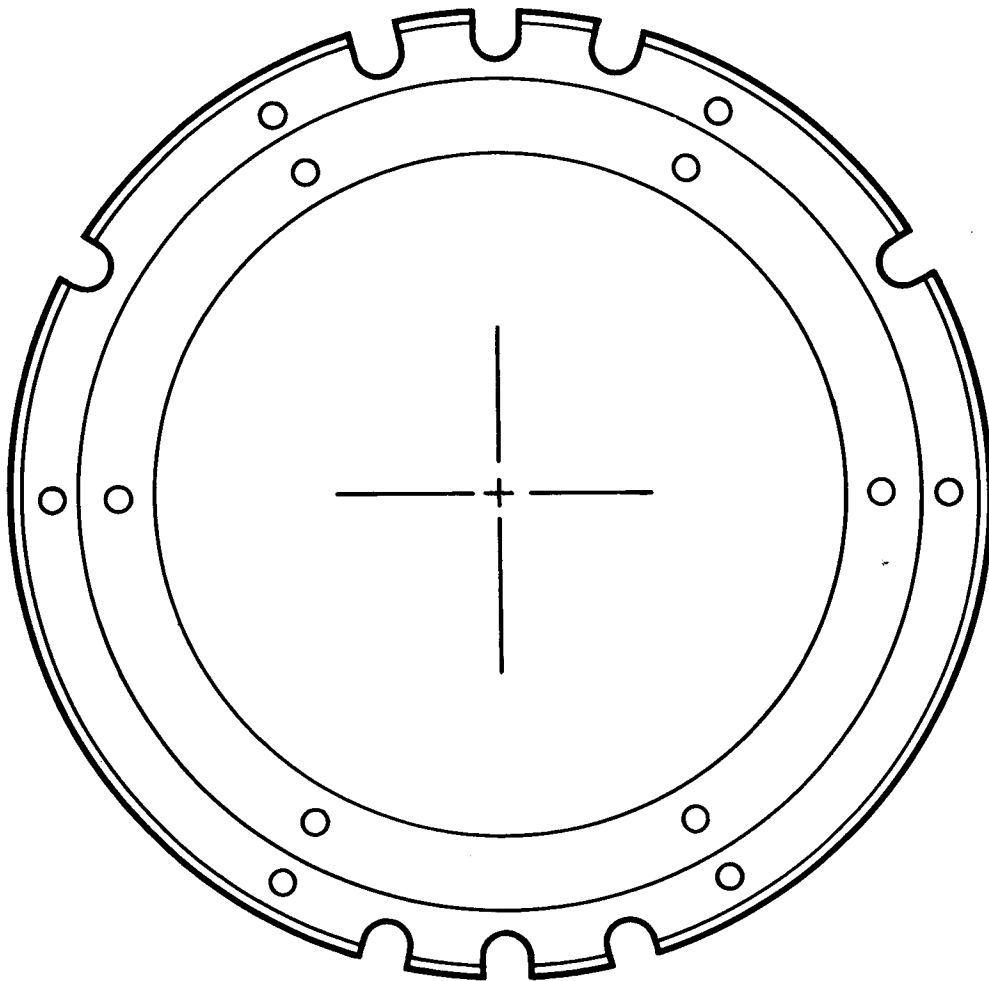


FIGURE 7. TOP VIEW OF INNER CYLINDER

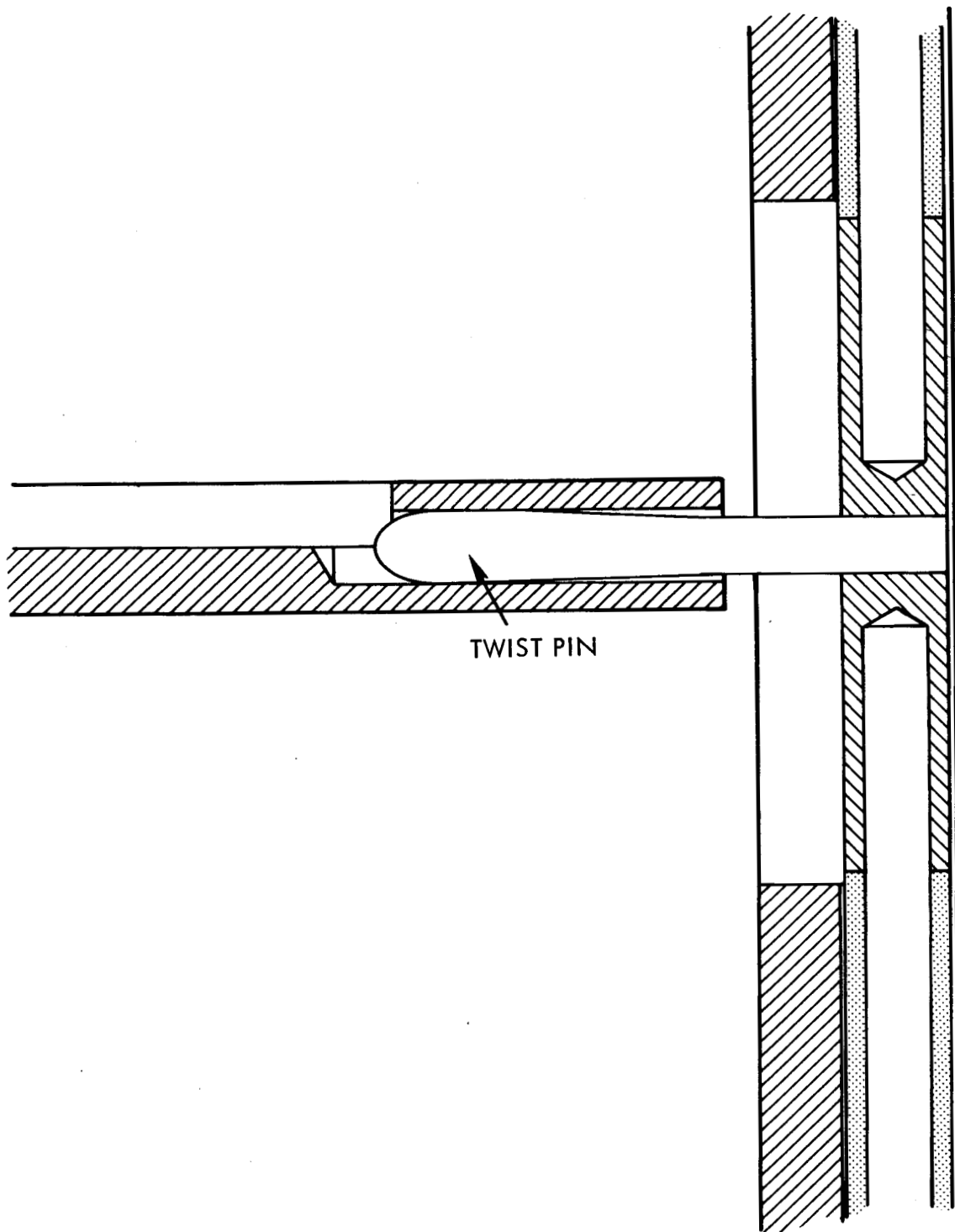


FIGURE 8. ELECTRICAL CONNECTOR

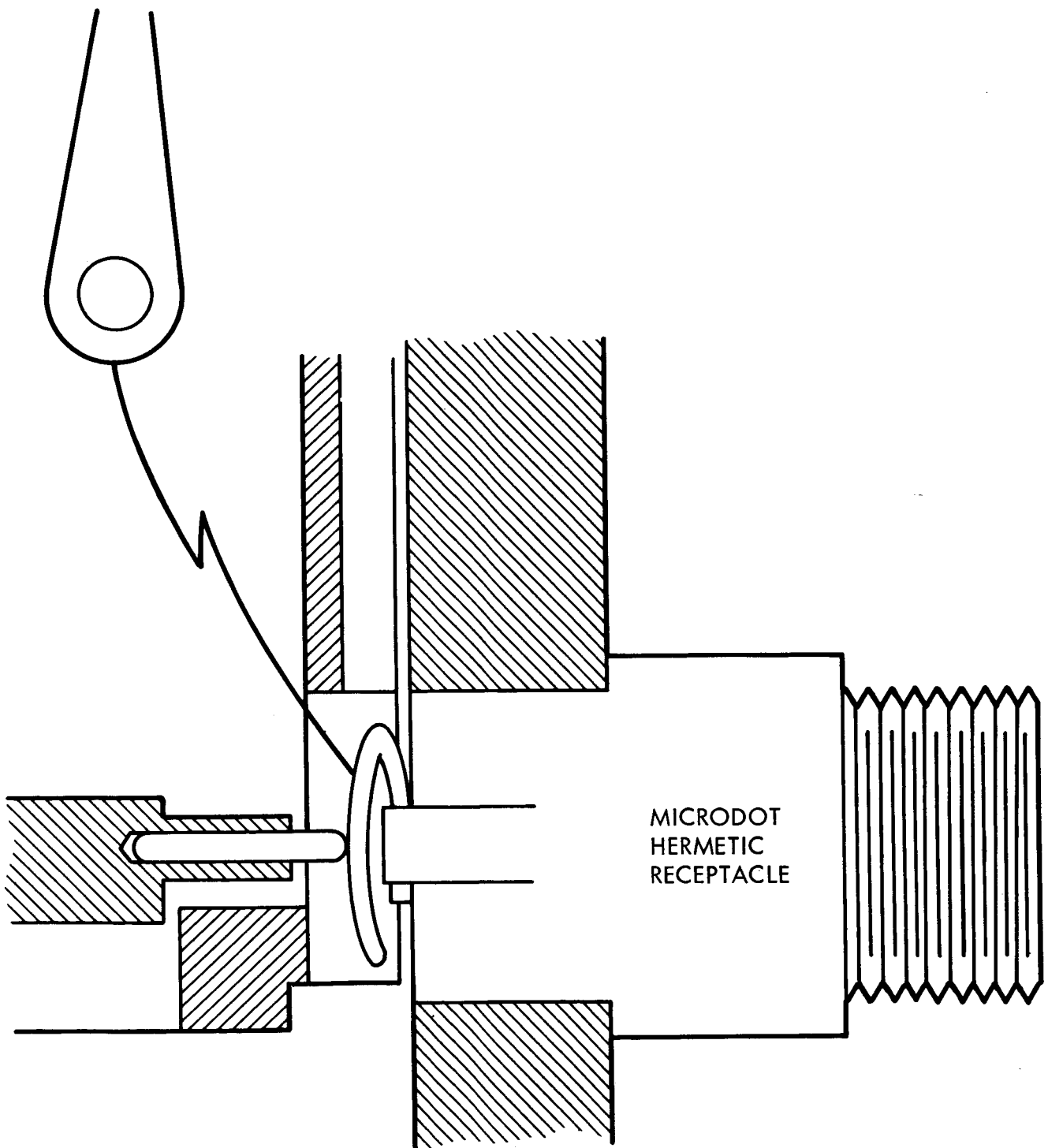


FIGURE 9. MICRODOT HERMETIC CONNECTOR

are tied to equally spaced points on a voltage divider and thus allow the use of a much smaller structure by largely eliminating the effect of the fringing field.

Construction

The four modules are separated by 1/32-in.-diameter sapphire balls positioned in holes that have been jig drilled for accurate alignment. Electrical connections for the reservoir heater, filament, anode, accelerating electrode, lens, and ground connections to all floating electrodes are made through teflon-insulated wire routed through grooves in the outside surface of the modules to a hermetic connector at the bottom of the assembly. Location of the grooves is shown in Figure 7 and details of the connection to a typical electrode are shown in Figure 8. The hermetic enclosure fits over modules securing the wires in place. The enclosure also includes a removable cover and a tabulation to allow storage or transport either under vacuum or inert gas.

Very-low-noise triple-shielded cable is used with the beam monitor and deflecting electrodes. A microdot hermetic connector is attached to the outer cylinder and modified to permit slide contact to the inner connector as shown in Figure 9. The inner braid of the cable is a driven guard shield to minimize the noise level of the system.

There are over 61 individual components that have to be accurately machined for this source. Many new and novel designs had to be invented and incorporated into the device because of the small size and complexity of the components. Since this is the first prototype of the source, the modules are designed so that they can be removed for modifications when required. Additionally, TMZ was used to replace the nickel components because of its superior performance, and this required considerable more machining hours than originally anticipated. As a consequence, further work is needed before the device can be tested.

Although most of the machining has been completed so that each of the modules could be assembled into a complete unit, there remains a significant amount of work prior to completion and checkout. The

reservior has to be completed, and the ionizer and feed tube must be electron beam welded. Machining of many holes for holding sapphire balls is still required. Most of this work, however, is routine and can proceed without undue difficulties.