Z-5267 CERAMIC TETRODE, 40 WATTS AT 3000 MC.

PRODUCTION ENGINEERING MEASURE

REPORT NO. 3

THIRD QUARTERLY PROGRESS REPORT

1 DECEMBER 1962 THROUGH 28 FEBRUARY 1963

CONTRACT NO. DA 36-039-SC-86735

UNITED STATES ARMY ELECTRONICS MATERIEL AGENCY

PHILADELPHIA, PENNSYLVANIA

CLASSIFICATION - NONE

RECEIVING TUBE DEPARTMENT

GENERAL ELECTRIC

OWENSBORO, KENTUCKY

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Subject: Third (3rd) Quarterly Report
Order No. 19057-PP-62-81-81
Contract No. DA-36-039SC-86735
U. S. Army Electronic Materiel Agency
Philadelphia 3, Pennsylvania

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Z-5267 CERAMIC TETRODE, 40 WATTS AT 3000 MC. PRODUCTION ENGINEERING MEASURE

REPORT NO. 3

THIRD QUARTERLY PROGRESS REPORT

1 DECEMBER 1962 THROUGH 28 FEBRUARY 1963

Objective: (1) To establish production techniques for assembling and testing the Z-5267 tube.

(2) To propose a final tube specification.

(3) To demonstrate 75 tube per month production capability.

CONTRACT NO. DA 36-039-SC-86735

SIGNAL CORPS INDUSTRIAL PREPAREDNESS
PROCUREMENT REQUIREMENTS NO. 15

CLASSIFICATION - NONE

REPORT BY - V. W. AMOTH

TABLE OF CONTENTS

1.0 ABSTRACT

A summary of the present status of the entire program is described in detail. Ten engineering sample tubes were shipped on the due date of 25 February 1963. Thirty more tubes are due near the end of the next quarter.

Some problems have occurred in receiving parts out-of-specification limits. These are being corrected. A cathode sublimation problem has caused a change in all chemical cleaning and plating baths. Considerable analysis work is in progress to trace the sublimation source.

The first exhaust set is in operation and operates satisfactorily except for a problem in the temperature controller.

The amplifier cavity has been reworked and higher power output obtained. Oscillator cavity work is continuing, for RF aging and life test purposes.

2.0 PURPOSE

The objective of this contract is to refine the assembly techniques and standardization of processes and procedures which would result in a more manufacturable product. Research work on this tube was performed under Contract DA 36-039-SC-75069. Parts processing in larger quantity along with tolerance tightening of both the parts and sub-assemblies will result in narrower tube specification limits for more consistent tube usage.

The objective test requirement is the General Electric Proposed Military Specification Sheet, Type Z-5267 dated 4 May 1962. The specification defines a ruggedized metal-ceramic planar tetrode which will produce 40 watts as a CW amplifier at 3000 megacycles. It includes a 400 G shock test, 50 to 1000 cycle vibration at 15 G and a 200 C ambient and RF life tests.

Forty engineering tubes will be supplied to evaluate various assembly improvements and aid in writing a final specification. Ten pre-production tubes will be supplied to this specification. In addition, seventy-five shippable tubes per month final production capability will be demonstrated.

Process studies will be conducted and included in an over-all Inspection and Quality Control Manual. In addition, a complete plan for producing 200 tubes per month will be submitted.

3.0 NARRATIVE AND DATA

The first ten engineering sample tubes were shipped on the due date of 25 February 1963. Tubes assembled during this quarter have shown several problems associated with the building of the tube. Initial tubes showed power output of about 20 - 25 watts. This low power was subsequently traced to burned out grid wires. However, tubes with known good grids produced powers in the range of only 30 to 32 watts output. Careful examination of the cavity showed no major difficulty, and attention was turned again toward the tube. As the major part of transit time loss is in the grid-cathode region, this distance was decreased 10%. Tubes built after this change showed a predominance of grid-cathode shorts. The previous wider spaced tubes did not have as many shorts. Careful dissection of tubes indicated that the grid had rotated with respect to the cathode so that the grid bar was touching the cathode and producing the short. In some cases the grid bar rested on the insulating cathode coating, so that the short was not evident unless the exhaust appeared abnormal or cathode breakdown occurred producing a short circuit. Investigation of the grid-cathode shift problem revealed that rotation of the locking mechanism for the spring tended to rotate the cathode with respect to the grid, giving direct grid-cathode shorts. A device was built to depress the spring separately so that the locking mechanism could be rotated without turning the spring. This was expected to eliminate the grid-cathode short problem. However, shorts continued to persist. Futher investigation showed that the flat cathode was buckling under the heat to a degree which allowed it to touch the grid wires at the center causing shorts.

Thicker cathode lids are now being procured in an attempt to have sufficient thickness of material so that buckling will not occur.

During the period when closer grid-cathode spaced tubes were built, in order to decrease the transit time loss and increase the power output, six tubes built on the former contract were obtained on loan from the Signal Corps. These were obtained for comparison of power output readings to determine if the cavity was operating properly. Although listed as 38 to 41 watts output in the previous contract, the tubes now tested 30 to 38 watts. Due to the lower power obtained, additional emphasis was placed on improving the amplifier cavity. A second cavity was assembled with some changes incorperated therein. A tuneable driver was built and one Signal Corps tube which had measured 33 watts now peaks at 38 watts. Additional tubes will be checked, as available.

After exhaust, testing of all tubes showed a fair amount of gas present in the envelope. Low voltage DC aging overnight cleared up this gas almost completely. However, additional gas was evolved as higher voltages were applied to the tube. DC aging was initially used up to 1000 V and 125 milliamperes plate current. After that, RF aging was used to continue the final aging process. Some difficulty was experienced in the DC aging and RF aging steps in that, as higher voltages and currents were applied at each step, additional gas was evolved which tended to cause an arc from anode to the grids resulting in grid wire burnout and catastrophic tube failure. It was found that if changes in voltages were made slowly enough, this arcing did not occur. It was thus concluded that the getter was gettering the gas as desired, but that the gas was being released at too rapid a rate unless small steps were taken upon increasing voltage and current. At this stage it was felt desirable to explore AC aging. A one position AC aging socket was wired up and a good tube was carefully brought up to 1000 volts AC and 100 milliamperes average plate current, and showed no degradation of long pulse emission. It was thus concluded that AC aging should not harm the tubes. Additional tubes put through this one position rack indicated that AC aging might replace a good deal of the RF aging previously used. However, the problem still remained that the voltage and currents had to be increased in small incruments. See section 3.11 for further information on AC aging.

A sublimation problem, which appears to be barium evaporation from the cathode, has appeared in the last few tubes built. This causes deposits on the anode ceramic, screen ceramic and leakage between all elements. The sublimation is severe enough that power output is appreciably decreased. We are using all available facilities to trace the source of sublimation. It is planned to open a tube in our mass spectrometer to determine what gasses evolve. It is planned also to exhaust tubes on the mass spectrometer for the same purpose. Analyses of sublimation materials will be made. Analyses of the cathode materials and any other suspected part will also be made for contaminants which may trigger sublimation. Factory processing has been used to date. Tubes are being made with nearly complete processing in the Development Shop, so as to eliminate this as a source of trouble. Other analyses will be made as tests indicate are needed.

3.1 TOLERANCES AND FIXTURES

Fixtures have been built to roll over the edge of the number one heater lip as discussed in the last quarterly report. This will give a rounded corner on the heater contact. Of the first ten tubes shipped to the Signal Corps, only one contained this rounded heater lip. However, additional tubes are being built with this feature.

3.2 ANODE CERAMIC

The brazing fixtures for centering this anode ceramic have been tried out and work quite satisfactorily. All tubes are now being built using these fixtures.

3.3 MOLYBDENUM CONTACTS

The initial strip forms rolled to circular shape and tacked with a nickel tab before brazing proved very satisfactory. However, subsequent parts received have shown tiny cracks on the first three fingers on one end of the strip. This is the same material that the first parts were made of so that the cracks must be due to the die and part making process. This is being reworked for correction.

3.4 SUPER DRY HYDROGEN

The only remaining super dry hydrogen process is used in the brazing of the grid package. It was intended to have tried a moly-manganese metalizing and brazing process by this time. However, press of other problems has not yet allowed this test to be run.

3.5 EXHAUST SETS

The first five position exhaust set was received during this period and put into operation. After initial debugging, the set shows quite satisfactory pressures. Single tubes are being pinched off at 5×10^{-8} mm of mercury or less. The second exhaust set is being slightly modified as experience is gained using the first set. Solenoid operating vacuum valves are being used in both sets, in an attempt to facilitate ease of operation and give protection to isolate portions of the system from damage in case of electrical power failure.

3.6 CATHODE COATING

Near the end of this period we were experimenting with denser coatings. Initially these seemed to work satisfactorily, however tubes were built which had thick dense coatings which caused the cathode coating to have poor adhesion to the base nickel of the cathode structure. Thus, separation of the two parts occurred giving poor emission and little interface formation on the cathode lid. These particular lots of cathodes did not spray the same as previous lots even under the same condition, so a new lot of cathode coating mix was made. Tubes made on the new lot have since proved similar to previous coatings which were satisfactory.

3.7 RADIATOR

No effort was spent on producing a reusable radiator during this period due to efforts toward building operable tubes. This work is scheduled to commence early during the next quarter.

3.8 ANODE SLOTTING

Plain faced anodes have been made and could be put into tubes. However, the cathode shucking problem of 3.6 and the subsequent problem of high sublimation of 3.0 in the cathode has made it undesirable to put these few parts into tubes until both of the problems have been corrected.

3.9 SCREEN CURRENT

Low power output in some tubes has been attributed to arcs which burn out screen wires. However, a more direct screen current problem has been that of primary emission from the screen due to its running at too high a temperature. During RF operation, application of drive to the grid of the tube has increased the screen current in some cases. In other cases it has decreased screen current due to the screen emission being greater than the normal increase due to drive. Grids are being more carefully assembled now to get better line up than previously in order to control the high screen wire temperature. Procedures are being set up to correlate grid-screen line-up with RF performance.

3.10 AMPLIFIER TEST SET

A second amplifier test position, using RF aging and life power supplies, was set up during this period so that further cavity optimization could be accomplished without interfering with other amplifier testing. Changes in the cavity on one set have increased the power of a tube from 34 to 38 watts. Additional tubes will have to be tested in order to determine whether this improvement occurs on all tubes.

3.11 RF STABILIZING AND LIFE TEST

As stated in Section 3.0, an AC stabilizing rack was built this month. This rack is very similar to the one position rack previously discussed, however, it has a very slow increase of voltage over a period of hours to the maximum condition. This is designed to allow the getter to getter gas as it is released while the AC voltage is increased slowly to its maximum values. This should overcome the previous method which released gas in bursts, particularly near maximum tube ratings. It is expected that a much shorter RF aging will be necessary using the system of AC aging.

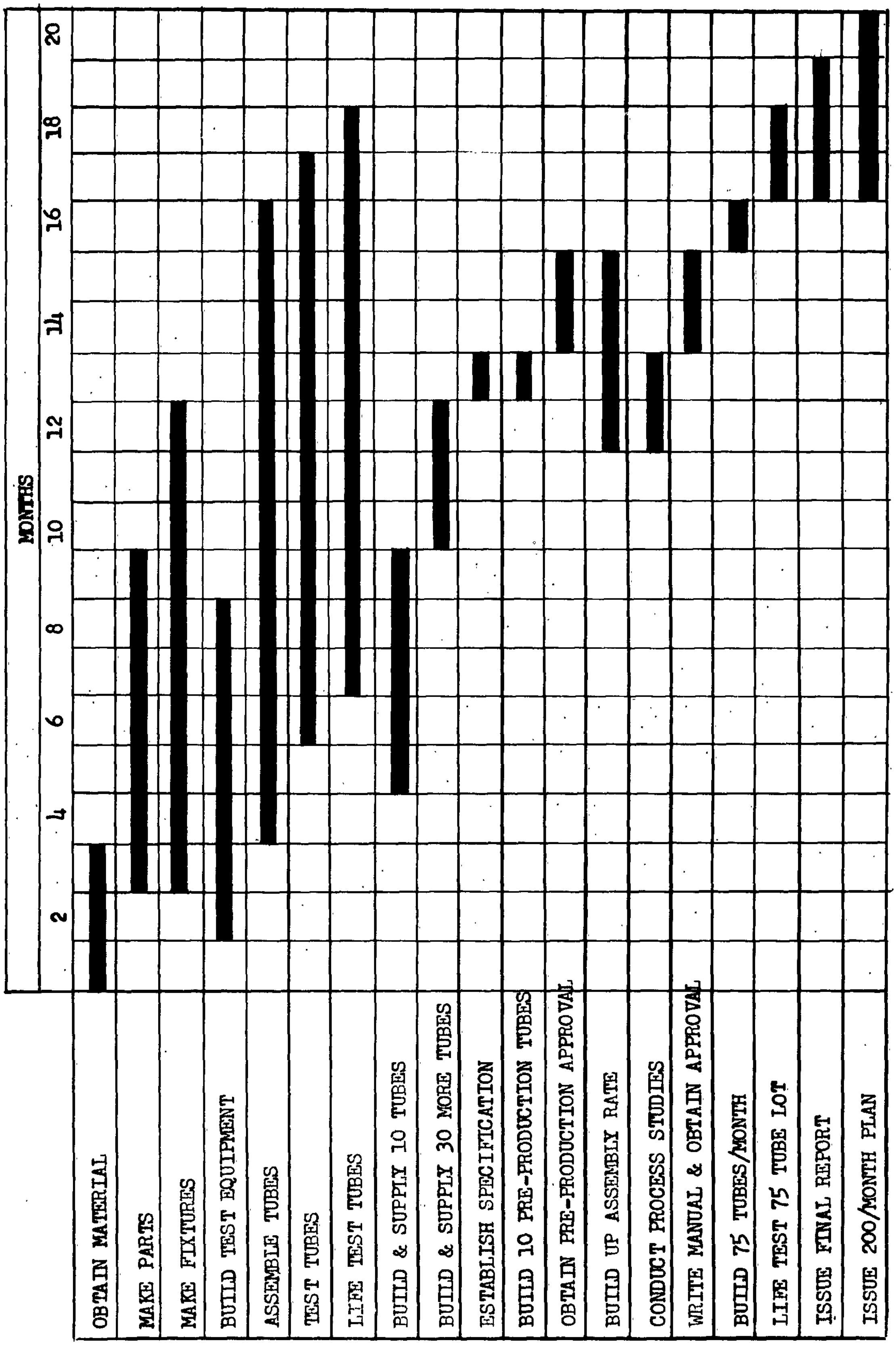
Oscillator cavities are still being worked on for RF stabilizing and life test. A circular mode output cavity is being built similar to the amplifier cavity. Due to the very narrow tuning range of this cavity, a parallel program is being carried on for the development of a wave guide cavity oscillator. These cavities should both be available for trial during the next quarter.

3.12 MISCELLANEOUS

Parts made on original die approval were entirely satisfactory. However, some parts supplied since then on the same dies have been unsatisfactory in one or more dimensions. We are working with the part supplier to alleviate these difficulties and sorting parts 100% in order to continue tube assembly.

Vibration of assembly facilities due to floor vibration has made it difficult to perform certain critical operations, corrective action is being taken.

TIME SCHEDULE - Z-5267



PROGRESS CHART - Z-5267 PEM
DA.36-039-SC-86735

	1962							1963											
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
I. BUILD 10 DESIGN TUBES																				
A. Purchase materials	(X)	(X)	(X)	Ⓧ																
B. Check all parts & fits		(X)	(X)	Ⓧ																
C. Purchase parts		(X)	(X)	(X)	Ⓧ															
D. Check design of all fixturing			(X)	(X)	Ⓧ															
E. Purchase assembly fixtures				(X)	(X)	Ⓧ														
F. Purchase 4 brazing fixtures				(X)	(X)	(X)	(X)	Ⓧ												
G. Try fixtures					(X)	(X)	(X)	Ⓧ												
H. Make sub-assemblies					(X)	(X)	(X)	Ⓧ												
I. Build, exhaust & test tubes					(X)	(X)	(X)	(X)	Ⓧ											
J. Life testing											X	X								
II. BUILD 30 DESIGN TUBES																				
A. Make sub-assemblies									(X)	X										
B. Build, exhaust & test tubes									(X)	X	X	X								
C. Life test tubes										X	X	X	X	X						
D. Propose final specification														X						
III. SUBMIT 10 PREPRODUCTION TUBES																				
A. Make sub-assemblies											X	X								
B. Build, exhaust & test tubes											X	X	X							
C. Life test tubes												X	X							
D. Perform pre-production in plant														X	X					
IV. BUILD TUBES AT 75 PER MONTH RATE																				
A. Build 6 more brazing fixtures									(X)	X	X									
B. Build up to final production rate												X	X	X						
C. Make sub-assemblies															X					
D. Build tubes																X				
E. Exhaust, age & test																X				
F. Life test																X	X			

X - Anticipated Progress
() - Actual Progress
◯ - Completed

Revision #1

PROGRESS CHART - Z-5267 PEM
DA.36-039-SC-86735

	1962							1963												
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
V. TUBE DESIGN IMPROVEMENTS																				
A. Tolerances & fixtures																				
1. Review & revise		(X)	Ⓧ																	
2. Modify drawings		(X)	(X)	Ⓧ																
B. Anode ceramic																				
1. Design fixture			Ⓧ																	
2. Build fixture					Ⓧ															
3. Try fixture						Ⓧ														
C. Molybdenum contacts																				
1. Try slit contacts			Ⓧ																	
2. Make tools			(X)	Ⓧ																
3. Try parts					Ⓧ															
D. Super dry hydrogen																				
1. Order braze materials			Ⓧ																	
2. Try braze materials				(X)	Ⓧ															
3. Build tubes					(X)	(X)	(X)	(X)	X											
E. Cathode coating																				
1. Purchase special spray gun				Ⓧ																
2. Optimize coating procedure					(X)	(X)	(X)	(X)	Ⓧ											
3. Build tubes						(X)	(X)	(X)	(X)	X	X									
4. Life test tubes									X	X	X									
F. Radiator																				
1. Design									X											
2. Purchase parts									X	X										
3. Build tubes										X	X									
G. Anode slotting																				
1. Purchase unslotted anodes									Ⓧ											
2. Build tubes									X	X										
3. Test tubes										X	X									
H. Screen current																				
1. Wind trial grids					(X)	(X)	(X)	(X)												
2. Build tubes					(X)	(X)	(X)	(X)	(X)	X										
3. Evaluate results						(X)	(X)	(X)	(X)	X	X									

X - Anticipated Progress
() - Actual Progress
O - Completed

Revision #1

PROGRESS CHART - Z-5201 PEM
DA.36-039-SC-86735

	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
	1962							1963												
VI. EXHAUST EQUIPMENT																				
A. Transfer equipment		⊗																		
B. Redesign equipment					⊗															
C. Rebuild sets						(X)	(X)	(X)	(X)	X										
D. Test for high vacuum									(X)	X	X									
VII. TEST EQUIPMENT																				
A. DC aging																				
1. Redesign			⊗																	
2. Rebuild				(X)	⊗															
B. AC aging																				
1. Design									⊗											
2. Build									⊗	X										
C. RF aging																				
1. Design					(X)	(X)	(X)	(X)	(X)											
2. Build						(X)	(X)	(X)	(X)											
D. RF amplifier test set																				
1. Design driver	(X)	(X)	⊗																	
2. Build driver			(X)	⊗																
3. Redesign amplifier				(X)	⊗															
4. Rebuild amplifier					(X)	(X)	(X)	(X)	⊗	X										
5. Redesign test set				○	X	X														
6. Rebuild test set					○	X	X													
E. RF life test set																				
1. Design oscillator cavity				(X)	(X)	(X)	(X)	(X)	(X)	X										
2. Build oscillator cavity					(X)	(X)	(X)	(X)	(X)	X										
3. Test oscillator cavity						(X)	(X)	(X)	(X)	X										
4. Design life test set						(X)	(X)	(X)	(X)	X										
5. Build life test set									X	X										
VIII. REPORTS																				
A. Quarterly				⊗			⊗			X			X			X				
B. Final																	X	X		
C. Inspection																				
1. Inspect parts			(X)	(X)	(X)	(X)	(X)	(X)	(X)	X	X	X								
2. Inspect sub-assemblies						(X)	(X)	(X)	(X)	X	X	X	X	X	X					
3. Process studies												X	X							
4. Write & submit report														X	X					
D. 200 per month production plan																	X	X	X	X

X - Anticipated Progress
() - Actual Progress
○ - Completed

Revision #1

4.0 CONCLUSIONS

The first ten tubes were shipped on the revised delivery date of 25 February 1963. Near the end of this period of production, several problems were encountered in the making of tube parts, assembly, sublimation and power output. Corrective action is in process in all of these areas with some progress already shown.

The next thirty tubes should incorporate most of the contractural changes in tube structure. Aside from the above problems, the primary area of difficulty is power output. Additional tubes will need to be tested to verify the power out improvement from 34 to 38 watts previously noted.

5.0 PROGRAM FOR THE NEXT INTERVAL

The next quarter will be spent in building up the tube production rate and making the changes as spelled out in the contract. The second exhaust set should be in operation along with all aging positions. All tests will be run including some life testing.

The 30 engineering samples will be built during the next quarter, and data taken on these tubes may be used for tentative specification limits.

6.0 PUBLICATIONS, REPORTS AND CONFERENCES

6.1 PUBLICATIONS - None

6.2 REPORTS -

Quarterly Report No. 2
PEM for the Z-5267, 40 Watt, 3000 Mc Tetrode
by V. W. Amoth for the period from
1 September 1962 through 30 November 1962

Monthly Report No. 6
PEM for the Z-5267, 40 Watt, 3000 Mc Tetrode
by V. W. Amoth for the period from
1 November 1962 through 30 November 1962

Monthly Report No. 7
PEM for the Z-5267, 40 Watt, 3000 Mc Tetrode
by V. W. Amoth for the period from
1 December 1962 through 31 December 1962

Monthly Report No. 8
PEM for the Z-5267, 40 Watt, 3000 Mc Tetrode
by V. W. Amoth for the period from
1 January 1963 through 31 January 1963

6.3 CONFERENCES - Organization and personnel present:

USASSA

L. Coblentz

General Electric Company

V. W. Amoth
H. L. Thorson

Place and date:

General Electric Company
Owensboro, Kentucky

16 January 1963

Subject:

Discuss progress on all items of the contract, and the expected delivery of the first engineering samples.

7.0 PERSONNEL

Engineering personnel qualifications not previously included in previous reports are described on the following pages. Time spent on the program during this report period was as follows:

V. W. Amoth	300 hours
T. Bogucki	476 hours
S. C. Crawford	11 hours
W. H. Grant	128 hours
C. T. Jackson	164 hours
L. F. Jeffrey	132 hours
L. K. LaDue	483 hours
W. V. Shipley	488 hours
J. W. Stuart	82 hours

Submitted by:

V W Amoth

V. W. Amoth
Planar Tube Product Design
Receiving Tube Department

Approved by: H L Thorson

H. L. Thorson, Manager
Planar Tube Product Design
Receiving Tube Department

MR. S. C. CRAWFORD - CHEMICAL ENGINEER - ADVANCED DEVELOPMENT

Mr. Crawford was born in Johnson City, Tennessee, and received a B.S. in Chemistry from East Tennessee State College in 1955. After one year of graduate work in Chemistry at Florida State University, he joined the General Electric Company's Chemical and Metallurgical Training Program in 1956. In 1957, he joined the Advanced Development Engineering Subsection of General Electric's Receiving Tube Department at Owensboro, Kentucky.

His assigned projects have included electrophoretic coatings, mica substitutes, anodizing, electroplating, parts cleaning, and insulating coatings for electronic tubes. He is a member, senior grade, of the American Chemical Society.

MR. LAWRENCE F. JEFFREY - SENIOR ENGINEER - ENGINEERING TEST LABORATORY

Mr. Jeffrey graduated from Wentworth Institute in 1934 after completing the course in Electrical Construction. Following graduation he was employed by the New York Power and Light Corporation as power plant engineer specializing in control and instrumentation, and system operation.

In 1941-42 he took a course in Radio Engineering at Rennselaer Polytechnic Institute.

In 1942 he joined the Tube Department of the General Electric Company as a laboratory assistant in equipment design and construction. The following year he was advanced to assistant supervisor of the laboratory in charge of tube test equipment design and construction. In 1952 he was appointed supervisor of the Engineering Test Laboratory of the Power Tube Department with responsibility for the operation of an organization to provide the equipment and services needed by the Engineering Section. Included in this was the administration of the laboratory's personnel, budget and safety programs.

His next assignment was supervisor of Tube Circuitry Engineering for the Power Tube Department in which capacity he directed a program of circuit development for tube evaluation and application covering a broad segment of the electron tube field with particular emphasis in the microwave portion of the spectrum.

His latest assignment from 1958 to date has been as Tube Circuitry Engineer, Planar Tube Design Engineering, where he was closely associated with tube design, evaluation and application problems, and with Signal Corps contract work, particularly in the area of long life, reliable tubes for satellite application.

He completed several GE sponsored courses in supervision and management and one term served as instructor in the "Better Business Management Course".

He has contributed numerous technical articles, particularly to amateur radio publications.

In September 1962 he joined the Engineering Test Laboratory, where he designs and developes advanced cavities and circuits for tubes.