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Tissue Stimulator Enclosure Welding Fixtures

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National Aeronautics and
Space Administration

Goddard Space Flight Center
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TISSUE STIMULATOR ENCLOSURE WELDING FIXTURES

INTRODUCTION

Electrical stimulation is an acknowledged, highly successful procedure used in the relief of human organic disorders. One acceptable method of accomplishing stimulation is the implantation of a miniature generator which delivers electrical pulses to the affected tissue.

Power for the Stimulator is supplied by batteries, developed from space-age technology, which can be recharged by induction. This process eliminates the necessity of removing the Stimulator surgically each time its batteries have discharged.

It has been demonstrated that the thickness of the Stimulator titanium enclosure is directly related to the battery recharge time cycle. Reduction of the titanium enclosure thickness from approximately 0.37 mm (0.015 inch) to 0.05 mm (0.002 inch) significantly reduces the recharge time cycle and thereby patient inconvenience. However, fabrication of titanium enclosures from the thinner material introduced problems in forming, holding, and welding that required improvement in state-of-the-art shop practices.

This document describes the procedures that were utilized to resolve these fabrication problems.

BACKGROUND

The GSFC Engineering Services Division was requested by the GSFC Technology Utilization Office to provide technical support in the fabrication of Electronics Tissue Stimulator titanium enclosures (an exploded view of the titanium enclosure component parts may be seen in Figure 1). The support was provided to Johns Hopkins Applied Physics Laboratory and their contractor, Pacesetter Systems, Inc. The following critical items were investigated:

1. The suitability of the electron beam (EB) welder now in use at Pacesetter Systems, Inc., for production welding of the 0.05 mm titanium Mark III enclosures.
2. Probe misalignment caused by stresses which occur during lid fabrication.

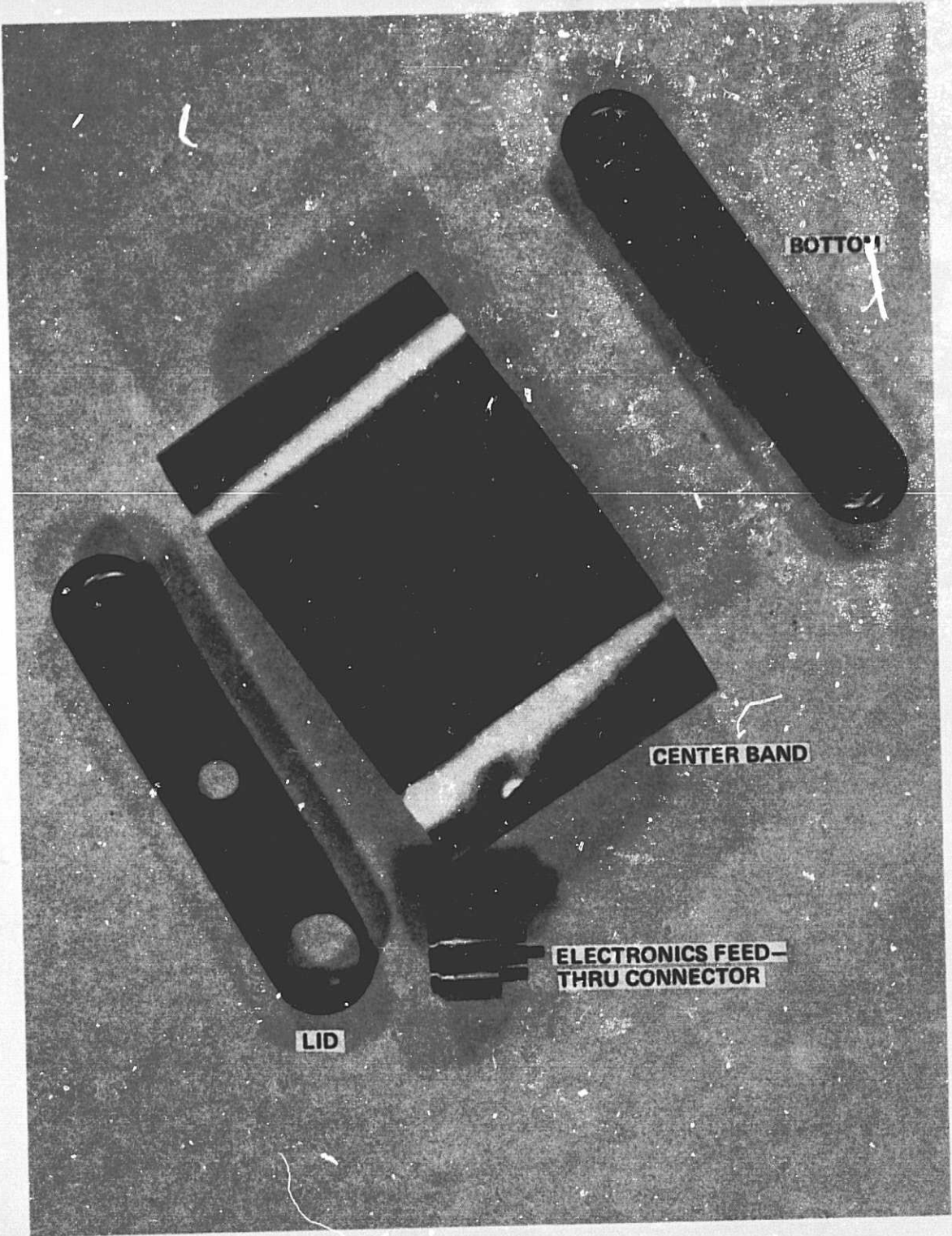


Figure 1. Exploded view of component parts for tissue stimulator enclosure

3. Forming the 0.05 mm Ti-3Al-2.5V and Ti-6Al-4V alloy enclosure component.
4. Resistance welding of MP35N wire to feed-thru pin of Inconel X750 alloy.
5. Designing a fixture to hold the 0.05 mm titanium during welding.
6. Welding the 0.05 mm Ti-3Al-2.5V and Ti-6Al-4V titanium alloys.

EVALUATION OF THE PACESETTER SYSTEMS, INC. ELECTRON BEAM (EB) WELDER

Investigations were conducted at Pacesetter Systems, Inc. by Pacesetter and Goddard personnel to determine the suitability of producing acceptable weld joints in 0.05 mm titanium with an electron beam welder. The following test samples were prepared. Their results are as follows:

1. Lap weld joint (0.05 mm Ti-3Al-2.5V)
Machine settings: 30KV, 0.5 ma, 30 in/min travel speed
Results: The weld burned through along the weld seam
2. Lap weld joint (0.05 mm Ti-3Al-2.5V)
Machine settings: 20 KV, 0.7 ma, deflection 10, 30 in/min travel speed
Results: Unsatisfactory due to insufficient fusing along weld seam
3. Butt weld joint 0.05 mm Ti-6Al-4V with 0.075 mm backup strip
Machine settings: 30 KV, 0.5 ma, deflection 10, 30 in/min travel speed
Results: The beam moved off the weld path and burned through near the end of the weld seam. Observation with a microscope showed the beam was not stable.

As a further test of the stability of the welder's electron beam, a 3.0 mm-thick block of stainless steel was placed in the welding machine. Several low-power runs were made across the block.

Results: Beam was not stable. Microscope examination revealed that the beam moved across the block in a random zigzag pattern, indicating that it was not stable at low-power settings.

Pulsing is necessary for performing final welding on the enclosure in order to minimize heat buildup, distortion of the enclosure, and to protect the electronics inside the enclosure. The aforementioned electron beam welding machine had no pulsing capability and because of the high cost it was deemed impractical to have it modified for pulsing.

Based on the above tests, it was mutually concluded that the electron beam welder was not suitable for production welding the 0.05 mm titanium Mark III alloy enclosures.

FORMING PROBLEMS

Misalignment of the Probe Attachment Nut Assembly on the Lid of the Mark III Enclosure

Stresses which occurred during the lid fabrication resulted in a non-flat condition around the surface of the hole on the enclosure lid. This caused misalignment of the nut assembly to the lid after welding. To solve this problem it was recommended that a fixture be designed such that the lid could be clamped flat and stress-relieved. The nut assembly may then be welded at the proper angle to the lid.

Forming the Bottom of the Mark III Enclosure

Partially formed bottom parts (Figure 2) and center band material of 0.05 mm (0.002 inch) titanium alloy Ti-6Al-4V were received from Pacesetter Systems, Inc., for welding tests. When the partially formed bottom part was trimmed, it sprung out of shape and would not fit on the welding fixture. To solve this problem, male and female dies (Figure 3) were fabricated. The partially formed bottom part from Pacesetter Systems, Inc. was placed between the dies which were clamped together, heated in a vacuum furnace at 1200°F for one hour and cooled to room temperature with argon gas. When the dies were separated, the formed part remained in the female die and had to be removed by use of compressed air. The part so formed held its shape very well and remained bright and shiny with no evidence of contamination or surface oxides.

WELDING PROBLEMS

Resistance Welding of MP35N Wire to Feed-thru Pin of Inconel X750 Alloy

Pacesetter Systems, Inc., encountered the following resistance welding problem. A length of 0.17 mm (0.007 inch) diameter MP35N wire that was resistance

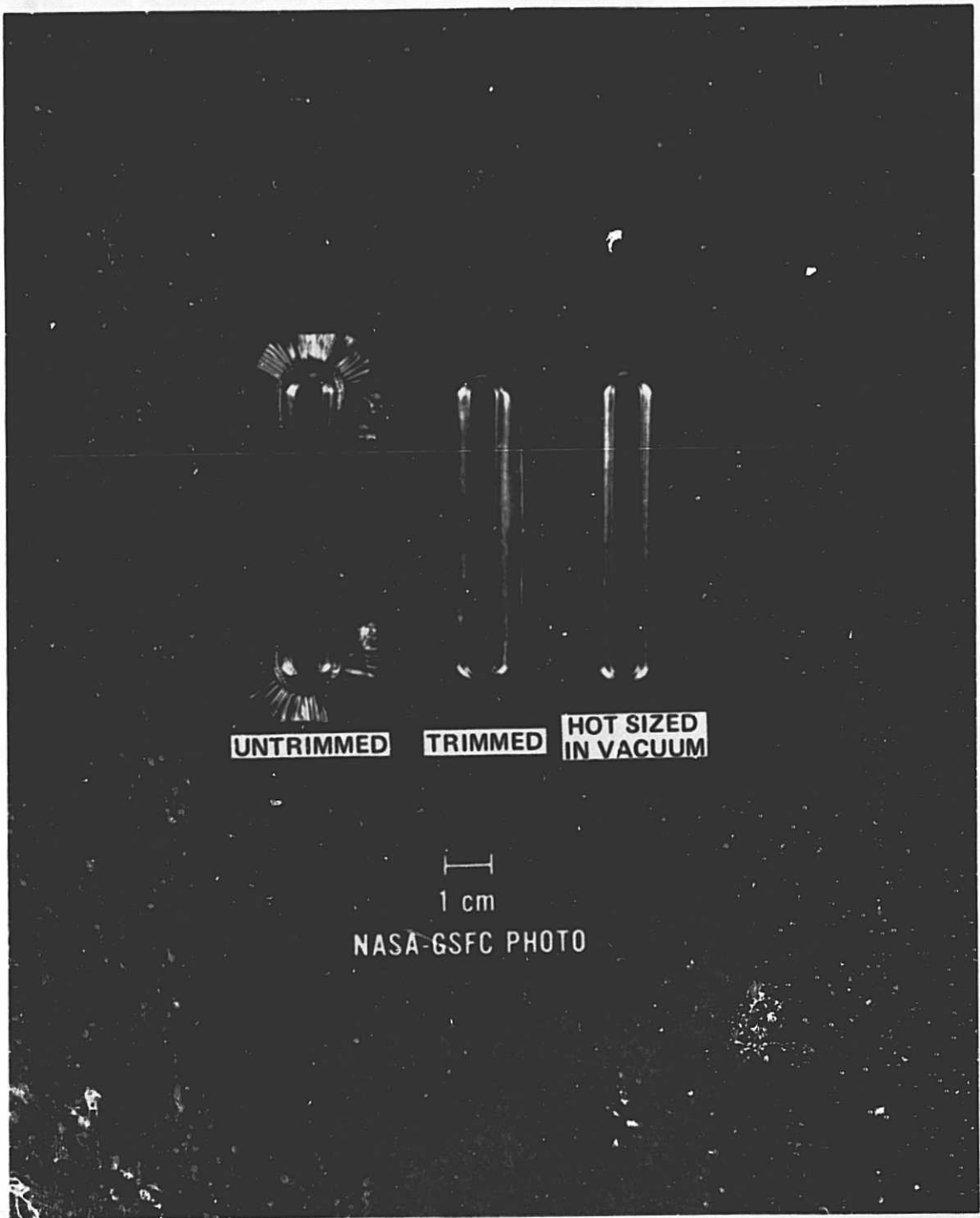


Figure 2. Bottom parts for tissue stimulator enclosure

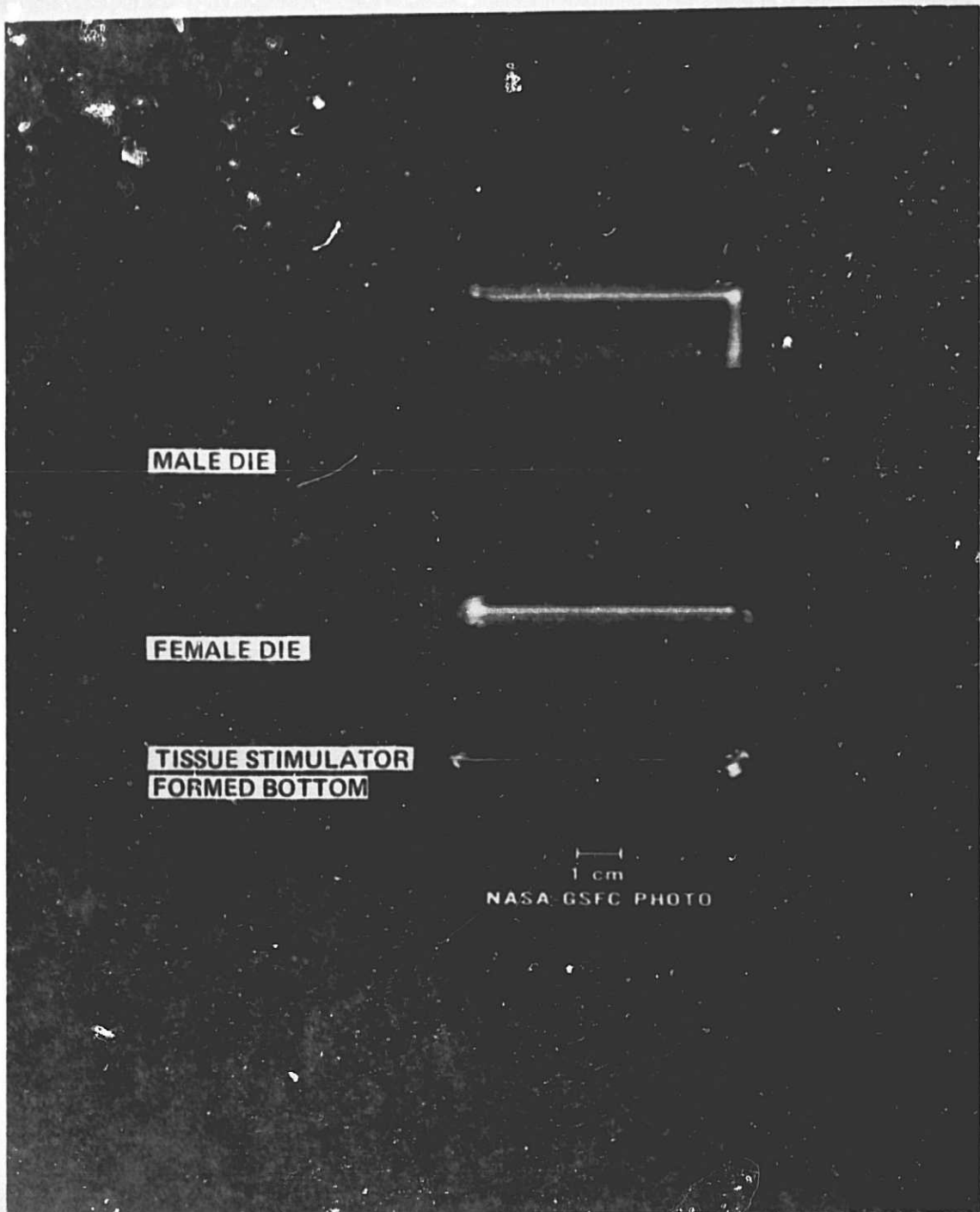


Figure 3. Dies for hot sizing and final forming of the tissue stimulator enclosure bottom

welded to the top of Inconel X750 feed-thru pin failed to pull the designed test load. See Figure 4.

Microscopic examination revealed oxides still present on the surface of the feed-thru pin where the weld was being applied. To resolve this problem, it was recommended that the feed-thru pin be chemically cleaned of all oxides prior to welding. Another problem Pacesetter Systems, Inc. encountered, concerning the same weld, was that the wire was breaking prematurely adjacent to the weld. An investigation showed that the weld was being applied adjacent to a 90-degree bend in the wire. The pressure of the welding electrode, together with the heat, was deforming the wire and setting up a stress concentration at the 90-degree bend, causing the wire to break prematurely. The recommendation in this instance was to drill a hole lengthwise through the center of the feed-thru pin slightly larger than the wire, run the wire through the feed-thru pin and fuse the wire to the bottom of the pin as shown in Figure 4.

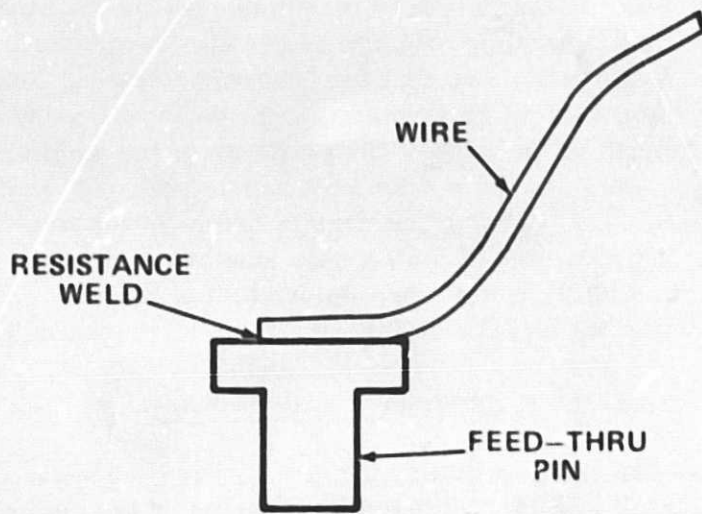
Design of the Center Band Welding Fixture

The center band welding fixture (Figure 5) was designed to size and hold the titanium foil for welding the longitudinal seam of the center band. The brass center heat sink has a copper insert for maximum heat transfer at the weld. The two stainless steel hold-down plates are aligned on the two stainless steel locating pins ensuring proper positioning of the center band for welding. The two brass wedge-shaped sizing bars provide precision sizing and are easily extracted to permit removal of the center band after welding. In Figure 6 the fixture is shown assembled with a welded center band.

Design of the Enclosure Welding Fixture

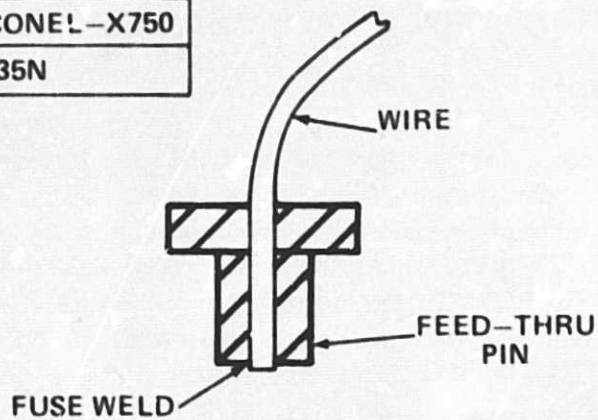
The welding fixture was designed specifically for holding the formed bottom or lid against the center band while welding the Mark III enclosure for the tissue stimulator. It should be noted that the welding fixture can also be utilized where different types of metals and/or different metal thicknesses are required. Furthermore, the Mark III enclosure is an acceptable housing for a heart pacemaker as well as a tissue stimulator. The fixture (Figure 7) consists of the following:

1. External heat sink mandrel including:
 - a. collet closure
 - b. collet
 - c. plate
2. Internal heat sink mandrel



UNSATISFACTORY METHOD

MATERIAL:	
PIN	INCONEL-X750
WIRE	MP35N



SUGGESTED METHOD

Figure 4. Resistance welding of wire to feed-thru pin

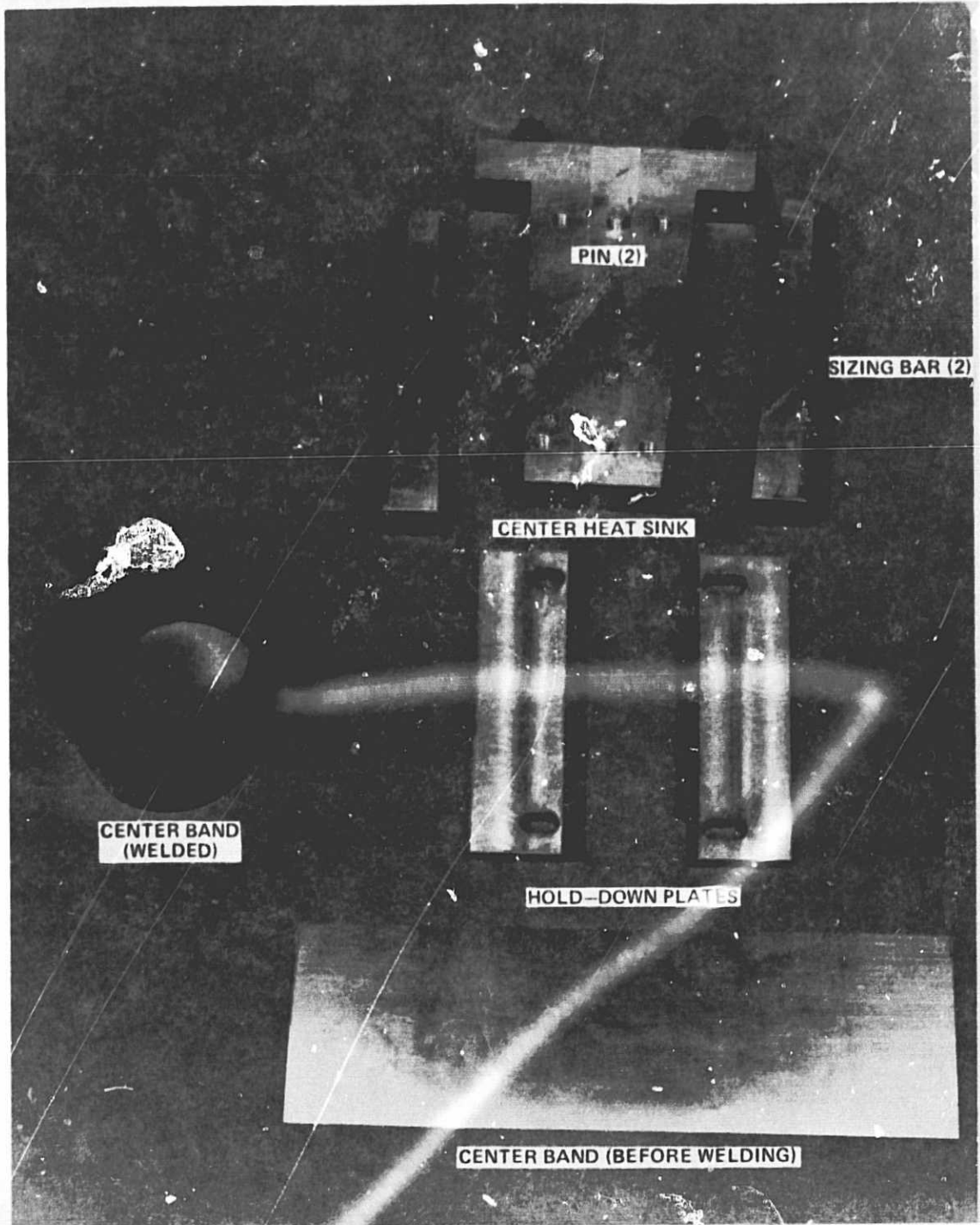


Figure 5. Disassembled center band welding fixture

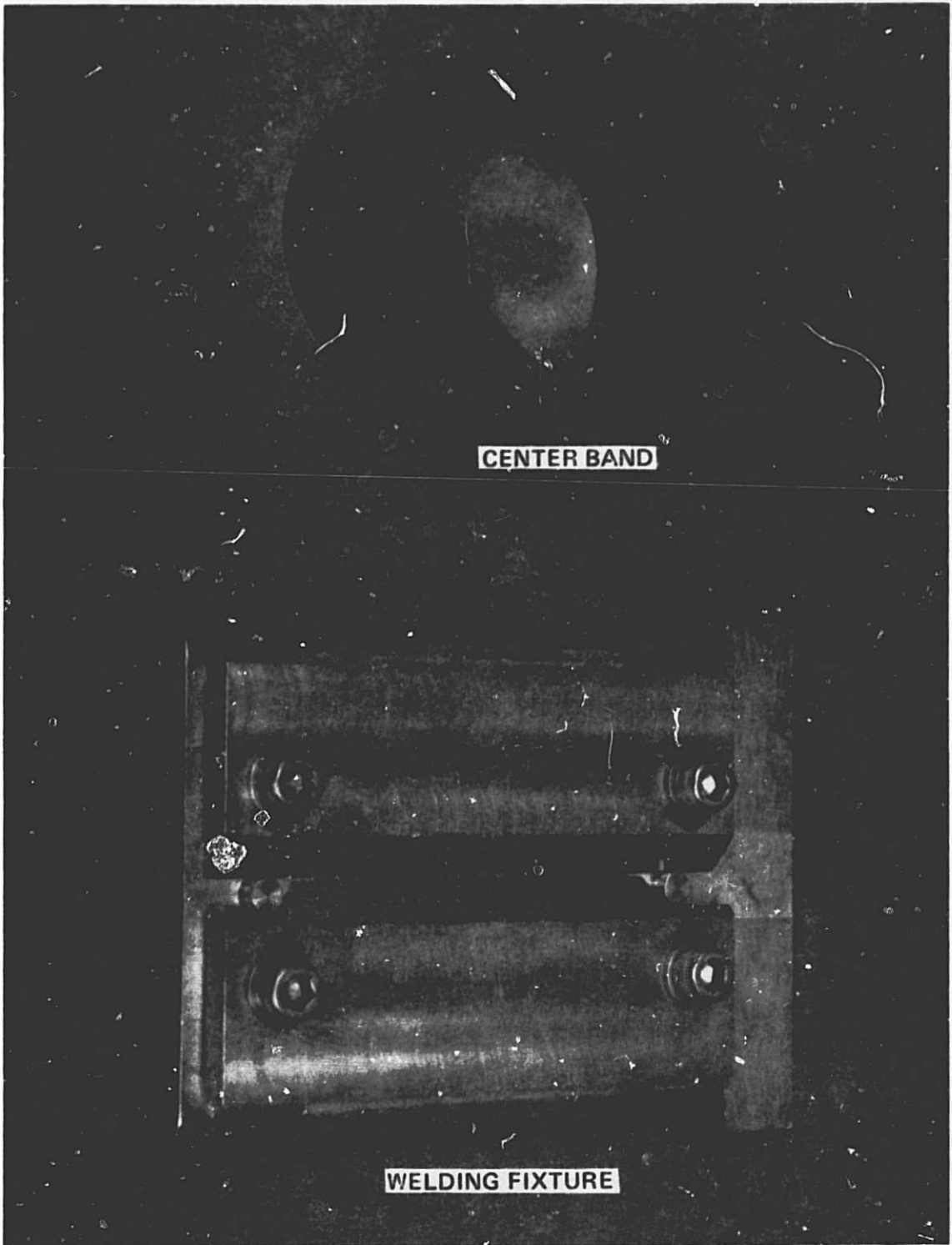


Figure 6. Assembled center band welding fixture

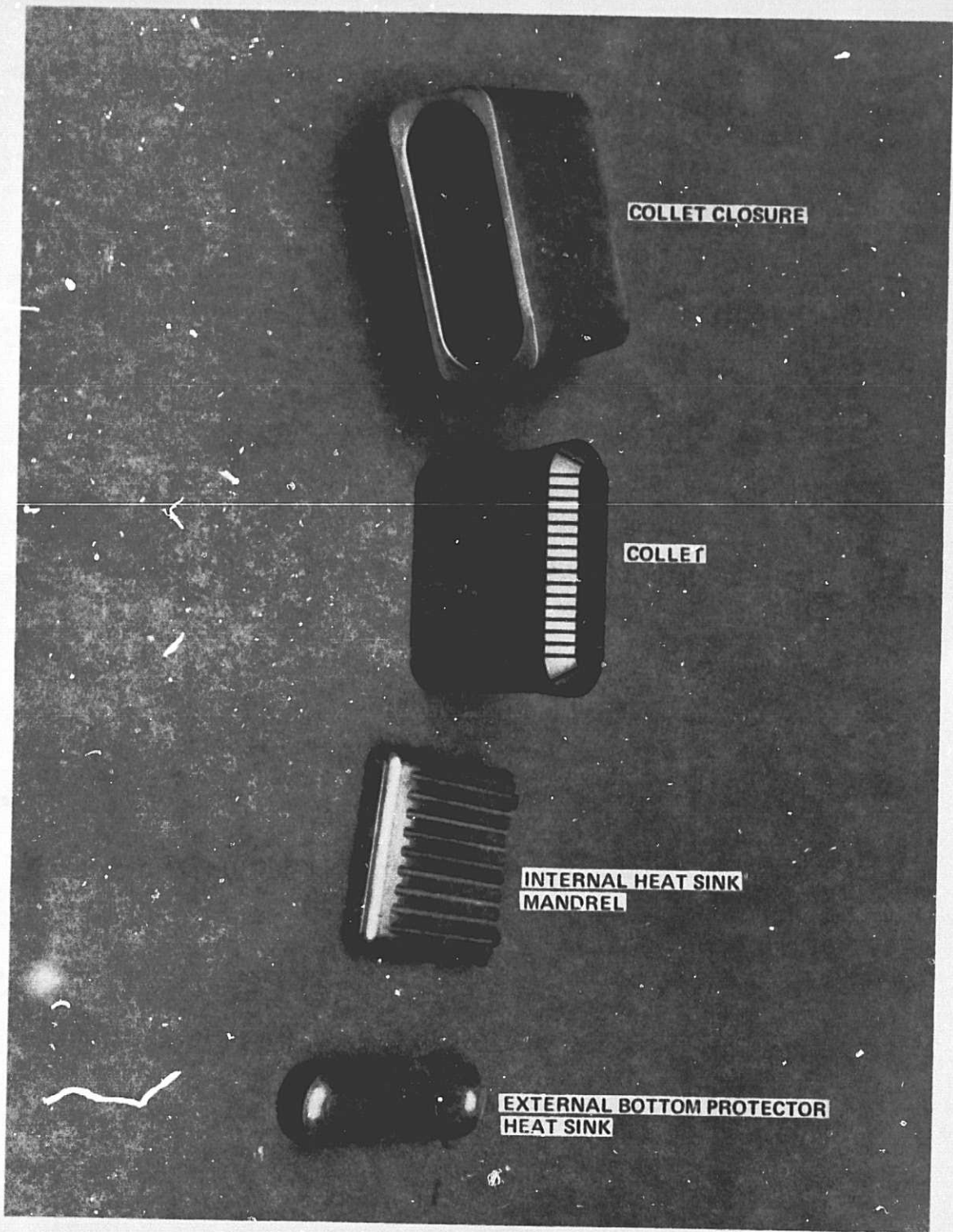


Figure 7. Enclosure welding fixture

3. External bottom protector heat sink

Figure 8 shows the enclosure welding fixture with formed parts and with the internal heat sink inserted into the enclosure. The fixture may be fabricated from stainless steel exclusively or, if weight is a factor, aluminum with a stainless steel plate may be used. Refer to Figures 9, 10 and 11 for engineering drawings of the enclosure welding fixture.

Operation of the Enclosure Welding Fixture

Welding the formed metal bottom to the center band is accomplished as follows (See Figure 8):

- 1. Place the formed bottom over the end of the internal heat sink mandrel.**
- 2. Slip the welded center band over the formed bottom and onto the internal heat sink mandrel.**
- 3. Place the internal heat sink mandrel with the center band and formed bottom in place inside the collet.**
- 4. Place the collet inside the closure.**
- 5. Place an allen head screw through the hole in the bottom of the closure and screw it into the threaded hole in the bottom of the collet until the fingers of the collet hold the center band tightly against the formed bottom.**
- 6. Place the external bottom protector heat sink on the formed bottom and clamp it to the holding fixture.**
- 7. The holding fixture is now ready to be placed on a turning fixture for welding.**

Welding the formed metal lid to the center band is accomplished as follows:

- 1. Install the electronic package into the housing.**
- 2. Slip the center band over the bottom edge of the housing lid.**
- 3. Slip the housing into the collet.**
- 4. Slip the collet into the closure.**

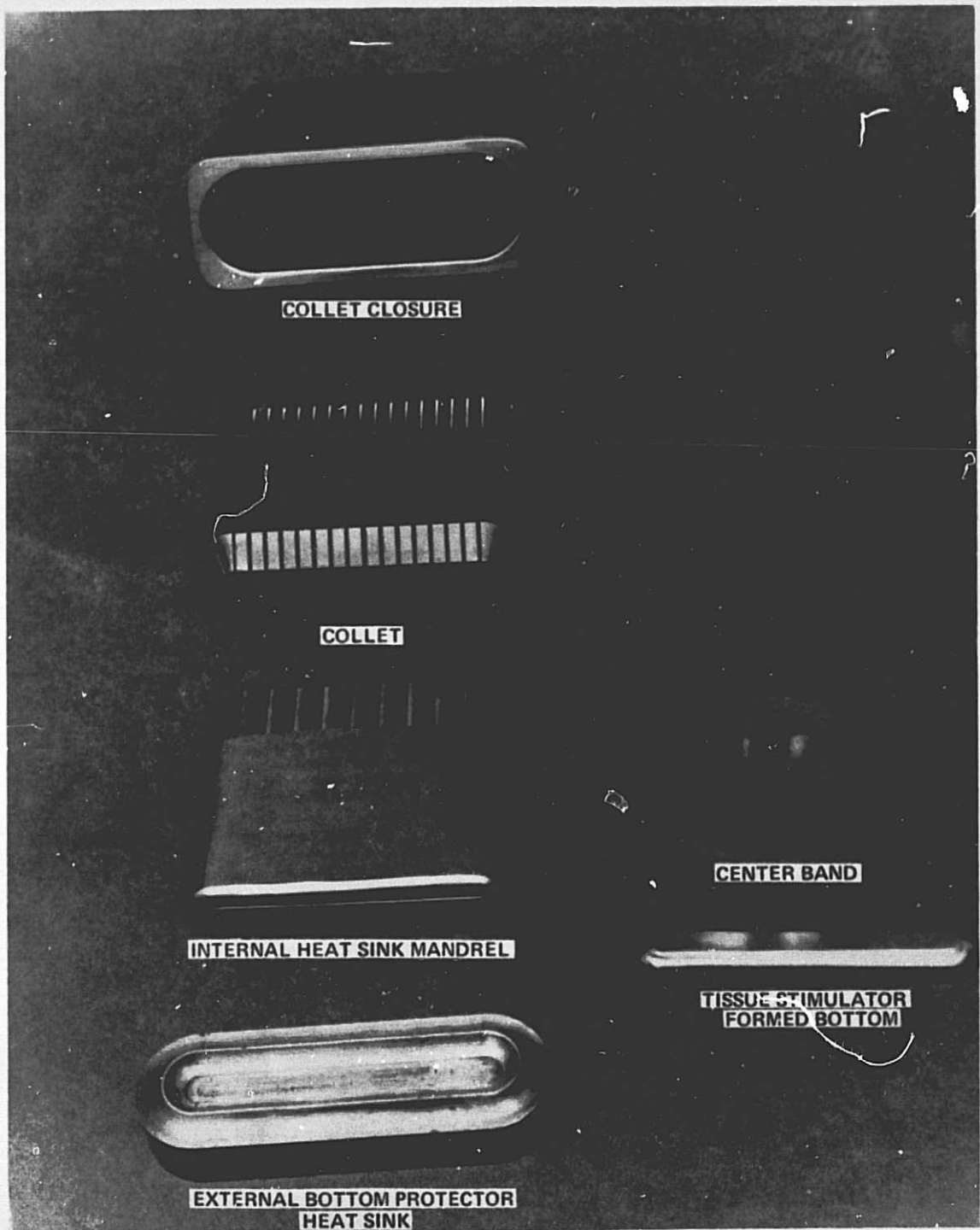


Figure 8. Enclosure welding fixture with formed parts

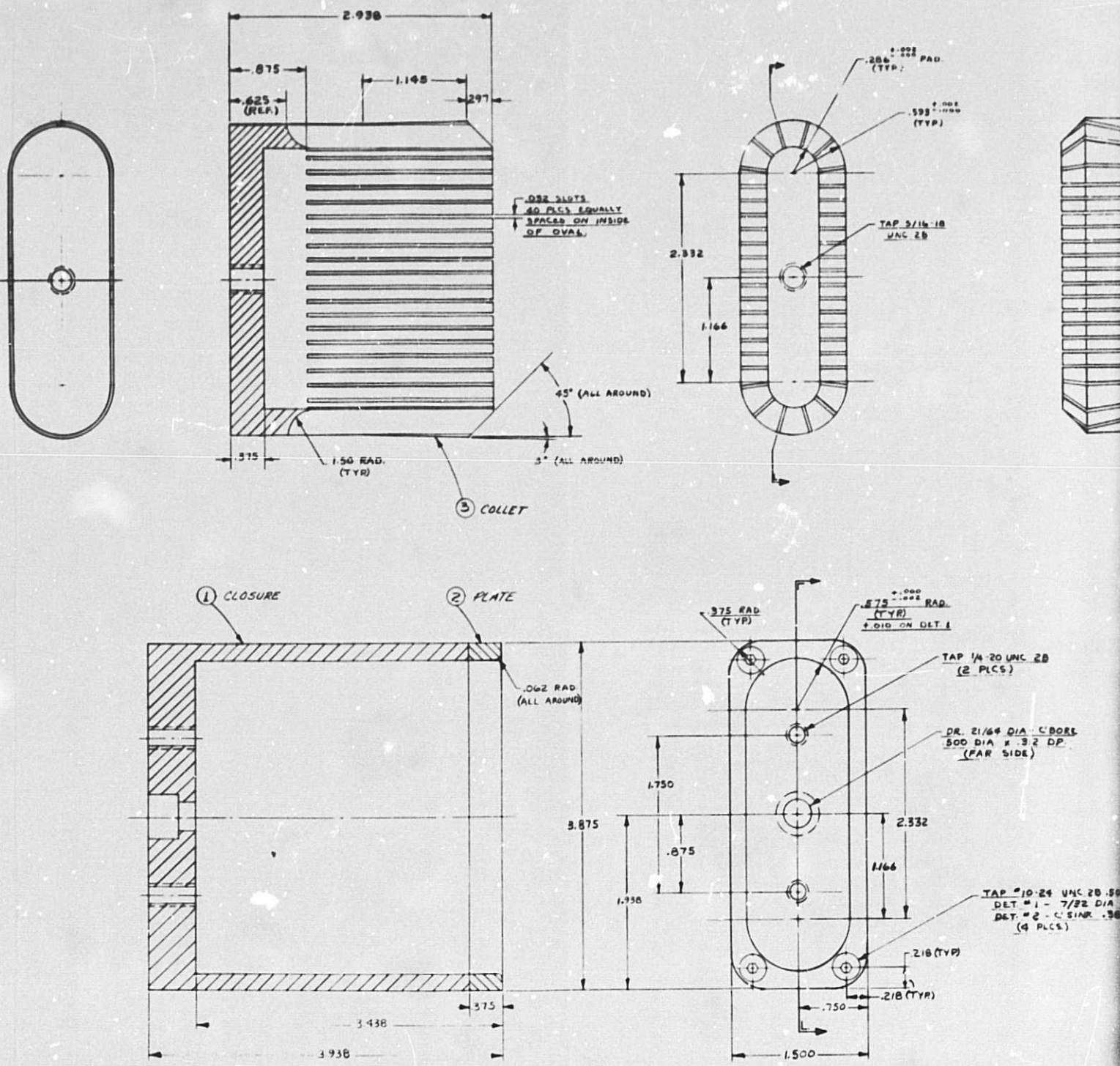
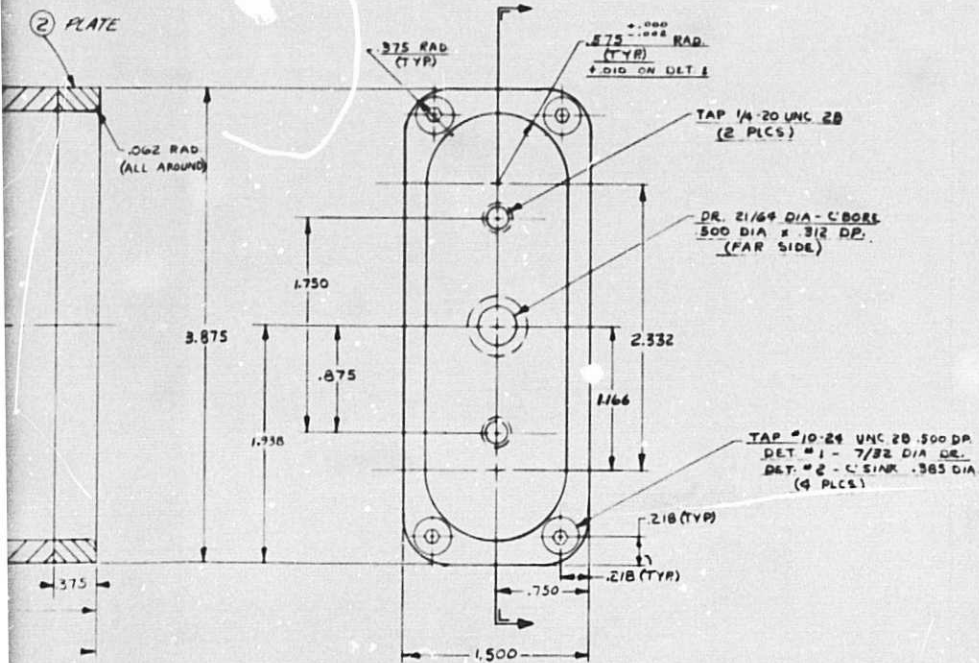
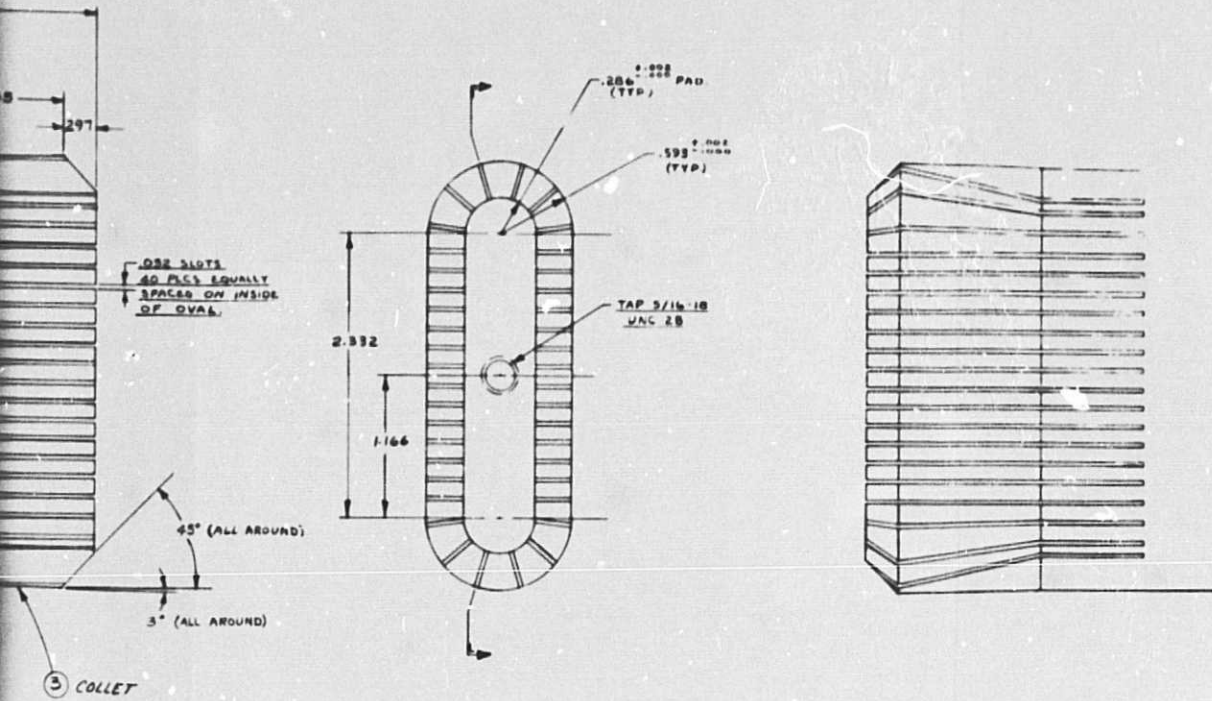


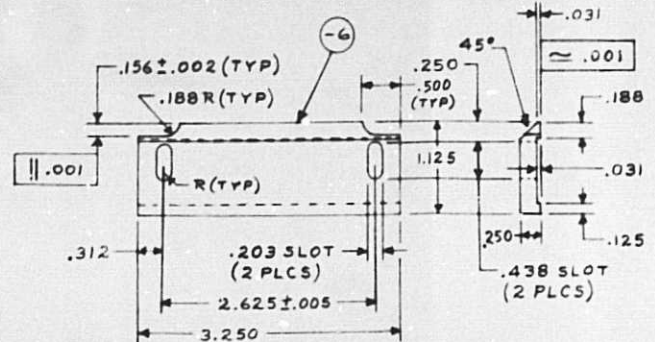
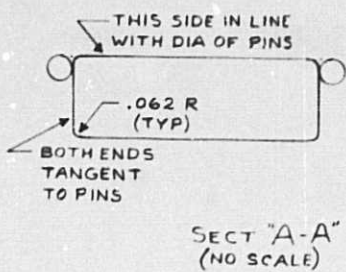
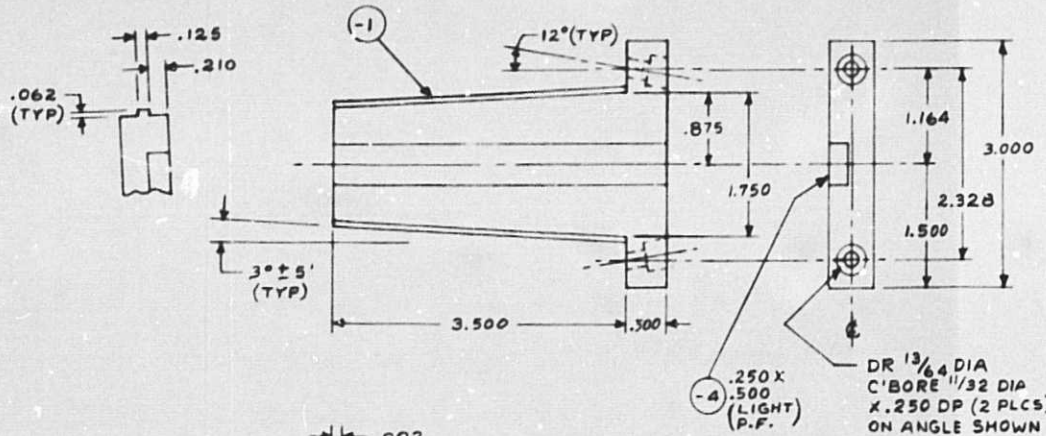
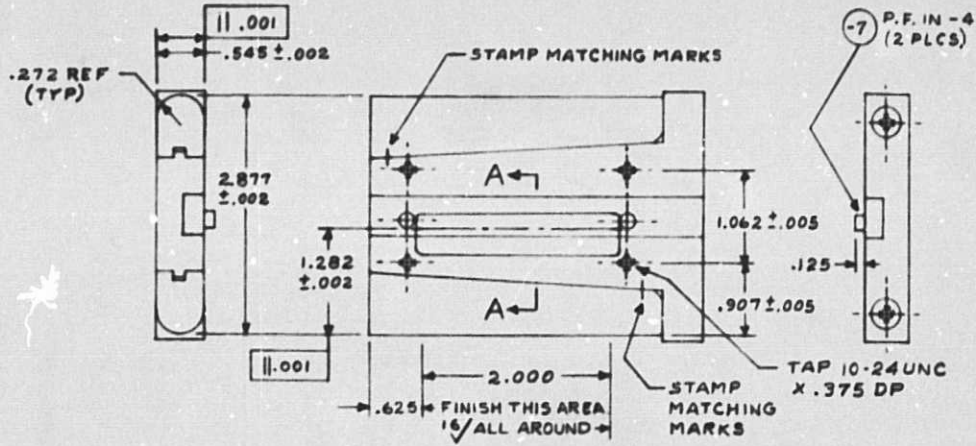
Figure 9. Enclosure welding fixture



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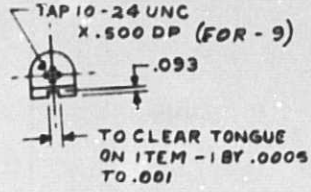
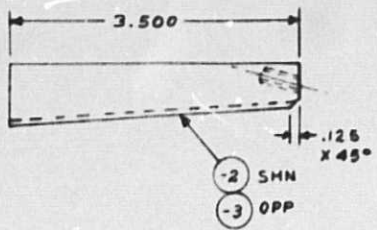
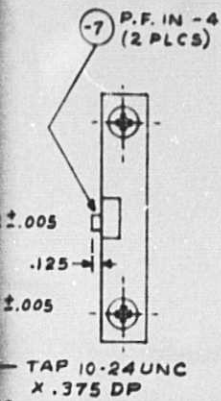
Figure 9. Enclosure welding fixture—external heat sink mandrel drawing

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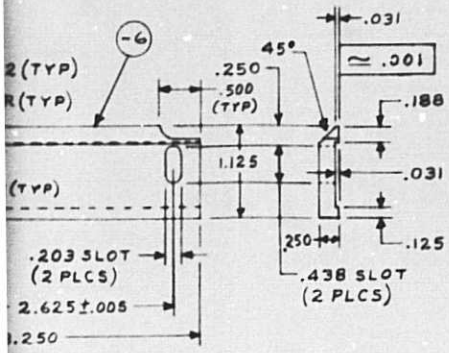
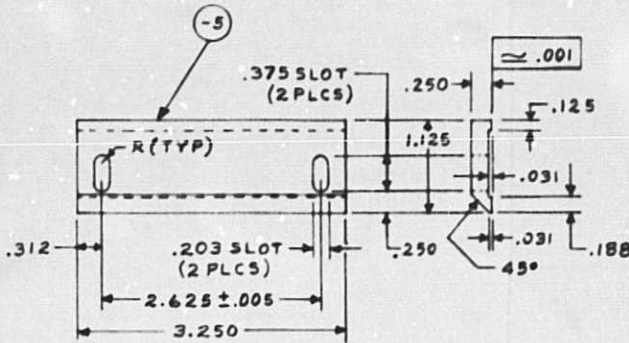
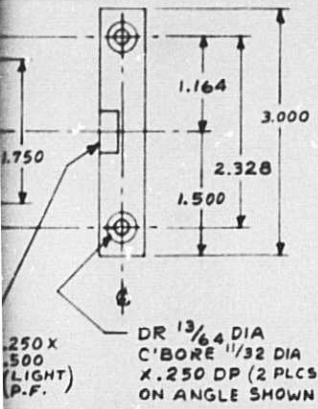
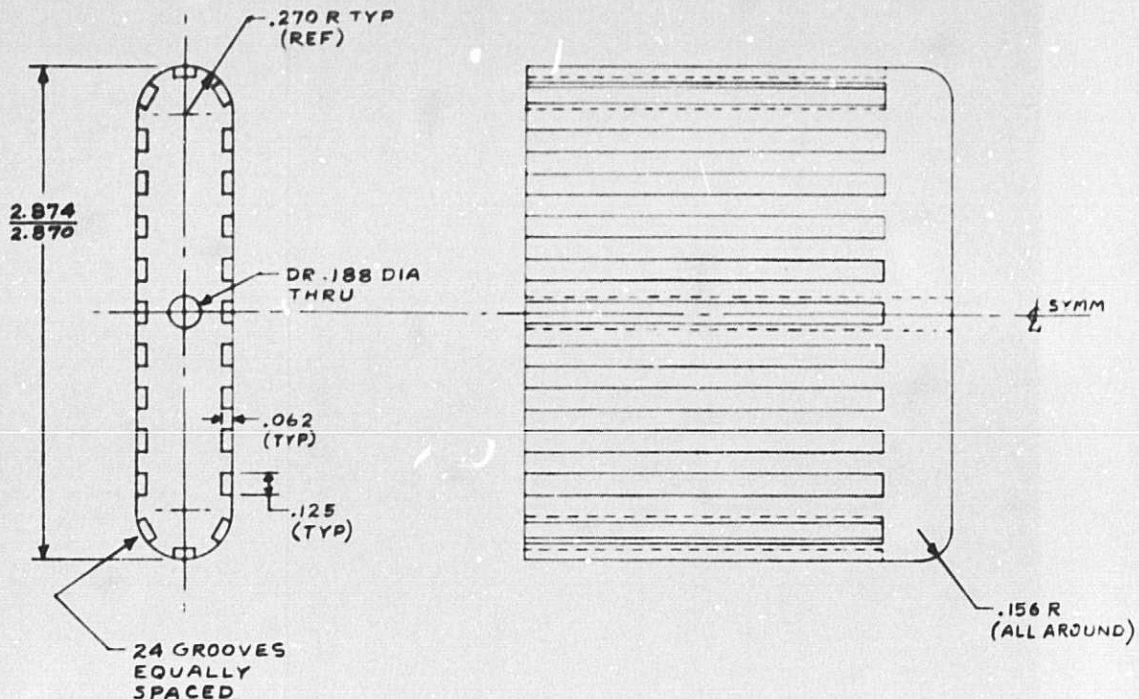


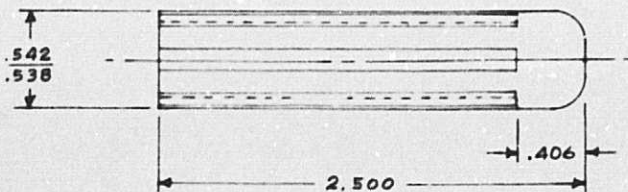
Figure 10. Enclosure welding fixture—center band fixture drawing

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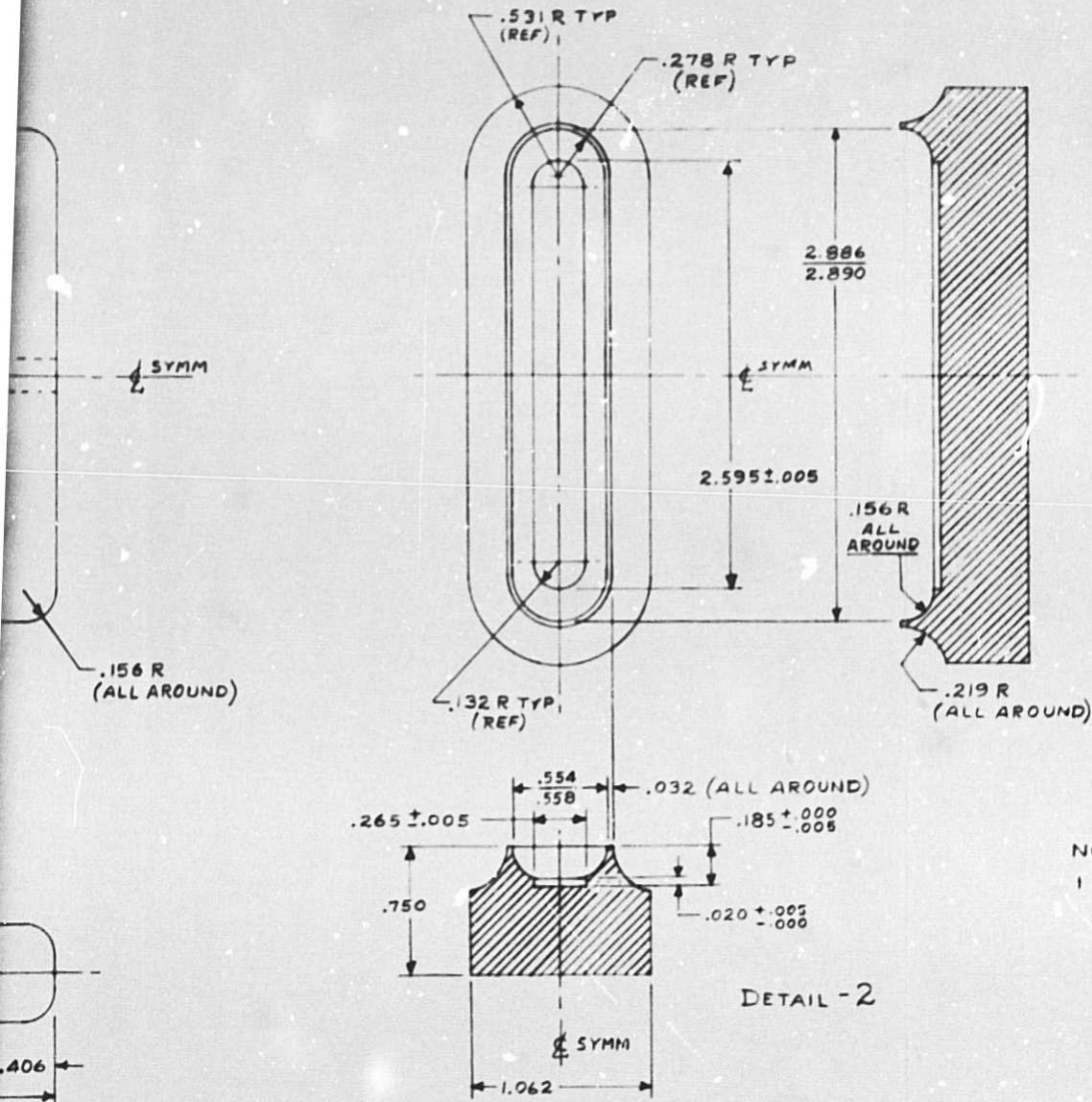


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Figure 11. Enclosure welding fixture—internal and external heat sink mandrel drawing

5. Place an allen head screw through the hole in the bottom of the closure and screw it into the threaded hole in the bottom of the collet until the fingers of the collet hold the center band tightly against the formed bottom.
6. Place the external bottom protector heat sink on the formed bottom and clamp it to the holding fixture.
7. The holding fixture is now ready to be placed on a turning fixture for welding.

Welding the formed metal lid to the center band is accomplished as follows:

1. Install the electronic package into the housing.
2. Slip the center band over the bottom edge of the housing lid.
3. Slip the housing into the collet.
4. Slip the collet into the closure.
5. Place an allen head screw through the hole in the bottom of the closure and screw it into the threaded hole in the bottom of the collet until fingers of the collet hold the center band tightly against the formed lid.
6. The holding fixture is now ready to be placed in the turning fixture for welding.

This fixture permits very thin material to be held under constant and equal force at all points on its perimeter because of the metal fingers of the collet. With this fixture 0.05 mm (0.002 inch) enclosures may be welded. Prior art does not permit welding enclosures at thicknesses as thin as 0.05 mm because of holding fixture problems.

Unique Features of the Enclosure Welding Fixture

The unique feature of the enclosure welding fixture is the design of the collet. When the allen head screw in the bottom of the closure is turned the fingers of the collet are forced inward, clamping the very thin metal parts at equal force on all points of contact. This feature constitutes an improvement in state-of-the-art shop practices whereby successful welding of 0.05 mm-thick metal enclosures is now possible.

Purpose of the Center Screw

The purpose of the center screw is to pull the collet into the closure. This forces the fingers of the collet inward, clamping them at equal force around the perimeter of the enclosure where the welding operation is accomplished.

CONCLUSIONS

The recommendations presented to Pacesetter Systems, Inc. regarding the six critical items listed under "Background" were as follows:

1. Discontinue use of the Pacesetter electron beam welder. It has been demonstrated that this welder is not suitable for producing acceptable welds on the Mark III titanium enclosure.
2. Fabricate a fixture such that the enclosure lid can be clamped on a flat surface and stress-relieved during fabrication. This will solve misalignment problems with the lid and probe attachment.
3. Size the formed bottom part as follows:
 - a. clamp between male and female dies
 - b. heat in a vacuum furnace
 - c. cool with argon gas
4. Resistance weld the MP35N wire to the X750 alloy feed-thru pin using the following procedure:
 - a. clean the feed-thru of all oxides
 - b. drill a hole through the center of the feed-thru pin slightly larger than the wire
 - c. insert the wire through the feed-thru pin
 - d. fuse the wire to the bottom of the pin
5. Utilize the welding fixture which was designed for welding the longitudinal seam of the center band, and utilize the fixture which was designed to hold the formed bottom against the center band when welding the Mark III enclosure.
6. Utilize the center band and enclosure welding fixture to accomplish acceptable production welds with electron beam, laser, or tungsten inert gas (TIG) welding processes.

A "Disclosure of Invention" document on the tissue stimulator enclosure was submitted to the GSFC Patent Counsel on August 9, 1977.

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