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THERMIONIC CATHODE EVALUATION STUDY

INTERIM REPORT NO. 5

MICROWAVE AND POWER TUBE DIVISION

MICROWAVE TUBE OPERATION, WALTHAM, MASS. 02154

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Microwave and Power Tube Division
Waltham, Massachusetts

INTERIM REPORT NO. 5
THERMIONIC CATHODE EVALUATION STUDY

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ABSTRACT

During the fifth interim period of thermionic-cathode evaluation, diodes rising pore-dispenser cathodes have completed at least 8580 hours of life burning and are operating satisfactorily at cathode temperatures of 950°C to 1100°C and at current densities of 0.2A/cm^2 to 1.6A/cm^2.

Diodes using standard barium-strontium oxide cathodes have completed life burning times varying from 5238 to 7368 hours. The diodes are showing cathode emission slump at current densities above 0.15A/cm^2 and cathode temperatures of 825°C to 850°C under T_3 and T_4 operating conditions.

The work on Modification No. 1 to the study program has been started.

This modification calls for the construction and testing of twenty diodes using 220 cathalloy A-33 and 0.170Zr in Ni-Pure nickel cathodes with standard barium-strontium oxide and coated-particle coating.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION

The Materials and Techniques Group of Raytheon's Microwave and Power Tube Operation is performing a study of the life capabilities of these different types of thermionic emitters for the Jet Propulsion Laboratory, California Institute of Technology.

The life capabilities of the following electron-tube cathodes are being evaluated for a period of two years of life testing.

a. Pore-dispenser cathode

b. Coated-particle cathode

c. Standard oxide cathode.

During this period of study, the thirty-one diodes using pore-dispenser cathodes and oxide cathodes were continued on life burning. The results are reported in Section 2.0 and 3.0.

Modification No. 1 of the study of the life capabilities of three different thermionic cathodes was received on July 28, 1967.

The modifications to the program are described in Section 4 of this report.

The three different cathode alloy materials (220, cathalloy A-33, and 0.170 Zr in Ni-Pure nickel) have been received and have been modified into cathode parts.

2.0 LIFE BURNING AND TESTING OF PORE-DISPENSER CATHODE

The test diodes, constructed with pore-dispenser cathodes and operating under T_1, T_2, and T_3 life-test conditions, have completed 8693 hours as of the end of this fifth interim period of study.

The test diodes, under T_4 conditions have completed 8580 hours of life burning. The life-test results are shown in Tables 1 (T_1), 2 (T_2), 3 (T_3) and 4 (T_4).

As noted in the tables, the diodes, at each interval of life burning, are tested for cathode current at constant anode voltage and cathode temperature and for cathode current at ± 20% of the specified anode voltage.

The diodes are removed from the life-test rack and are read for dip temperature and 95% of the dip temperature according to the procedure described in the first interim report, Thermionic Cathode Evaluation Study, January 1 - June 30, 1967.

TABLE 1

LIFE TEST RESULTS

PORE - DISPENSER CATHODES

Test	Diode	Hours	Ip(ma)	Volts	Ip ± 20% V	Dip T°C	Ip at 95% T
T1-950°C	M1	0	10.0	39V	8.4 - 12.0	880	8.80
0.2A/cm^2	Ef=9.0V	2688	11.0		8.9 - 13.2	891	8.00
		6848	11.0		8.9 - 13.0	887	8.75
		7252	11.0		9.0 - 13.4	877	8.75
		8049	11.0		9.0 - 13.3	874	8.81
		8693	11.0		9.0 - 12.9	904	8.57
	M4	0	10.0	26V	8.3 - 12.5	888	8.81
	Ef=9.0V	2688	10.0		8.4 - 12.2	906	8.25
		6848	9.8		8.1 - 11.8	887	8.41
		7252	9.8		8.2 - 11.8	899	7.88
		8049	9.7		8.1 - 11.6	897	7.88
		8693	9.9		8.4 - 12.0	896	7.11
T1-950°C	M2	0	20.0	49V	15.1 - 27.3	916	19.3
0.4A/cm^2	Ef=9.0V	2688	21.2		16.1 - 25.9	896	17.5
		6848	20.0		15.6 - 23.2	882	17.8
		7252	20.9		16.2 - 24.7	899	17.8
		8049	20.0		15.9 - 23.8	928	15.6
		8693	20.0		15.9 - 23.2	893	17.3
	M3	0	20.0	35V	16.5 - 27.0	897	15.0
	Ef=9.0V	2688	20.7		16.2 - 25.2	907	16.6
		6848	20.8		16.5 - 24.1	901	16.3
		7252	20.8		16.2 - 24.9	904	16.3
		8049	19.8		15.7 - 23.4	870	17.5
		8693	20.0		15.8 - 23.4	919	15.8

TABLE 2

LIFE-TEST RESULTS

PORE - DISPENSER CATHODES

Test	Diode	Hours	Ip(ma)	Volts	Ip ± 20% V	Dip T°C	Ip at 95% T
T2-985°C	M7	0	20.0	34.5V	16.8 - 27.5	899	19.3
0.4A/cm^2	Ef=9.0V	2688	20.0		15.8 - 24.4	957	16.6
		6848	22.2		17.9 - 28.0	940	17.5
		7252	22.1		17.8 - 28.0	947	17.3
		8049	23.2		18.9 - 29.7	941	17.0
		8693	23.9		18.8 - 29.9	957	16.3
	M9	0	20.0	40V	14.6 - 28.5	910	18.8
	Ef=9.0V	2688	22.5		15.9 - 29.1	938	17.7
		6848	22.0		15.8 - 28.4	936	17.9
		7252	22.1		15.9 - 28.8	921	17.8
		8049	21.9		15.7 - 28.2	934	18.2
		8693	21.5		15.8 - 27.2	941	17.5
T2-985°C	M11	0	40.0	65V	32.0 - 49.5	964	28.0
0.8A/cm^2	Ef=9.0V	2688	37.5		30.8 - 45.8	979	30.3
		6848	35.0		29.0 - 39.1	975	27.5
		7252	35.4		29.0 - 41.8	985	30.0
		8049	33.2		27.2 - 39.2	985	32.2
		8693	34.3		28.4 - 41.2	970	31.6
	M12	0	40.0	54V	31.0 - 50.0	913	38.0
	Ef=9.0V	2688	37.0		29.2 - 45.0	957	32.0
		6848	33.5		26.9 - 40.0	971	29.3
		7252	34.6		27.8 - 40.9	985	32.0
		8049	33.5		27.1 - 39.9	961	31.0
		8693	32.1		25.9 - 37.3	951	31.6

TABLE 3

LIFE-TEST RESULTS

PORE - DISPENSER CATHODES

Test	Diode	Hours	Ip(ma)	Volts	Ip ± 20% V	Dip T°C	Ip at 95% T
T3-1035°C	M13	0	30.0	45V	22.5 - 38.5	965	29.2
0.6A/cm^2	Ef=11.0V	2688	30.0		23.9 - 39.8	961	26.4
		6848	31.7		23.9 - 39.8	980	26.5
		7252	32.0		24.0 - 39.9	984	27.0
		8049	31.3		23.9 - 39.9	986	26.0
		8693	32.2		24.6 - 41.0	1001	25.8
	M18	0	30.0	48.5V	21.5 - 38.0	949	29.2
	Ef=11.0V	2688	30.0		23.0 - 37.8	1003	25.6
		6848	31.2		24.3 - 39.2	1005	25.5
		7252	31.8		24.7 - 39.2	1002	24.8
		8049	31.2		24.3 - 39.0	1003	22.5
		8693	32.0		24.9 - 40.0	1001	25.0
T3-1035°C	M17	0	60.0	90V	45.0 - 78.5	993	55.5
1.2A/cm^2	Ef=11.0V	2688	61.2		47.8 - 77.4	1020	51.6
		6848	63.0		49.4 - 76.8	1023	52.0
		7252	62.9		49.4 - 76.9	1035	52.0
		8049	62.4		49.3 - 75.9	1035	52.0
		8693	62.2		49.1 - 75.8	1035	51.6
	M14	0	60.0	98V	44.5 - 69.0	995	56.0
	Ef=11.0V	2688	54.9		41.2 - 70.2	977	55.2
		6848	55.2		41.8 - 70.3	988	55.0
		7252	55.3		41.8 - 70.8	990	53.4
		8049	53.5		40.0 - 67.9	971	57.0
		8693	53.8		40.2 - 67.9	980	55.2

TABLE 4

LIFE-TEST RESULTS

PORE - DISPENSER CATHODES

Test	Diode	Hours	Ip(ma)	Volts	Ip ± 20% V	Dip T°C	Ip at 95% T
T4-1100°C	M21	0	40.0	57V	23.0 - 52.0	957	37.6
0.8A/cm^2	Ef=11.0V	2521	46.4		28.8 - 59.5	1055	34.6
		6729	50.0		30.9 - 63.0	1049	33.0
		7139	48.8		30.5 - 62.8	1032	34.3
		7936	50.3		31.2 - 63.9	1015	34.0
		8580	51.8		31.4 - 64.0	1042	32.5
	M23	0	40.0	73V	24.0 - 51.0	997	38.0
	Ef=11.0V	2521	37.2		23.9 - 45.8	1079	31.0
		6729	34.0		23.9 - 40.8	1100	31.0
		7139	38.0		26.4 - 45.0	1100	27.0
		7936	41.7		29.0 - 49.8	1100	27.5
		8580	35.9		23.9 - 42.3	1100	25.0
T4-1100°C	M22	0	80.0	106V	59.0 - 100.0	1039	73.0
1.6A/cm^2	Ef=11.0V	2521	86.5		71.7 - 110.0	1051	66.0
		6729	88.0		74.9 - 110.0	1100	65.0
		7139	87.8		74.9 - 110.0	1100	68.5
		7936	88.2		75.0 - 110.0	1100	64.0
		8580	86.9		74.2 - 110.0	1100	62.0

The diodes operating under T_1 conditions have not shown any significant changes in operational or test parameters for 8693 hours of life burning.

The diodes operating under T_2 conditions (cathode temperature 985°C and 0.4A/cm^2) have not shown any changes up to 8693 hours of life burning. The diodes under T_2 conditions (cathode temperature 985°C and 0.8A/cm^2) have shown a slump of 15% and 20% up to this point in life burning.

One diode (cathode temperature 1035°C and 1.2A/cm^2) under T_3 conditions has shown a 10% slump in 8693 hours. The other three diodes under T_3 conditions have not shown any significant changes.

One diode (cathode temperature 1100°C and 0.8A/cm^2) has shown a slump of 15% and 20% up to this point in life burning.

One diode (cathode temperature 1035°C and 1.2A/cm^2) under T_3 conditions has shown a 10% slump in 8693 hours. The other three diodes under T_3 conditions have not shown any significant changes.

One diode (cathode temperature 1100°C and 0.8A/cm^2) under T_4 conditions has shown a 10% slump in cathode current in 8580 hours. The other two diodes under T_4 conditions have not shown any significant changes in cathode current behavior.

In summary, it can be said that the pore-dispenser cathodes have been operating satisfactorily up to 8580 hours of life burning from 950°C to 1100°C with the cathode current varying from 0.2 A/cm^2 to 1.6A/cm^2.

3.0 LIFE BURNING AND TESTING OF OXIDE-COATED CATHODES

The test diodes with oxide-coated cathodes under T_1 and T_2 conditions have completed 5238 hours of life burning.

The test diodes with oxide-coated cathodes under T_3 and T_4 conditions have completed 7368 hours of life burning.

The life-test results are compiled in Tables 5 (T_1), 6 (T_2), 7 (T_3) and 8 (T_4).

The diodes with oxide cathodes under T_1 and T_2 conditions are showing cathode current slump from 0-20% in 5238 hours. The dip temperatures for the diodes operating at T_2 conditions have shown a rise to 825°C (operating temperature).

Three diodes under T_3 conditions have shown a slump of 25% to 48% up to 7368 hours of life burning. The dip temperature has risen to 825°C (operating temperature).

The diodes under T_4 conditions have shown a slump of 12% to 51% in cathode current up to 7368 hours of life burning. The dip temperature is up to 850°C (operating temperature).

An analysis of the test results show the diodes operating above 0.15A/cm^2 (T_3 and T_4) are showing varying conditions of slumping emission.

4.0 BEHAVIOR OF OXIDE-COATED AND COATED-PARTICLE CATHODES WITH THREE DIFFERENT CATHODE ALLOYS

Modification No. 1 of the study of the life capabilities of three different thermionic cathodes was received from the Jet Propulsion Laboratory in July 28, 1967.

TABLE 5

LIFE - TEST RESULTS

OXIDE - COATED CATHODES

Test	Diode	Hours	Ip(ma)	Volts	Ip ± 20% V	Dip T°C	Ip at 95% T
T_1 - 800°C	O-32	0	6.0	19.5V	4.7 - 7.9	722	4.13
0.075A/cm^2	Ef = 8.0V	1371	6.0		4.9 - 7.4	666	5.14
		3390	5.6		4.6 - 6.7	718	5.03
		3805	5.3		4.3 - 6.3	707	4.88
		4594	5.1		4.2 - 6.1	669	4.90
		5238	5.1		4.2 - 6.1	693	5.19
	O-35	0	8.0	18.5V	7.1 - 9.7	750	4.13
	Ef = 8.0V	1371	7.8		7.2 - 8.9	740	5.14
		3390	7.9		7.5 - 9.0	776	4.88
		3805	7.9		7.5 - 9.0	753	4.89
		4594	7.3		7.4 - 8.6	747	4.88
		5238	7.1		7.4 - 8.0	774	4.88
T_1 - 800°C	O-39	0	12.0	36.0V	9.0 - 15.1	655	10.9
0.15A/cm^2	Ef = 8.0V	1371	11.8		8.9 - 14.3	680	10.5
		3390	11.9		8.9 - 14.2	683	10.5
		3805	11.9		8.9 - 14.2	691	10.5
		4594	11.9		8.9 - 14.4	679	10.4
		5238	11.8		8.9 - 14.4	692	10.3
	O-40	0	12.0	29.0V	9.6 - 14.7	769	9.3
	Ef = 8.0V	1371	12.0		9.9 - 14.1	703	10.1
		3390	10.9		9.0 - 12.9	728	10.1
		3805	10.9		8.9 - 12.5	691	9.8
		4594	10.5		8.9 - 12.3	720	9.8
		5238	10.3		8.9 - 12.2	747	9.1

TABLE 6

LIFE - TEST RESULTS

OXIDE - COATED CATHODES

Test	Diode	Hours	Ip(ma)	Volts	Ip ± 20% V	Dip T°C	Ip at 95% T
T_2 - 825°C	O-38	0	12.0	29V	9.3 - 15.2	741	11.0
0.15 A/cm^2	Ef = 8.0V	1371	11.0		8.0 - 13.0	804	10.2
		3390	10.1		8.2 - 12.4	825	9.1
		3805	10.0		8.2 - 12.4	825	8.7
		4594	10.0		8.0 - 11.1	825	8.6
		5238	9.9		8.0 - 11.4	825	8.7
	O-41	0	12.0	34V	9.1 - 14.7	727	10.8
	Ef = 8.0 V	1371	12.0		9.3 - 14.9	758	10.8
		3390	11.0		8.4 - 13.3	825	9.8
		3805	11.0		8.4 - 13.3	825	9.9
		4594	10.9		8.4 - 13.2	825	10.3
		5238	11.0		8.5 - 13.2	825	10.1
T_2 - 825°C	O-33	0	24.0	45V	19.0 - 30.4	787	21.0
0.30 A/cm^2	Ef = 8.0V	1371	20.9		16.2 - 25.4	825	20.8
		3390	21.3		16.4 - 26.3	825	19.5
		3805	21.4		16.5 - 26.1	825	19.5
		4594	20.2		15.9 - 24.8	825	18.8
		5238	19.2		15.0 - 23.0	825	18.0
	O-37	0	24.0	56V	19.1 - 30.7	735	22.6
	Ef = 8.0V	1371	21.0		17.0 - 24.7	825	18.0
		3390	20.4		16.9 - 24.0	825	20.3
		3805	20.7		16.9 - 24.2	825	20.4
		4594	20.0		16.2 - 23.2	825	19.5
		5238	20.0		16.5 - 23.5	825	19.1

TABLE 7

LIFE - TEST RESULTS

OXIDE - COATED CATHODES

Test	Diode	Hours	Ip(ma)	Volts	Ip ± 20% V	Dip T°C	Ip at 95% T
T_3 - 825°C	O-11	0	18.0	31V	14.0 - 22.2	779	16.4
0.225 A/cm^2	Ef = 8.0V	3439	11.0		9.0 - 12.4	825	11.6
		5520	10.0		8.3 - 11.8	825	15.7
		5933	10.0		8.2 - 11.9	825	14.7
		6724	10.0		8.2 - 11.9	825	12.6
		7368	10.4		8.9 - 12.4	825	12.4
	O-15	0	18.0	28V	13.9 - 23.5	769	16.6
	Ef = 8.0V	3439	14.2		11.3 - 18.0	825	13.5
		5520	12.8		11.0 - 17.2	825	13.2
		5933	13.4		10.8 - 17.3	825	13.9
		6724	13.2		10.7 - 15.7	825	11.4
		7368	13.4		10.7 - 15.9	825	10.8
T_3 - 825°C	O-7	0	36.0	34V	28.0 - 45.5	783	33.5
0.45 A/cm^2	Ef = 8.0V	3439	20.0		17.0 - 22.4	825	32.8
		5520	17.0		14.3 - 20.0	825	30.2
		5933	15.8		13.2 - 18.2	825	29.3
		6724	18.0		15.9 - 21.0	825	28.2
		7368	18.6		16.3 - 21.9	825	28.4
	O-14	0	36.0	67V	28.0 - 44.5	768	31.7
	Ef = 8.0V	3439	35.4		27.0 - 46.2	825	29.3
		5520	33.8		26.4 - 47.4	825	30.3
		5933	33.2		25.8 - 46.9	825	31.5
		6724	31.8		25.0 - 45.8	825	26.8
		7368	33.0		26.9 - 44.2	825	24.8

TABLE 8

LIFE - TEST RESULTS

OXIDE - COATED CATHODES

Test	Diode	Hours	Ip(ma)	Volts	Ip ± 20% V	Dip T°C	Ip at 95% T
T_4 - 850°C	O-21	0	24.0	39V	18.2 - 29.0	774	21.6
0.3 A/cm^2	Ef = 8.0V	3439	15.0		12.2 - 19.8	850	18.3
		5520	15.8		12.9 - 18.4	850	17.3
		5933	14.9		12.2 - 17.9	850	16.7
		6724	14.8		11.3 - 16.4	850	15.8
		7368	13.5		10.9 - 17.4	850	16.9
	O-22	0	24.0	46V	19.7 - 28.0	775	18.2
	Ef = 8.0V	3439	15.8		13.1 - 21.2	850	19.3
		5520	13.0		11.0 - 15.0	850	14.3
		5933	12.4		10.3 - 14.2	850	14.5
		6724	12.0		10.0 - 13.4	850	13.5
		7368	11.7		10.0 - 13.1	850	13.5
T_4 - 850°C	O-19	0	48.0	57.5V	35.0 - 59.3	796	42.0
0.6 A/cm^2	Ef = 8.0V	3439	41.9		31.4 - 64.5	850	36.0
		5520	42.4		32.2 - 60.0	850	42.0
		5933	42.8		32.4 - 60.0	850	36.9
		6724	39.2		31.0 - 51.9	850	34.2
		7368	42.2		32.2 - 55.8	850	35.1
	O-20	0	48.0	70V	36.8 - 60.0	769	42.6
	Ef = 8.0V	3439	41.4		32.0 - 55.3	850	37.5
		5520	36.9		29.0 - 45.4	850	39.6
		5933	35.5		28.3 - 47.2	850	37.5
		6724	33.4		25.7 - 44.0	850	40.6
		7368	35.8		26.9 - 44.9	850	31.2

The life-test conditions for the diodes are shown in Table 9.

The total number of diodes involved in the tests is twenty. Three different cathode alloys (220, cathalloy A-33 and 0.1% Zr in Ni-Pure nickel) will be used with the Raytheon coating mixture C51-3 and two different cathode alloys (cathalloy A-33 and 0.1% Zr in Ni-Pure nickel) will be used with coated-particle cathode coating.

4.1 Cathode Preparation

The cathodes are being machined from the appropriate nickel alloy to the dimensional specification of Figure 1.

The nickel alloy is drawn into a rod, 0.150 - 0.250 in. in diameter, and then machined, using Cut Max 115 cutting oil made by the Houghton Company.

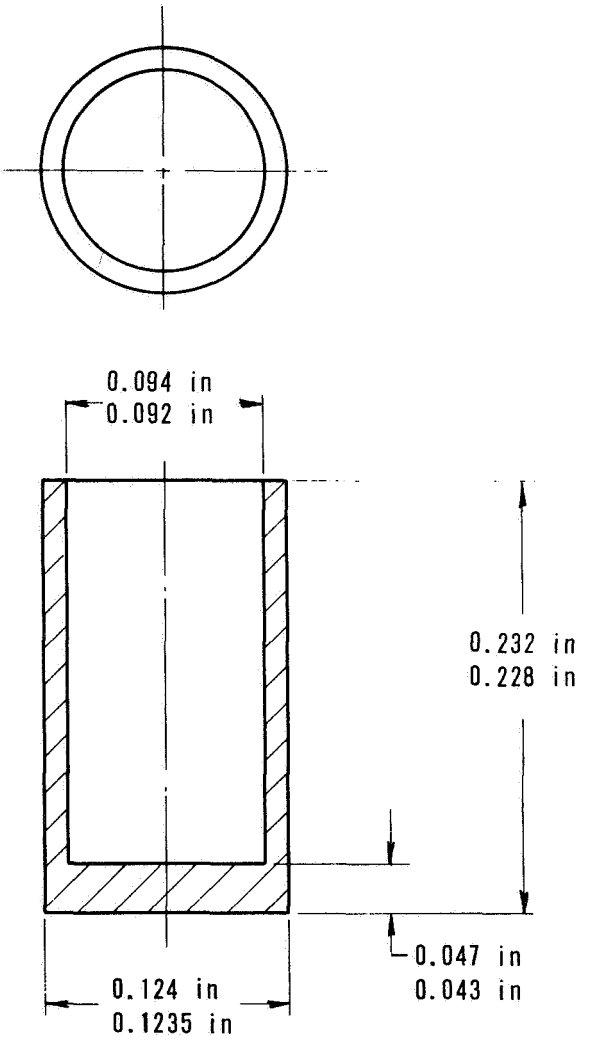
The cathodes are being cleaned according to the specifications noted in Table 10.

After cleaning, the cathodes are removed from their vacuum envelopes and are sprayed with oxide coating (Raytheon formulation C51-3) to a density of 1.0 gm/cm^3 and a thickness of 0.0025 $\pm$ 0.0005 inch.

The cathodes being used for coated-particle coating are being cleaned by the specifications noted in Table 10, plus a surface burning step with 320 mesh alumina and calcium carbonate as noted in the first interim report, January 1 - June 30, 1967.

The cathodes are then sprayed with coated-particle coating to the same dimensions noted for oxide-coated cathodes.

The cathodes will be mounted in diode assemblies as shown in Figure 2. The cathode-to-anode spacing will be maintained at 0.025$\pm$.001 inch.



NOTE: USE ONLY NUJOL AS LUBRICANT FOR MACHINING

Figure 1. Emission Cathode - Nickel-Alloy Type

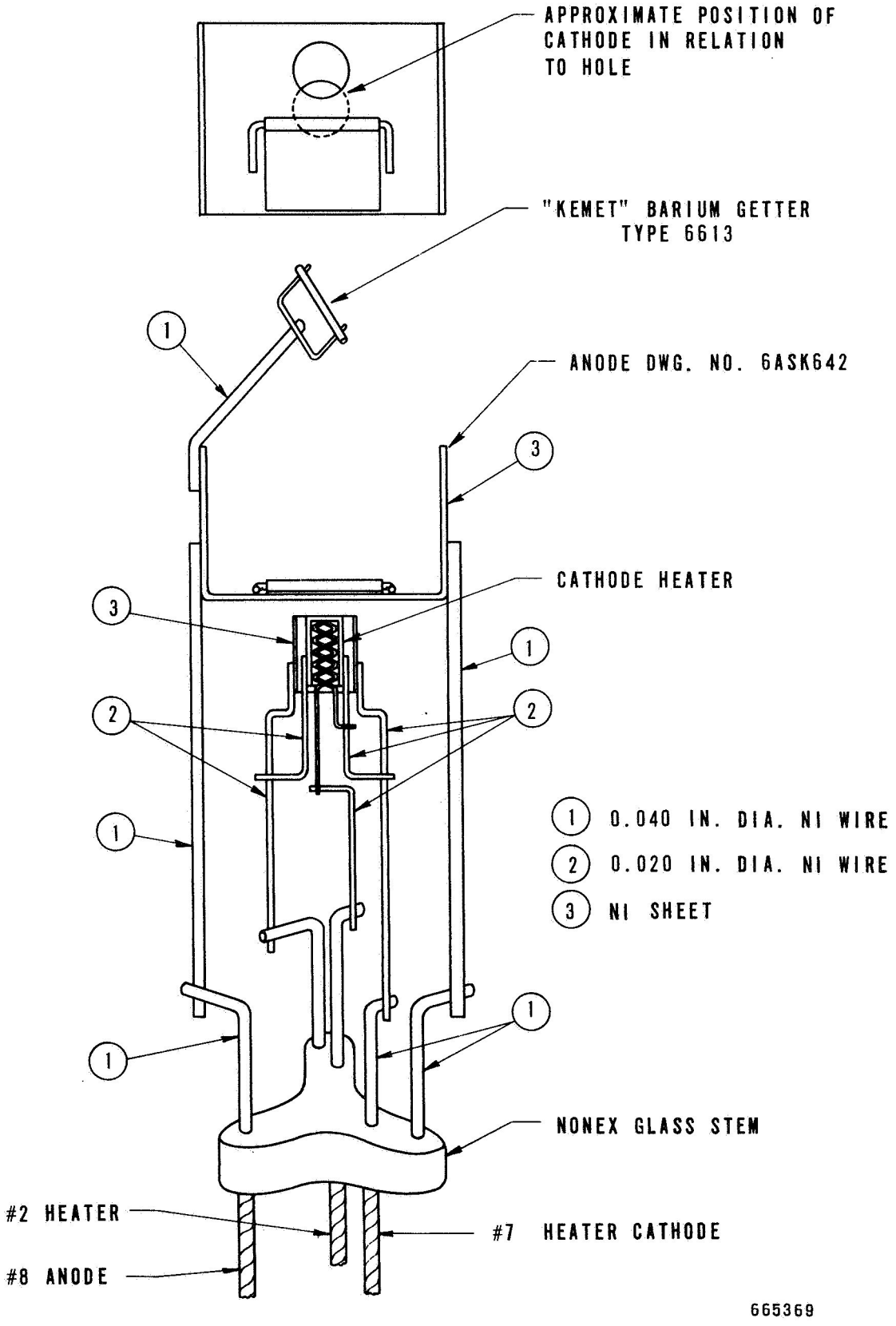


Figure 2. Diode Assembly for Thermionic-cathode Evaluation Study

TABLE 9

LIFE TEST PROCEDURES

MODIFICATION NO. 1

CATHODE	LIFE TEST TEMP.	REQ'D UNITS	CURRENT DENSITY ma/cm^2
	T_2	1	150
Oxide Cathode	T_2	1	300
Using 220 Alloy	T_3	1	225
Nickel Base	T_3	1	450
(4 Units)			
Oxide Cathode	T_2	1	150
Using Cathalloy	T_2	1	300
A-33 Nickel Base	T_3	1	225
(4 Units)	T_3	1	450
Oxide Cathode	T_2	1	150
Using 0.1% Zr in	T_2	1	300
Ni-Pure Nickel Base	T_3	1	225
(4 Units)	T_3	1	450
Coated Particle	T_2	1	275
Cathode Using Cath-	T_2	1	550
alloy A-33 Nickel Base	T_3	1	415
(4 Units)	T_3	1	830
Coated Particle	T_2	1	275
Cathode Using 0.1%	T_2	1	550
Zr in Ni-Pure Nickel Base	T_3	1	415
(4 Units)	T_3	1	830

TABLE 10

NICKEL CATHODE CLEANING SPECIFICATIONS

a. Place cathodes in stainless steel basket.

b. Insert basket into vapors in Permachlor degreasing tank and hold for 1 - 2 minutes and then immerse in the liquid for 2 - 4 minutes.

c. Core in tank above Permachlor vapor for 15 to 30 seconds.

d. Place basket with cathodes in a Pyrex basket.

e. Cover with Enbond solution (12 ozs, Enbond No. 160 per gallon of distilled water) and heat to 170 - 190°F for 4 - 5 minutes with ultrasonic agitation.

f. Rinse in running tap water to remove bulk of Enbond solution.

g. Cover cathodes with 15% antic-acid solution in distilled water and agitate for 30 seconds. Pour off antic-acid solution.

h. Rinse in distilled water.

i. Pour off distilled water and cover with isoproponol for 10 minutes.

j. Air dry for 5 - 6 minutes in circulating hot air at 150°F.

k. Fire cathodes at 1000°C in wet hydrogen for 30 minutes in nickel boat.

l. Assemble cathode with heater on glass stem and seal into glass envelope.

m. Mount assembly on vac-ion system and bakeout at 450°C for 18 hours.

n. Heat cathode to 1000°C for 30 minutes. Pressure should be in the 10^{-8} Torr range.

o. Tip off and store bottle.

5.0 PLANS FOR THE SIXTH INTERIM PERIOD

During the next interim period from October 1 to December 31, 1968, the following program will be in effect:

a. Continue life testing of pore-dispenser cathodes now on life burning.

b. Continue life testing of oxide cathodes now on life burning.

c. Assemble and exhaust 20 diodes according to Table 9.

d. Start life-burning tests of 20 diodes according to Table 9.

6.0 CONCLUSIONS AND SUMMARY

The Raytheon Materials and Techniques Group, in conducting a study of the life capabilities of the pore-dispenser cathode and the oxide cathode, has drawn the following conclusions from twelve months of life burning under the conditions noted in Tables 1 through 8.

a. The pore-dispenser method is suitable for dc operation for at least 8580 hours at current ranges of 0.2 A/cm^2 to 1.6 A/cm^2 and temperatures ranging from 950°C to 1100°C.

b. The standard barium-strontium oxide cathodes are showing emission slump at current densities above 0.15A/cm^2 under T_3 and T_4 operating condition from 5238 to 7368 hours. Though the emission level in these diodes is decaying, they should not be counted as failures at this point of life.

c. The coated-particle cathode life testing under the program using dc conditions indicated early cathode degradation under the more severe testing conditions. Investigation is underway to determine the possible role of anode poisoning, as indicated by Bell Labs.

d. At this point, the only candidate for satisfying the program objective of 30,000 hours at 1A/cm^2 would be the pore-dispenser cathode.

The life-test procedures for testing three other nickel-cathode alloys are listed in Table 9.

The purpose of this modification is to test the life capabilities of standard barium-stronium-oxide and coated-particle cathode coatings with other nickel-cathode activators. It is hoped that higher emission levels can be obtained for these cathode coatings with different nickel-cathode bases.

At this point of the study of thermonic emitters, the diodes using the above-mentioned modifications are in the construction stage.