ULTRASONIC WELDING PROCESS AND EQUIPMENT FOR CONSTRUCTION OF ELECTRON-TUBE MOUNTS

Eighth Quarterly Progress Report
For the Period
April 1 through June 30, 1964

Contract No. DA-36-039-sc86741
Order No. 19063-PP-62-81-81

Placed by
Industrial Engineering Division
United States Army Electronics Command

AEROPROJECTS INCORPORATED
West Chester, Pennsylvania

ULTRASONIC WELDING PROCESS AND EQUIPMENT FOR CONSTRUCTION OF ELECTRON-TUBE MOUNTS

Eighth Quarterly Progress Report
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The object of this program is to design and construct prototype welding equipments and their associated accessories to perform by ultrasonic techniques the welding operations required in the assembly of electron tubes.

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Specifications SCS-114A, SCIPPR-15
and MIL-E-1/1121A

Report Prepared by: J. W. Thomas

Report Approved by: J. Byron Jones

ABSTRACT

Modifications in the original scope of work of this program have been agreed upon. The revised program provides for additional investigation in specific areas, deletion of some items from the original scope, and a modified delivery schedule.

Efforts originally directed toward ultrasonic welding of the Types 5814WB and 6205 electron tubes have been replaced by a concentrated effort to obtain a totally ultrasonically welded Type 6080WB tube with superior performance capabilities to those presently in production, while maintaining a competitive manufacturing cost.

Since this program was initiated, a tungsten-3% rhenium alloy wire has been developed with properties of significant interest to electron-tube manufactures. An investigation of the ultrasonic weldability of this wire has been included in the program as an additional area of study.

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PURPOSES

The objectives of this Production Engineering Measure (PEM) are to:

1. Demonstrate the capability limits of ultrasonic welding to join combinations of metallic materials of interest to the electron-tube industry. Devote major effort to making satisfactory joints in materials and geometries which might be difficult or impossible to join by other means.

2. Analyze the welding requirements for a specific electron tube - Type 6080WB. This type was selected by the U. S. Army Electronics Command because it is widely used in military equipment, and has a record of failures due to improperly welded joints.

3. Redesign components of the Type 6080WB electron tube where possible, to permit ultrasonic welding of connections previously found impractical. This effort will result in a tube mount with as many connections as possible joined by ultrasonic welding so that evaluation of electron-tube performance will not be confused by the influence of connections produced by other methods.

4. Determine the feasibility of joining molybdenum grid wires to molybdenum side bars by ultrasonic welding for frame grid manufacture. If successful, redesign applicable components of the Type 6080WB electron-tube mount to permit the use of frame grids.

5. Prepare fixturing and tooling for the Type 6080WB electron tube, compatible with ultrasonic welding equipment.

6. Ultrasonically weld the parts required to assemble electron-tube mounts for the 6080WB tube type, and compare results obtained against similar sub-assemblies made by conventional joining methods. Tests will include strength and environmental tests.

7. Build production ultrasonic welding equipment which will enable an electron-tube manufacturer to make the welded connections in a broad range of electron-tube types.

8. Install the ultrasonic welding equipment in a production company, and produce on a pilot basis with that company's personnel, a limited lot size of Type 6080WB electron tubes for subsequent evaluation in accordance with the applicable military specification.

NARRATIVE AND DATA

I. Revised Scope of Work

During the course of this program, all of the welded connections for three specified electron tubes - Types 5814WB, 6205, and 6080WB - have been examined for possible application of ultrasonic welding. The 6080WB tube has the most welded joints of the three, and ultrasonic welding has been successfully applied to a much higher percentage of these joints than those in the two smaller tube types.

Since it was considered advisable, for best evaluation of the ultrasonic welding technique, to produce as many joints as possible in any electron tube by this process so that evaluation of performance would not be confused by the presence of joints made by other methods, a revised program was evolved through discussion with representatives of USAECOM and Tung-Sol Electric Incorporated. In addition, since the Types 5814WB and 6205 electron tubes contained insufficient areas of ultrasonic welding application to make further effort with these tubes profitable, the Type 6080WB tube only was selected for continued welding investigation. The objective of the additional work with the Type 6080WB tube is to consider redesign of the three junctions which had previously been unsuccessful in ultrasonic welding attempts. No over-all tube redesign is contemplated. Changes in the tube will be limited to geometrical or material changes in the tube elements directly concerned with the three junctions of interest.

All but three of the twenty-two types of welded connections in the Type 6080WB electron tube have been made successfully with ultrasonic welding. One junction, which could not be made because of its geometry (getters to snubber supports; see Assembly Sequence No. 22 in Quarterly Progress Report No. 6, Page 12), can be redesigned to permit accessibility for ultrasonic welding. A second junction which is presently inaccessible for ultrasonic welding tooling (grid radiator to grid; Assembly Sequence No. 8), may also be redesigned for adequate accessibility. The third junction (snubber to snubber supports, Assembly Sequence No. 18) presented difficulty because of the material combination (hard Inconel to relatively soft Nickel).

Two additional new tasks have also been incorporated into the revised program. The first involves the ultrasonic welding of molybdenum frame grid assemblies for the Type 6080WB electron tube. Frame grids made of molybdenum are significant in the fabrication of electron tubes, particularly since their use permits high operating temperatures with minimum distortion. Fabrication of the frame grids is exacting, however, requiring precise dimensional control (without deformation during processing), accurate grid wire spacing, and intimate contact between the grid wire and side bars. If one contact does not form satisfactorily and with proper spacing, the entire assembly is discarded.

Many frame grid designs are rectangular, with 0.030- to 0.050-inch diameter molybdenum side bars and 0.0025- to 0.006-inch diameter molybdenum wire which is usually gold-plated to reduce secondary emission (Figure 1). The contact between the grid wires and the side bars is usually obtained by one of several methods:

1. Parts can be gold-plated and the joint made by heating the assembly in a furnace to fuse the gold at the contact areas.

2. A nickel or silver strip can be welded to the side bars and the grid wires subsequently welded to the nickel or silver overlay.

3. The side bars may be coated with glass frit after the grid wires are wound. The glass frit is then fused to secure the contact.

4. On small grids, the wrapping tension of the fine grid wire may be sufficient to produce the required contact.

In view of the successful results achieved in the ultrasonic welding of molybdenum during the earlier material feasibility survey (Second Quarterly Progress Report), it is believed that the method can be used to advantage in the manufacture of this type of grid and reduce processing costs. The welded frame grids, after feasibility demonstrations, can be incorporated into the Type 6080WB tubes for evaluation. Techniques developed for ultrasonically welding these assemblies will be such that the welding equipment required under the program can be used by Tung-Sol Electric Incorporated or any electron tube manufacturer to fabricate production quantities.

The second new task involves the investigation of the ultrasonic weldability of a tungsten-rhenium alloy wire for filaments, which has properties of substantial interest to electron-tube manufacturers. The tungsten-3% rhenium alloy is more ductile than pure tungsten wire, and is therefore less difficult to fabricate and join. Industry is presently using the wire in the 0.003-inch to 0.008-inch diameter range. A welding investigation paralleling the scope of the earlier materials combination feasibility study (Second Quarterly Progress Report) will be undertaken with 0.003-inch diameter tungsten-3% rhenium wire welded to tungsten, molybdenum, and nickel sheet.

II. Welding Tungsten-3% Rhenium Wire

Work with the 0.003-inch diameter tungsten-3% rhenium wire to 0.060-inch tungsten, molybdenum, and nickel was carried out with the 100-watt ultrasonic welder acquired under the program. The tungsten and molybdenum sheet material was ground and electropolished prior to welding. The nickel sheet was prepared by cleaning in a solution consisting of 3 parts HNO_3, 1 part HF, and 20 parts water. No surface preparation was given to the wire.

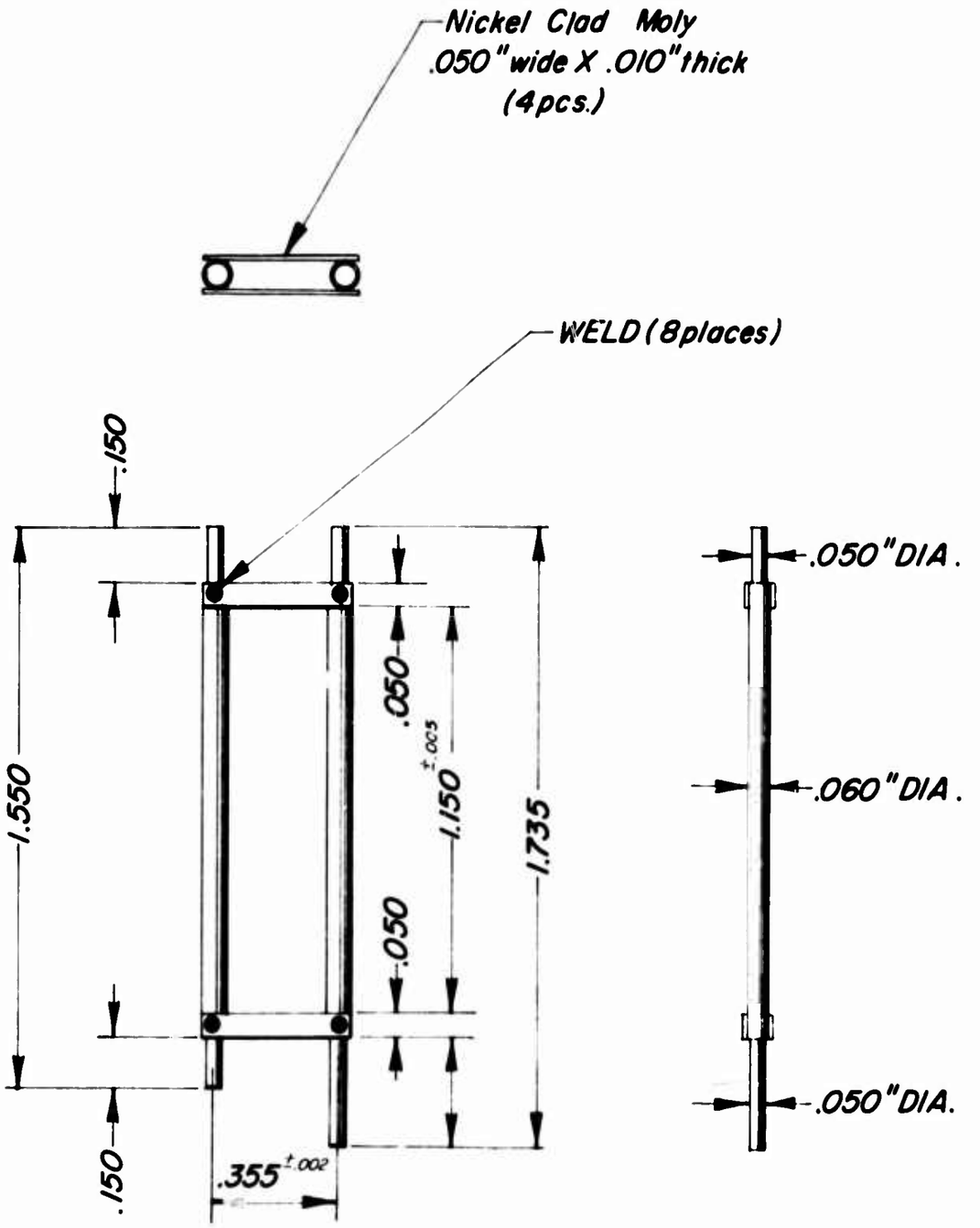

Figure 1

GRID FRAME TYPE 6080WB
(XA-60) CONTRACT
(Redrawn from Tung-Sol Electric Inc. Drawing)

The 100-watt unit did not provide sufficient power to accomplish satisfactory bonding, although incipient bonding was achieved. These experiments will be repeated with a standard 600-watt welder comparable to that which was delivered to Tung-Sol under this program, which should be adequate to accomplish the welds.

III. Conclusions

The program will be continued under the modified scope of work and delivery schedule. Efforts will be concentrated upon the fabrication by ultrasonic welding of a revised Type 6080WB electron-tube mount.

Preliminary investigation of ultrasonically welding the tungsten-3% rhenium wire indicates that power requirements are beyond the capability of a 100-watt unit.

PROGRAM FOR NEXT INTERVAL

Welding of the molybdenum grid assemblies will be undertaken upon receipt of appropriate material from Tung-Sol Electric Corporation. Redesign of the Type 6080WB electron tube and reevaluation of welding procedures will be pursued in an effort to complete the three junctions previously noted. Welding studies with the fine diameter tungsten-3% rhenium wire will be continued using a 600-watt welder, and specimens for test evaluation will be prepared.

PUBLICATIONS AND REPORTS

No publications were issued or technical conferences held during this reporting period.

TECHNICAL MAN-HOURS

EXPENDED DURING THIS REPORT PERIOD

1. Aeroprojects

Name	Project Position	Hours Expended This Report Period
W. N. Rosenberg	Project Supervisor	24
J. Koziarski	Director of Welding Lab	24
J. G. Thomas	Metallurgist	27-1/2
N. Maropis	Physicist	12
W. B. Devine	Director of Publications	22-1/2
	Sub Total	110
2. Tung-Sol Electric Incorporated	Sub Total	0
	Total	110

PROJECT SCHEDULE

	Year	1962						1963												1964												1965					
	Quarter	1			2			3			4			5			6			7			8			9			10			11			12		
PHASE I	Month	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
BASIC WELD STUDY		■	■	■	■	■	■	■	■	■	▭	▭	▭	▭	▭	▭	▭	▭	▭																		
TUBE STUDY			■	■	■	■	■	■	■	■	▭	▭	▭																								
WELDING EQUIPMENT (Construction) - 100 w										■	▭	▭	▭	▭	▭	▭	▭	▭	▭																		
600 w										■	■	■	▭	▭	▭	▭	▭	▭	▭																		
4-kw										■	■	■	■	■	■	▭	▭	▭	▭																		
EQUIPMENT AND TOOLING CHECKOUT										■	■	■	■	■	■	■	▭	▭	▭	▭	▭	▭																
W-Re WIRE WELDING STUDY																							■	■	■	■	■	■	■	■	■	■	■	■			
FRAME GRID WELDING STUDY																										■	■	■	■	■	■	■	■	■			
6080WB REDESIGN																										■	■	■	■	■	■	■	■	■			
PHASE II																																					
WELDING EQUIPMENT (Delivery) - 100 w																																			o		
600 w																																			o		
4-kw																																			o		
INSTRUCTION MANUALS																																					o
REPRODUCIBLE DRAWINGS																																					o
SPECIAL SPARE PARTS																																			o		
PHASE III																																					
TUNG-SOL ACTIVITY																										■	■	■	■	■	■	■	■	■			
Training																										■	■	■	■	■	■	■	■	■			
Tube Assembly																													■	■	■	■	■	■			
Age and Test																																■	■	■			
Life Test																																■	■	■	■	■	
Data Compilation																																			■	■	■
METALLURGICAL EXAMINATION REPORT																																					o
QUARTERLY PROGRESS REPORTS				●			●			●			●			●			●			●			o											
FINAL SUMMARY REPORT																																					o

LEGEND: ■ Proposed Work Schedule
▭ Work in Progress
o Contractual Delivery Date
● Contractual Item Delivered

Technical surveillance of this contract is under the control of the Industrial Engineering Division, USAECOM, Philadelphia, Pennsylvania 19103. For further technical information contact Mr. Harry Shienbloom, Project Engineer, Telephone No. Area Code 215-K16-3200, Extension 8137.

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