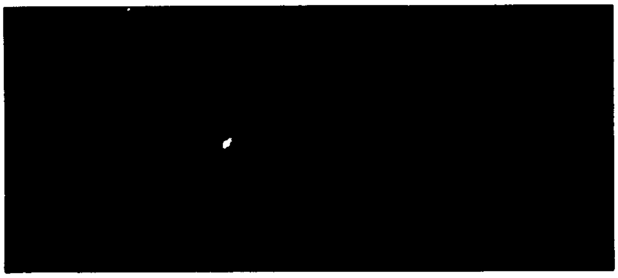
PRODUCTION ENGINEERING MEASURE FOR A PHASE II SUPER POWER HYDROGEN THYRATRON TUBE



Contract Number: DA-36-039-sc85985
Order Number: 19035-PP-62-81-81

PLACED BY: INDUSTRIAL PREPAREDNESS DIRECTORATE

U. S. Army Electronics Materiel Agency
225 South 18th Street
Philadelphia 3, Pennsylvania

ITT Electron Tube Division
KUTHE LABORATORIES, INC.
A Subsidiary of The International Telephone & Telegraph Corporation
730 South 13th Street
Newark 3, New Jersey

PRODUCTION ENGINEERING MEASURE FOR A

PHASE II SUPER POWER HYDROGEN THYRATRON TUBE

Fourth Quarterly Progress Report

Dec. 7, 1962 - Mar. 6, 1963

Report Number 4

Object: Construction and Test of Super Power Hydrogen Thyratrons of Ceramic-Metal Design

Contract Number: DA-36-039-sc85985
Order Number: 19035-PP-62-81-81
Signal Corps Specification Number: SCL-7001/60
SCS-103
Signal Corps Specification Number: SCS-72A
Signal Corps Industrial Preparedness
Procurement Requirements: No. 15 - Revised 1 Oct. 1958

Placed by: Industrial Preparedness Directorate
U.S. Army Electronics Materiel Agency
225 South 18th Street
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Report Approved by: A E Gordon
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1. ABSTRACT

Based on experience obtained with the first two tubes constructed under this contract, three additional Phase II tubes per Design "A" were built during the fourth quarter period covered by this report. They were made with a heavier flange and different seal for the anode as contemplated in the previous progress report. Owing to this change, assembly of the tube was made safer and more flexible, and better alignment between sub-assemblies and more accurate inspection became possible during assembly. Exhaust and thorough baking did not affect these tubes in any noticeable way. Operating characteristics were investigated and found to possess satisfactory reproducibility. Two tubes were operated successfully at the power level of the Stanford Linear Accelerator (epy = 40KV; Ib = 4.0 Adc; ib = 3000a). Construction of the Phase II test equipment is proceeding as scheduled.

2. PURPOSE

The purpose of this contract is:

A Production Engineering Measure (PEM) in accordance with Step 1 of Signal Corps Industrial Preparedness Procurement Requirements (SCIPPR) No. 15, for a stacked, ceramic-metal construction Phase II, Super Power Hydrogen Thyratron Tube, per Signal Corps Technical Requirements SCL-7001/60 dated 11 October 1960 and SCS-103 dated 19 January 1961 to include the following sub-items:

(1) All work under paragraph 3.1 of SCIPPR No. 15 necessary to establish the capability to manufacture the above mentioned Phase II tube on a production-type basis.

(2) Engineering Sample of Phase II Tube.

(3) Four preproduction samples of Phase II Tube.

(4) Production type equipment necessary to manufacture and test four (4) Phase II tubes per month.

(5) Six production type Phase II Tubes.

3. NARRATIVE AND DATA

3.1 Problem Areas. In the design of the Phase II tube, mechanical stability and inter-electrode alignment and spacing were the primary considerations. Others, which are related to these were reliability, reproducibility of operating characteristics, and the possibility of disassembly for salvage or repair. Experience gained with the first two tubes showed that Design "A" satisfies mechanical requirements stemming from construction and processing during manufacture. However, the original anode flange used in these tubes revealed a marginal condition during exhaust as a consequence of intensive baking through which the relatively thin wall of this flange was damaged. It was, therefore, decided to abandon this particular type of flange and to replace it by a much stronger heavy walled flange in connection with the same heliarc-welded seal as used on both ends of the control grid. There were also other important reasons for this decision. With the new seal, the anode is added to the ceramic envelope section at a later step when most convenient during final assembly. This means that this section which contains the gradient grid is sealed without the anode. Conditions for good alignment between the gradient grid and the ceramic wall, and for checking this alignment,

3. NARRATIVE AND DATA (continued)

are greatly improved. Also, when assembling this section with the control grid, inspection for proper alignment and spacing becomes feasible. Obviously, the same situation applies to the anode, and the danger of losing an anode in connection with the unsuccessful sealing of a gradient grid section does not exist. On the other hand, with the new seal, an anode may be easily removed from a finished tube, and replaced.

Problems of alignment or of a mechanical nature have not shown up for the base-cathode-reservoir assembly, and they are not expected at present. Electrically, both cathode and reservoir heaters have proved to be reliable. Cathode heater wattage was held at 500 watts as originally planned, but performance at the specified Phase II power level remains to be seen, and a reduction may have to be contemplated in view of cathode life requirements. As discussed in the last progress report, thermal shielding of the reservoir was reduced and heater wattage increased without sacrificing hydrogen fill. Although no major changes are planned at present, it is felt that the need for a larger reservoir with improved operating characteristics may become visible once the tube is operated at full power.

3. <u>NARRATIVE AND DATA (continued)</u>

The effect of water cooling of the anode and of the control grid has not been explored up to now. Investigation will have to wait until the Phase II test set is available. Then the performance of the gradient grid and the possible need for intensive cooling of it may become one of the major problems. Up to now, and at the power level of the SLAC modulator (epy = 40KV; ib = 4.0 Adc; ib = 3000a; Ip = 110 Aac RMS) tubes have been operated in trial runs of several hours without any cooling by forced air or water at all. This seems to indicate that artificial cooling is necessary under high Pb conditions only as imposed by the Phase II specification, and that under less rigid conditions, cooling with forced air will be sufficient.

<u>3.2 Construction of Tubes.</u> Three tubes, Nos. 3, 4, and 5 were built, exhausted and aged. They were made with the new anode assembly shown in Figure 1. This anode has a heavy walled flange and a solid copper ring which, in connection with a nickel sleeve, forms part of the seal with the ceramic envelope. The thin walled flexible flange of the old anode used in tubes No. 1 and 2 was replaced by this structure, but besides this, no other

3. <u>NARRATIVE AND DATA (continued)</u>

changes were made in this assembly. However, as a consequence of this change, a modification in the ceramic section which contains the gradient grid, shown in Figure 2, became necessary as a second KOVAR flange had to be substituted for the original anode flange. No changes were made in the control grid assembly, Figure 3, and the base flange section, Figure 4, which form the other part of the envelope. The control grid assembly is shown with two cooling jacket sleeves to which a cooling jacket (not shown) is welded at a later step (after exhaust).

The gradient grid section is sealed under hydrogen in a vertical bell jar type furnace, and as both ends are open, jigging and subsequent inspection for alignment of the grid shields and of the KOVAR flanges with the ceramic rings is not difficult to carry out. These alignments obviously are essential for inter-electrode alignments.

Assembly of the tube envelope followed the same steps described in the third quarterly report. Since the anode does not form an integral part of the gradient grid section, which is open on both ends and perfectly symmetrical, alignments and spacings between these assemblies

3. NARRATIVE AND DATA (continued)

and with the control grid assembly, can be inspected accurately and if necessary, corrections can be made before final assembly and welding of the seals.

The base-cathode-reservoir structure was sealed to the base flange of the envelope as described in the previous report. No changes were made except in one detail through which the pressure characteristic of the reservoir is improved. It had been noted that a reduction in thermal shielding would permit running the reservoir at a higher wattage without the necessity of reducing the hydrogen fill. Consequently, four large windows were made i. the cylindrical part of the base assembly shown in Figure 5 of the third quarterly report, in which the reservoir is installed. This measure actually permitted operation of the reservoir at a 20% higher wattage.

The exhaust schedule for tubes No. 3, 4, and 5 was essentially the same as for tubes No. 1 and 2, and as explained in the previous report. Baking temperature was between 600°C and 630°C and was held at this level for two hours. After exhaust, the tubes were cleaned by sand-blasting and nickel plated with the coo g cavities

3. NARRATIVE AND DATA (continued)

of the anode and of the control grid still open. The plated cavities were subsequently closed by heliarc welding with their respective cylindrical jacket and flat top which are shown in the outline drawing of the finished tube in Figure 5.

3.3 Data and Results. Tubes 3, 4, and 5 were made without shrinkage of any part or sub-assembly and without any failure in the heliarc welded seals of the complete assemblies, and they went through exhaust and high baking temperatures without being affected mechanically in any way. This seems to confirm that the seal design of the control grid which was used on the anode is adequate in both places.

This picture is somewhat darkened by a mishap which occurred to tube No. 3 during exhaust. As was found later, the valve through which the exhaust manifold was connected to the leak detector had an internal leak which allowed some air to get into the tube whenever the leak detector was flooded for other tests As a consequence, this tube during aging exhibited all signs of being contaminated, and had to be given up. Care was taken to

3. <u>NARRATIVE AND DATA (continued)</u>

make sure that this performance was not due to a leak in the tube.

Tubes 4 and 5 were aged and operated in a Girdler Senior Set under the following conditions: epy = 40KV; Ib = 2.75 Adc; ib = 2400a; Pb = 40 X 10^9. Operating characteristics were very much like those found in tube No. 1. No cooling by water or forced air was used during these runs as the anode temperature did not exceed 250°C. Tube No. 4 was also operated in an improvised set at the power level of the Stanford Linear Accelerator (epy = 40KV; Ib = 4.0 Adc; ib = 3000a). This was done in order to compare with successful runs made with tube No. 1 in one of the Stanford Modulators. Although the improvised set had many shortcomings, satisfactory runs of several hours' duration were made with tube No. 4 at voltages up to epy = 44KV.

Some data obtained during the inspection and processing of Phase II assemblies and tubes, per Design "A", which are related to the question of reproducibility of dimensions and other tube data, are shown in Tables 1 and 2

TABLE 1: Dimensions of the Anode, the Control Grid, and the Gradient Grid Section on which Inter-Electrode Spacings Depend

Assembly Dimension*	Anode		Control Grid		Gradient Grid Section			
	A	B	A	B	AA	AG	BA	BG
Design	3.370	1.728	3.370	1.728	3.483	3.483	1.835	1.835
Tube #3	3.382	1.733	3.372	1.725	3.485	3.480	1.833	1.843
Tube #4	3.364	1.719	3.376	1.722	3.490	3.495	1.841	1.835
Tube #5	3.377	1.719	3.369	1.723	3.479	3.488	1.831	1.838
Tube #6**	3.359	1.714	3.362	1.720	3.490	3.473	1.825	1.838
Tube #7**	3.366	1.714	3.385	1.729	3.486	3.480	1.833	1.841

* See Figures 1, 2, and 3. Dimensions in inches.

** Tubes not finished during fourth quarter

TABLE 2: Gas Fill and Operating Data

Tube No.	Fill	Ps	Er(Base)	T	If	Ir
1 (see note)	87	750	4.3	200	73.0	24.0
3	90	560*	-	-	-	
4	83	590	4.9	220	81.5	24.1
5	93	650	4.7	215	81.2	24.0

* Pressure reading may be affected by air.

Fill: Amount of hydrogen in liter x millimeter at room temperature

Ps: Pressure in microns at which the reservoir stabilizes with Er = 5.0 Vac;

Er(Base): Calculated base setting of the reservoir corresponding to 550 microns;

T: Time in seconds for the control grid to fire at Er = 5.0 Vac trigger = 1100 V;

If: Cathode heater current in Aac at Ef = 6.3 Vac

Ir: Reservoir heater current in Aac at Er = 5.0 Vac

Note: In tube No. 1 stabilizing pressure Ps is higher as the reservoir is more effectively shielded. Fill is 87 liter x mm and not 100 as indicated by mistake in last report. Cathode heater current of 73.0 Aac is due to smaller diameter heater wire.

3. NARRATIVE AND DATA (continued)

3.4 Test Equipment. A Final Design Review Meeting was held on December 27, 1962 at Evans Signal Area, Belmar, New Jersey. Construction work is being carried out as planned by the G.E. Company in Holyoke, Massachusetts.

4. CONCLUSIONS

Design "A", with an improved anode seal, provides a Phase II tube which is mechanically adequate and has inter-electrode alignments and spacings within close tolerances. Reproducibility of operating data and reliability of operation are satisfactory.

5. PROGRAM FOR NEXT INTERVAL

a) Construct a group of preproduction tubes per Design "A". Improve dimensions of sub-assemblies, alignments and spacings. Work out jigging and inspection methods. Obtain more information on operating characteristics.

6. PUBLICATIONS AND REPORTS

A Final Design Review Meeting was held on December 27, 1962 at Evans Signal Area, Belmar, New Jersey, and attended by the following:

Name	Affiliation	Title
Harry Shienbloom	USAEMA	Project Engineer
Sol Schneider	USAERDL	Physicist
John E. Creedon	USAERDL	Physicist
A. J. Buffa	USAERDL	Electronic Engineer
G. E. Lewis	General Electric	Mfg. - Eng'g. & Mktg. HVST Sect.
R. S. Ringland	General Electric	Systems Engineer
L. B. Riddell	General Electric	Sales Engineer
W. C. Stone	General Electric	Marketing
Herman E. Krefft	Kuthe Laboratories	Senior Physicist
A. E. Gordon.	Kuthe Laboratories	Chief Engineer

IDENTIFICATION OF TECHNICIANS

During the period covered by this report, 963 man-hours were devoted to this contract:

		Hours Spent On Contract
A. E. GORDON	Chief Engineer	125
H. E. KREFFT	Project Leader	378
W. PELECHATY	Draftsman	72
M. STREET	Laboratory Technician	388
	Total	963

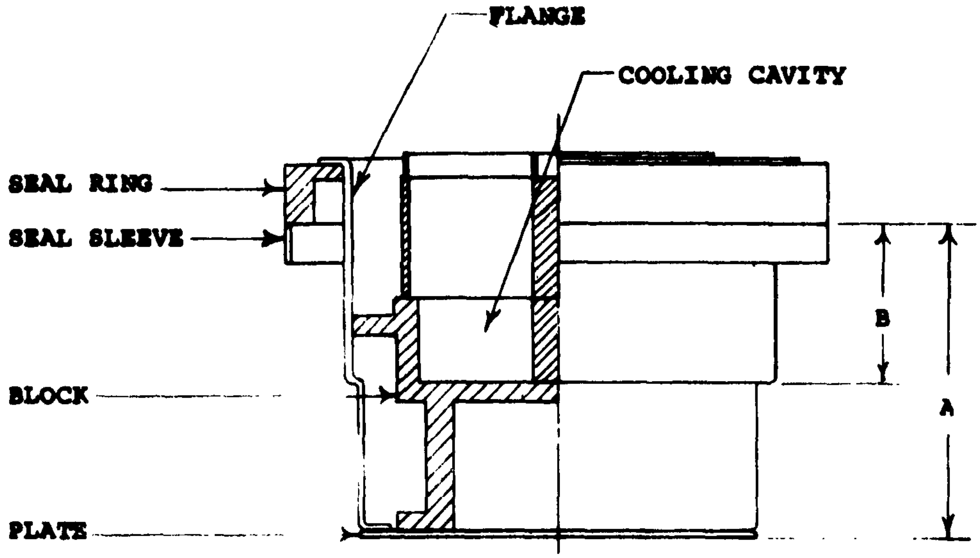

FIGURE 1

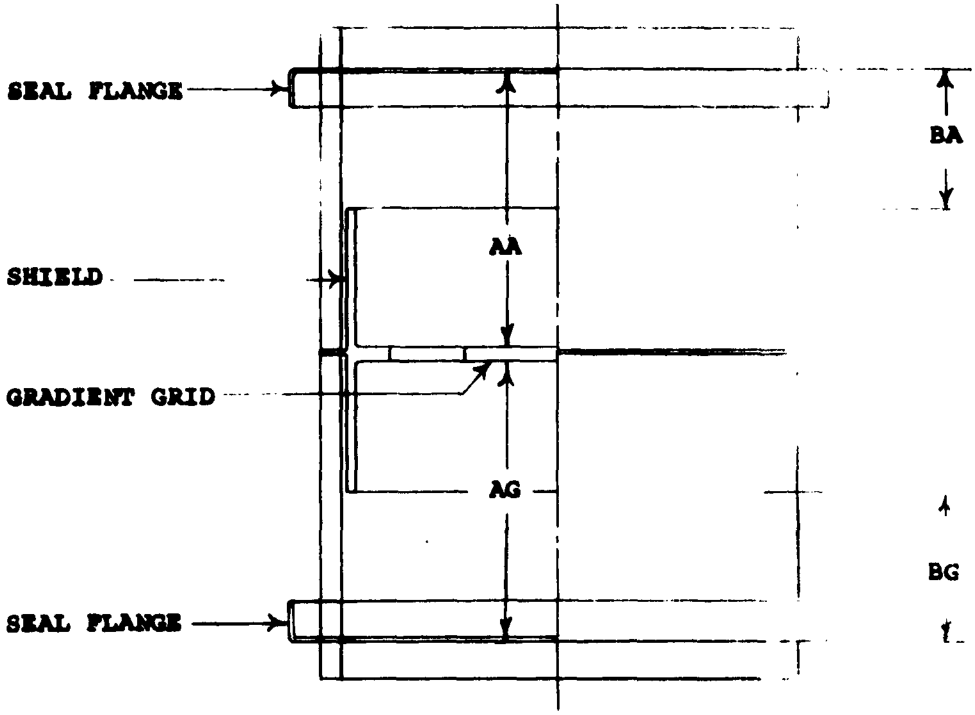

FIGURE 2

FIGURE 1: ANODE ASSEMBLY
FIGURE 2: GRADIENT GRID SECTION

Phase II Super Power Hydrogen Thyratron Tube
Design "A"

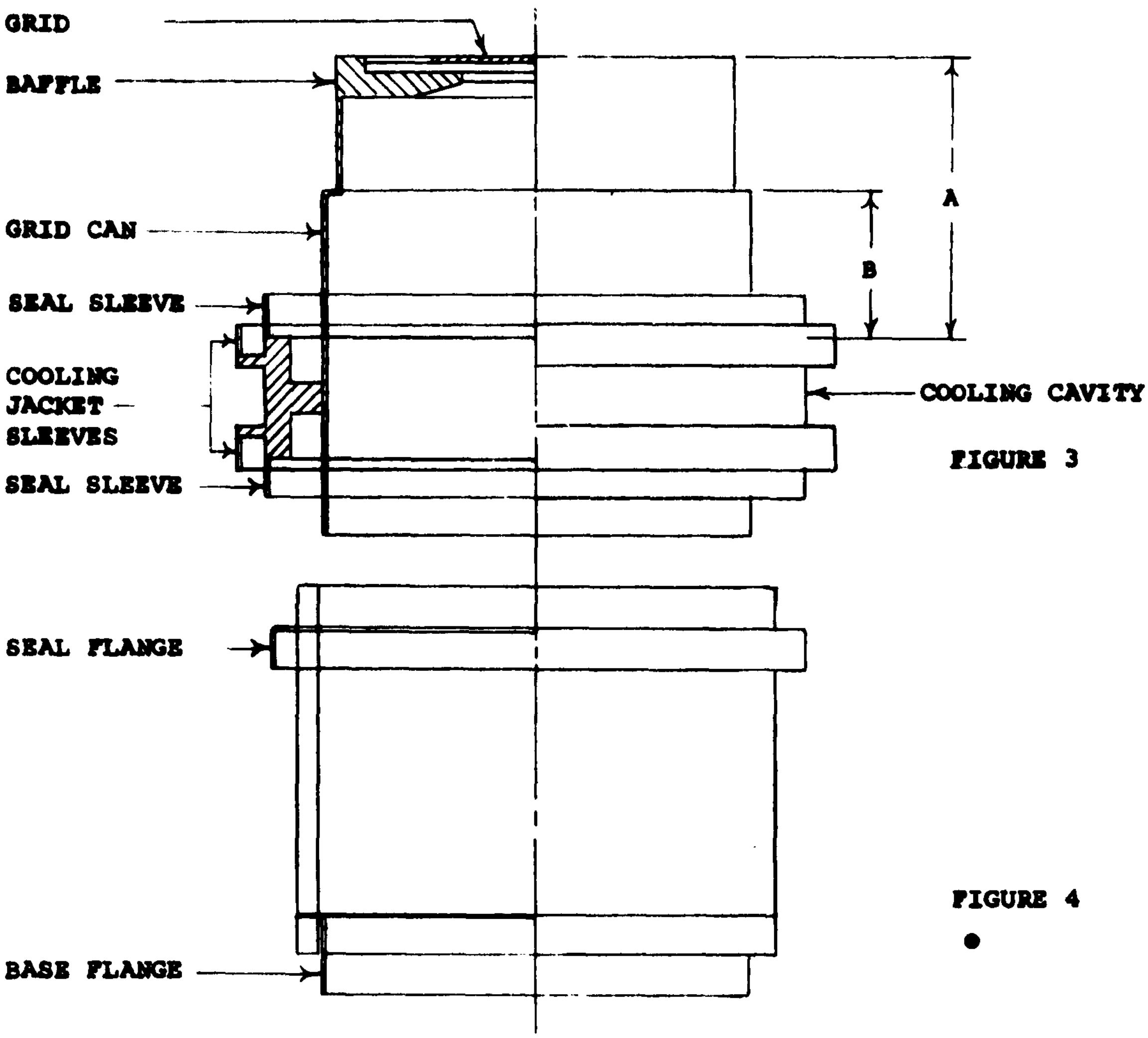

FIGURE 3: CONTROL GRID ASSEMBLY
FIGURE 4: BASE FLANGE SECTION

Phase II Super Power Hydrogen Thyratron Tube
Design "A"

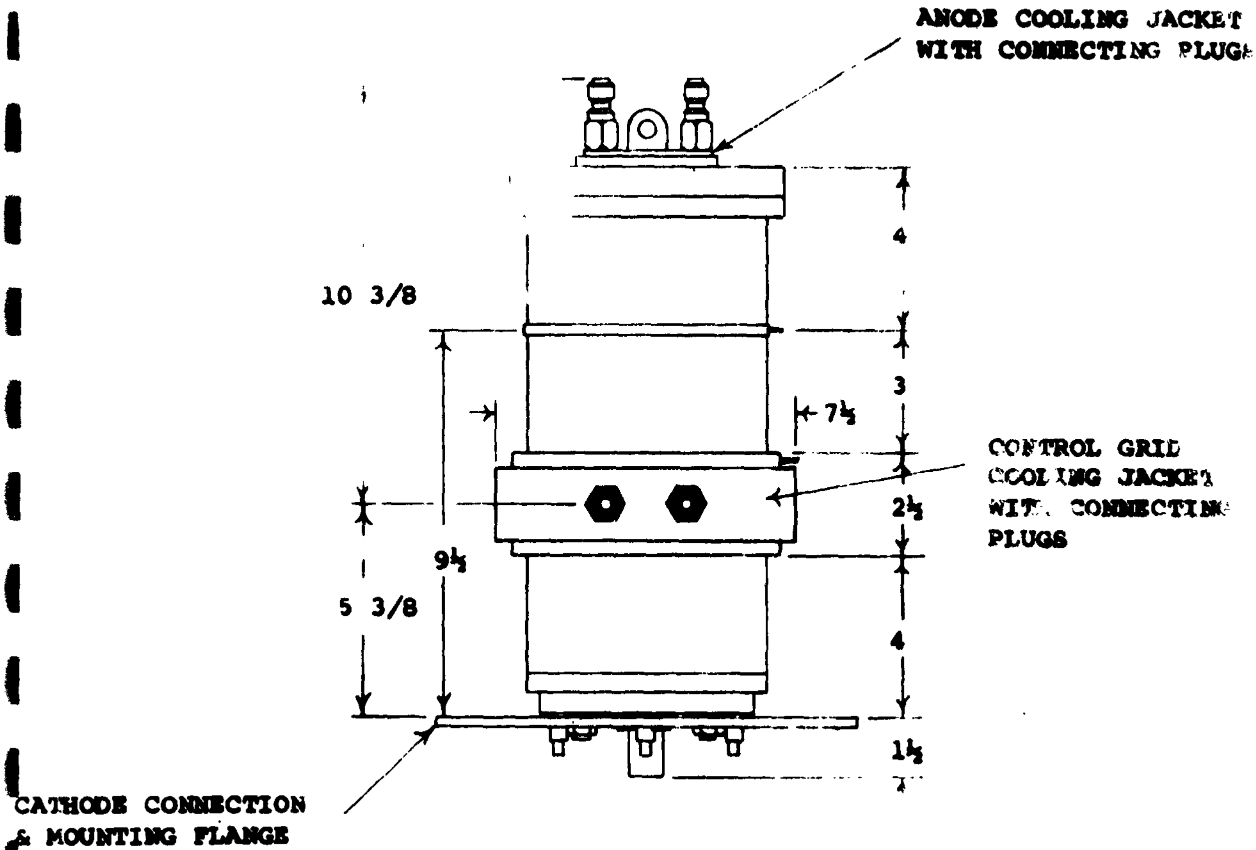

FIGURE 5: OUTLINE OF PHASE II SUPER POWER
HYDROGEN THYRATRON TUBE

9. APPENDIX

1. Work Schedule and Delivery.

The chart on page 20 illustrates planning and accomplishment of the work on the Phase II tube in relation to required delivery dates.

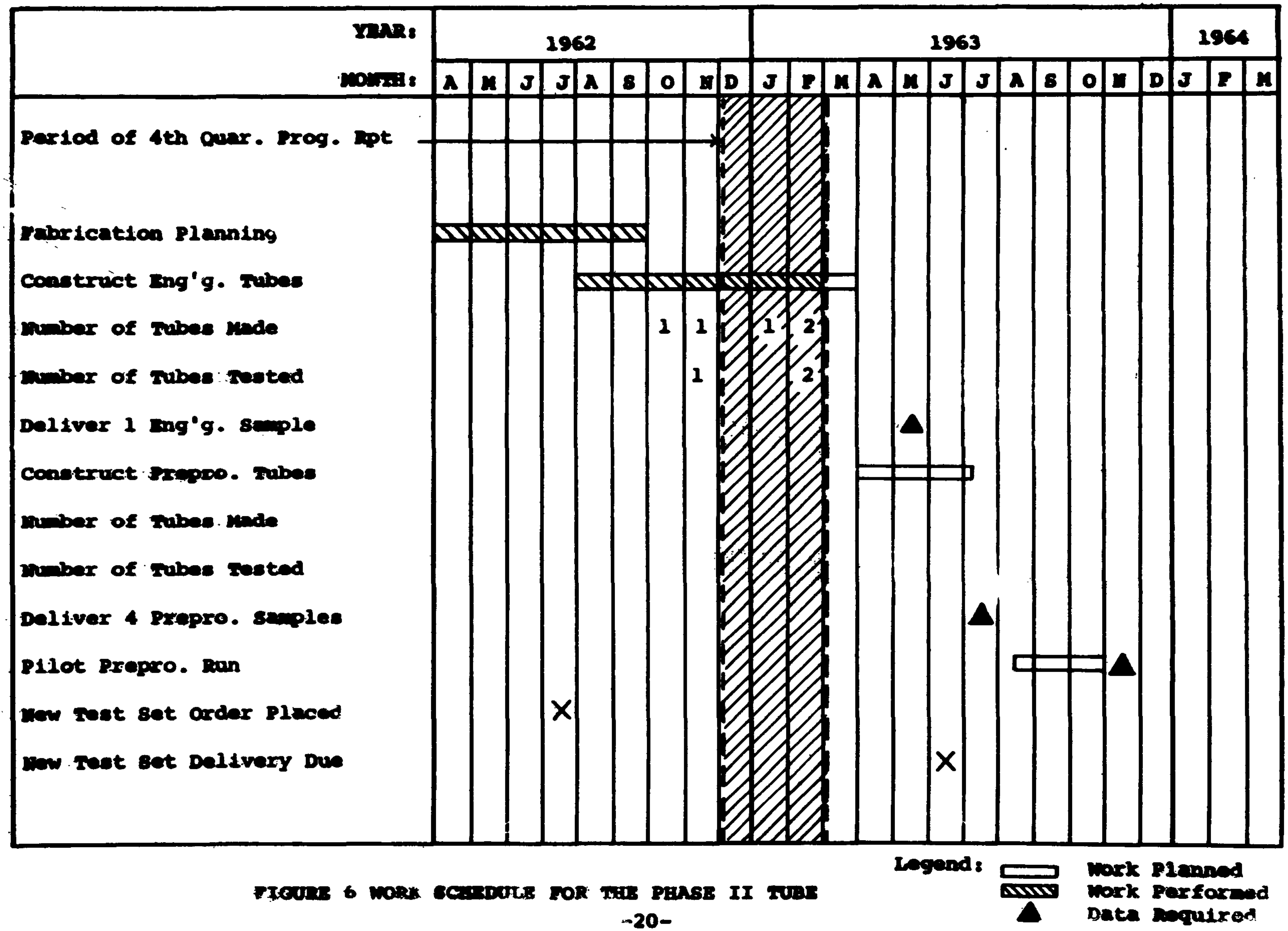

FIGURE 6 WORK SCHEDULE FOR THE PHASE II TUBE

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Chatham Electronics Division of Tung-Sol Electric, Inc. 630 W. Mt. Pleasant Avenue Livingston, New Jersey ATTN: Mr. B. F. Steiger	1

AD Accession No.

Kuthe Laboratories, Inc.
Newark, New Jersey

CERAMIC METAL PHASE II SUPER POWER HYDROGEN THYRATRON TUBE
H. E. Krefft

Fourth Quar Prog Rpt 7 Dec 62 to 6 Mar. 63, 23 pp, 6 illus.
(Contract DA36-039-sc85985)
Unclassified Report

Data on electrode alignments, spacings; reproducibility of operating characteristics.

Unclassified

1. Thyratron Tube
2. Hydrogen Thyratrons
3. Ceramic Tubes
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