ELECTRO-OPTICAL SYSTEMS

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Third Quarterly Report

DEVELOPMENT OF THERMIONIC CONVERTERS

Prepared for
California Institute of Technology
Jet Propulsion Laboratory
4800 Oak Grove Drive
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SECTION 1
INTRODUCTION

This is the third quarterly progress report under JPL Contract 952255. It is a 20-month program to design and develop low-power, high-efficiency thermionic converters of cylindrical geometry. The converters will be capable of being integrated to form a modular power supply. The central philosophy of this approach is to increase the reliability of thermionic space power supplies by redundancy of the basic component.

Seven converters and a bombardment heater unit are deliverable items per the contract Statement of Work. The converter development is to proceed in an iterative fashion whereby each converter design is reviewed separately and approved by JPL before fabrication. Subsequent performance data are reviewed separately, and will formulate the basis for redesign.

SECTION 2
CONVERTER SC-2

Converter SC-2 has been performance-tested successfully and delivered to JPL. Most of the results were reported in EOS Report 4018-Q-2. The completion of the required dc data at 1500°C emitter temperature is presented in Fig. 1. At 0.4V the current was 53A giving a power density of 5.3W/cm^2. The collector temperature was 775°C at a reservoir temperature of 325°C. At 0.5V the current was 36A for a power density of 4.5W/cm^2. The collector temperature was 762°C and the reservoir temperature was 325°C. At 0.6V the current was 22A for a power density of 3.7W/cm^2. The collector temperature was 704°C with a reservoir temperature of 300°C.

Figure 2 is a photograph of SC-2 after removal from the test gantry following performance testing.

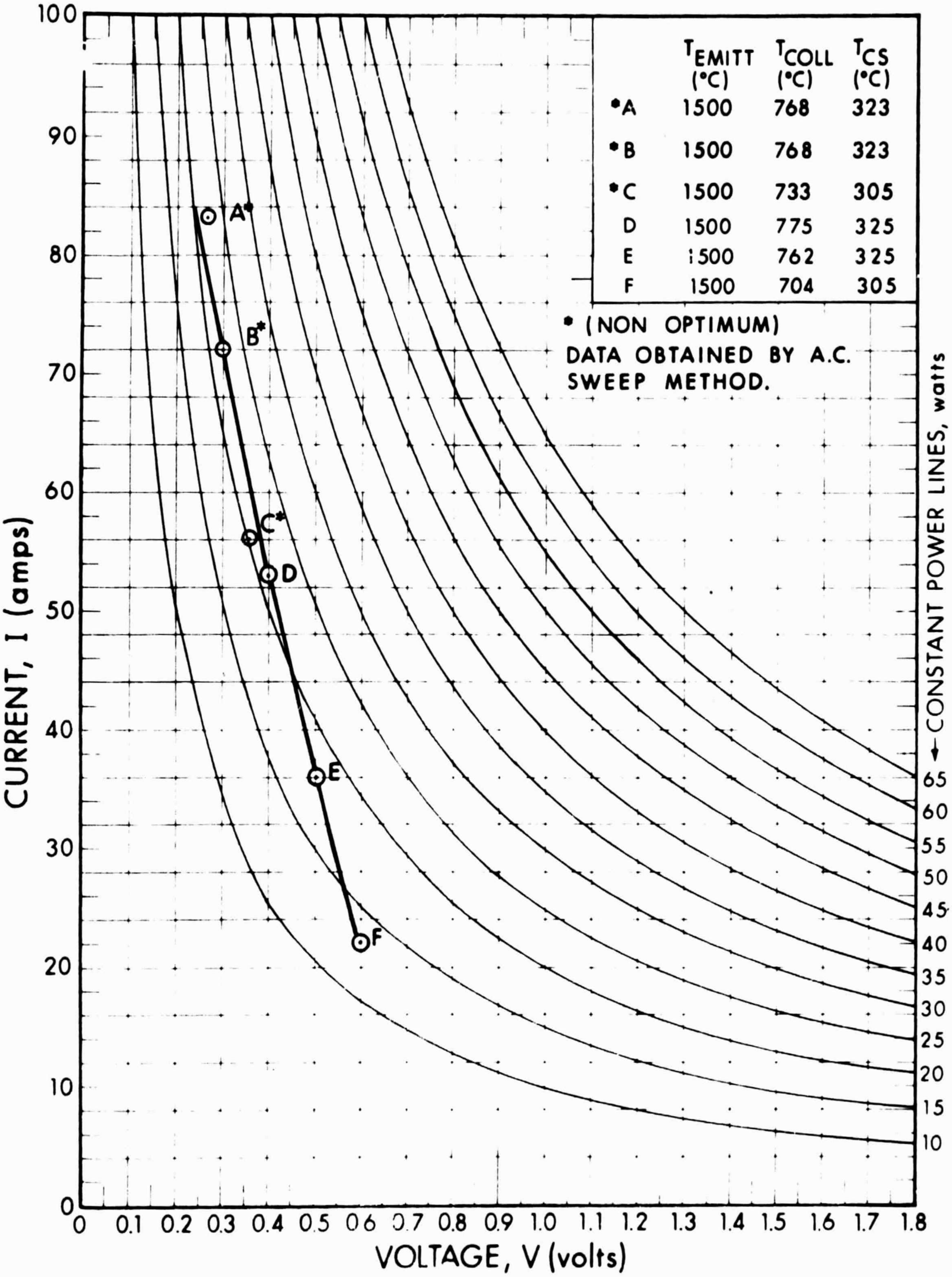

Figure 1. Performance Plot for SC-2 at T_E = 1500°C

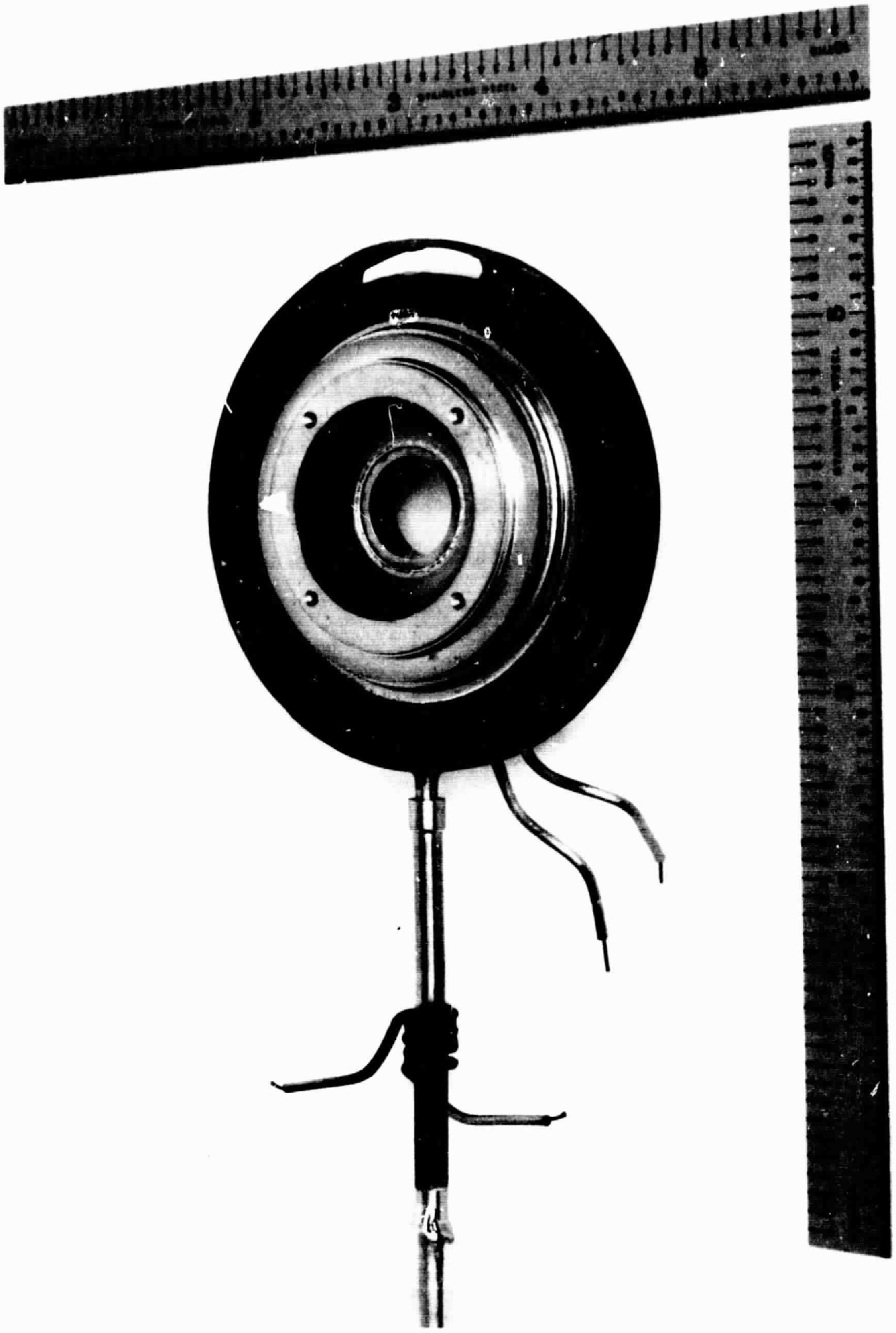

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Figure 2. Converter SC-2

SECTION 3

CONVERTER SC-3

Converter SC-3 has been designed to improve upon SC-2 in the following areas.

1. Stronger emitter support system for resistance to environmental stress convolute and conical bent in rhenium envelope.
2. More compact converter — reduce emitter lead width by 20%.
3. Better radiator sizing.

Figure 3 is an assembly drawing of SC-3. The conical shape of the envelopes with the convolute is shown. The emitter is slightly longer to accommodate the envelope. Converter SC-2 emitter area was 4 cm^2. Converter SC-3 will have a 4.06 cm^2 emitter.

The thickness of the converter is reduced by designing a prefabricated ceramic metal seal with a convolute in the flange. The convolute in the flange is an allowance for thermal expansion. With this design, the ceramic subassembly can be electron-beam welded directly to the collector, with the plane of the bottom of the ceramic coincident with the collector surface.

The area for collection of emission of the collector is 3.67 cm^2. Side wall collection from the envelope should be very small. The side wall spacing of SC-1 and SC-2 was 0.010 in. The added 0.020 in. provided by the new envelope design sets the side wall spacing at 0.030 in. at the plane of the collector face.

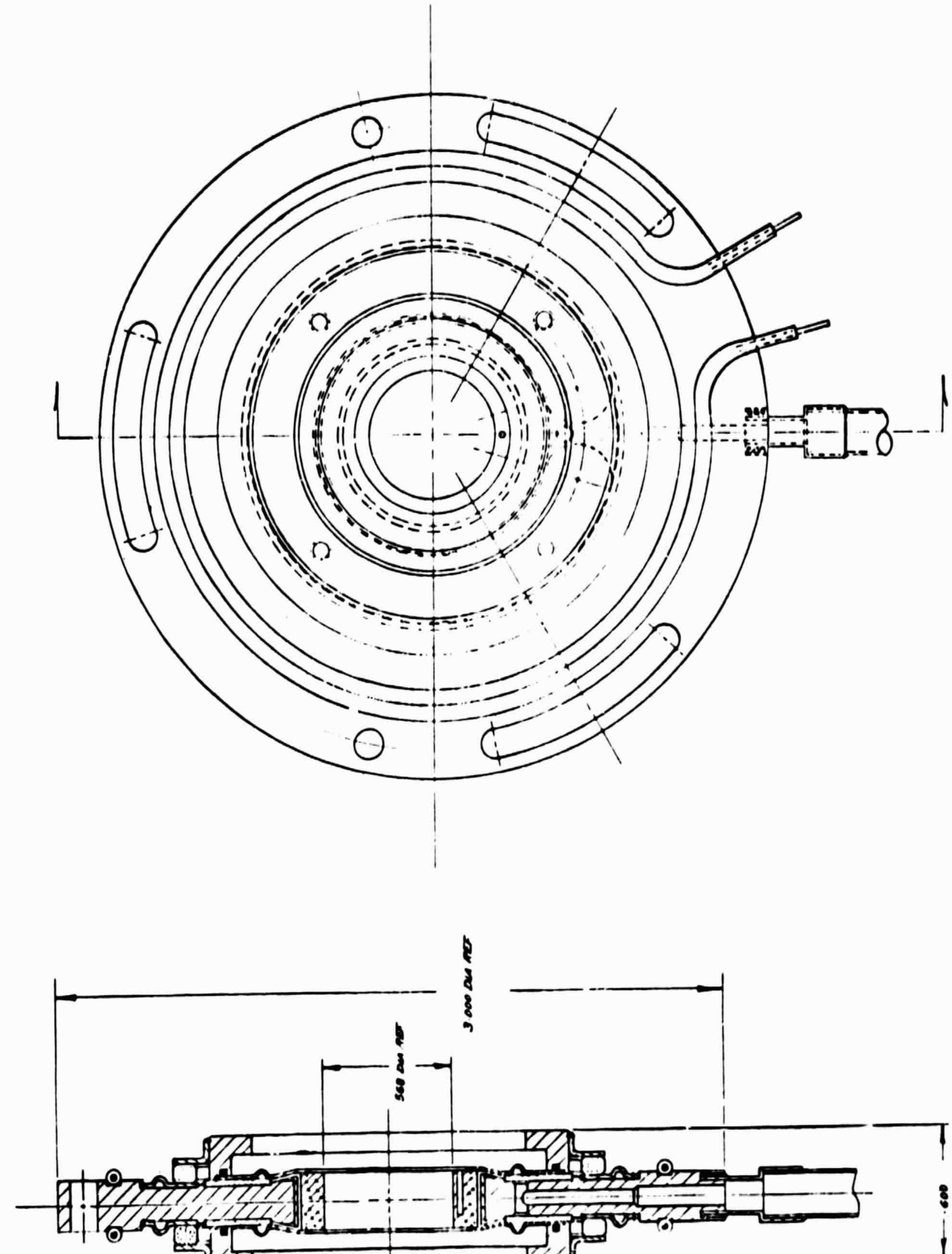

Figure 3. SC-3 Cylindrical Converter Assembly

The electron gun design for SC-3 will be identical to the design for SC-2. This design was presented in EOS Report 4018-Q-1.

Figure 4 is a drawing of the emitter support structure (envelope). A stronger emitter support system is accomplished by a single convolution and a conical bend in the rhenium envelope. The convolution will allow the envelope to expand radially with temperature. The conical bend also provides added strength to the envelope for resistance to environmental stresses.

The envelope convolution and bend are cold-formed in the rhenium. Two vacuum interstage anneals of 15 minutes each at 1700°C were required during the fabrication of the structure.

Figure 5 shows the ceramic-to-metal seal assembly. The overall converter thickness was reduced by providing a convolution in the collector flange of the seal assembly. The seal subassembly is electron-beam welded to the collector-radiator assembly. The plane of the seal flange is now coincident to the plane of the collector-radiator.

Converter SC-3 subassemblies are presently being electron-beam welded into the final configuration.

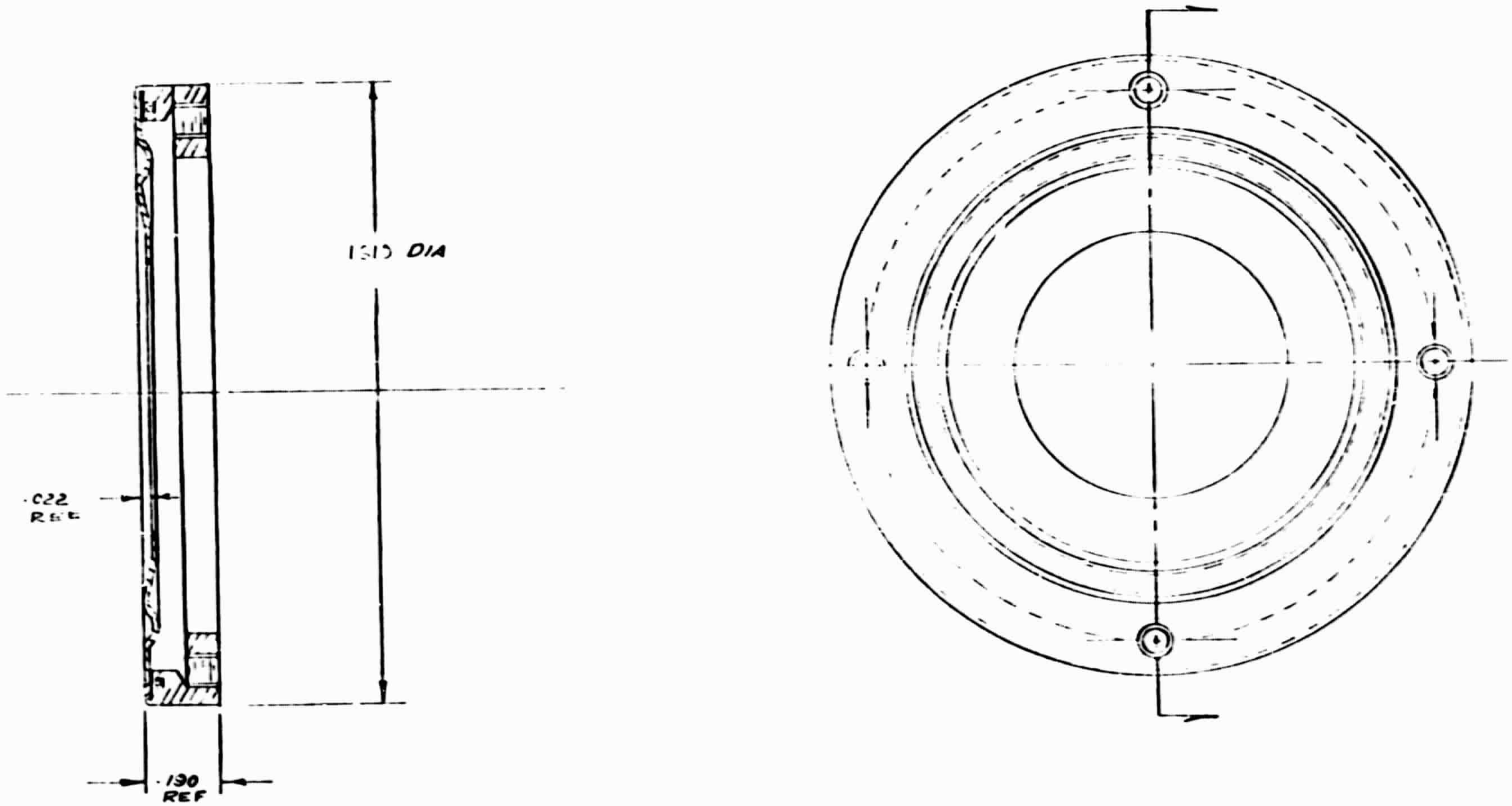

Figure 4. Emitter Support Structure (subassembly)

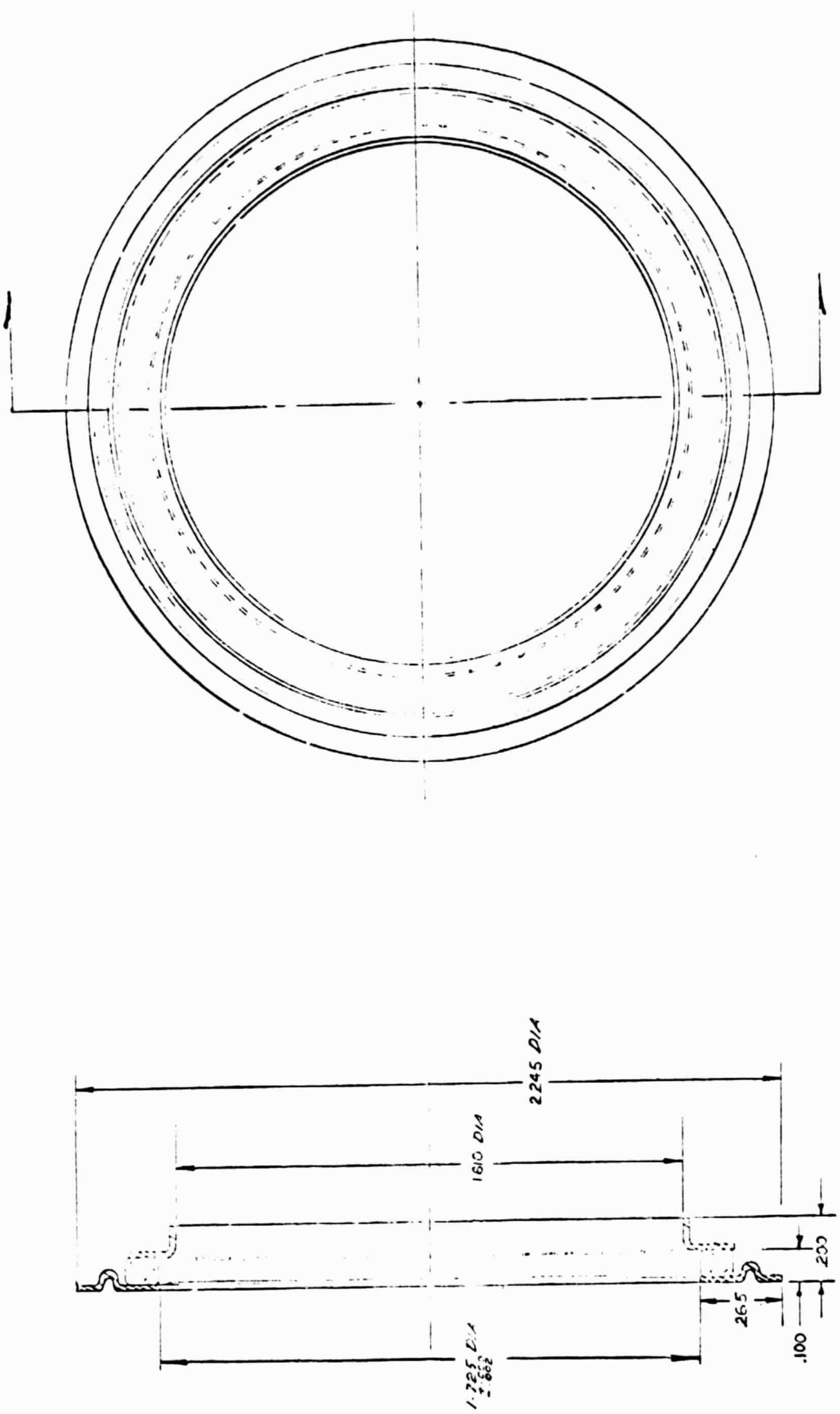

Figure 5. Ceramic-to-Metal Seal Subassembly