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AEROJET-GENERAL CORPORATION

Ordnance Division
11711 Woodruff Avenue
Downey, California

PULSE-SENSITIVE ELECTROEXPLOSIVE DEVICES

Monthly Progress Report for March 1963

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Naval Weapons Laboratory
Dahlgren, Virginia

Prepared by: H. M. Kenworthy

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Reviewed by: H. J. Fisher
H. J. Fisher, Head
Initiator Research Dept.

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Approved by: L. Zernow
L. Zernow,
Director of Research

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1. INTRODUCTION

This is the ninth monthly progress report of the program to study the behavior of electrically pulsed metal films on substrates of high thermal conductivity submitted in partial fulfillment of the contract (Reference 1). Phase I is the feasibility and process development study.

2. PURPOSE

The purpose of this program is to investigate the behavior of a metallic film when it is electrically heated and is in physical contact with a heat sink. Specifically, the aim is to study the variable parameters and to develop a manufacturing process or processes for applying a bridge heating element to a ceramic surface with the required thermal contact.

3. WORK PERFORMED DURING MARCH

3.1 BERYLLIUM OXIDE HEADERS

Ninety of 100 beryllium oxide (BeO) header units expected in December 1962 were received 15 March 1963. Sixteen units were not acceptable because of cracks in the BeO ceramic between the connecting pins.

3.2 FILM DEPOSITION

The improved header holding fixtures have been completed. These consist of four aluminum blocks each holding 10 units as shown in Figure 1. Each block is identified with a Roman numeral. Gold film depositions were made on twenty BeO header units and twenty glass header units. The glass and BeO units were randomly placed in the holding fixtures and numbered from 1 to 10 in each block. The film bridges were deposited on all 40 units in one run, and the relative position can be identified by the numbering system.

The film deposition procedure used consisted of two depositions. The header units were positioned at a distance of approximately 4-1/2 in. from the tungsten boat evaporating source. The first deposit, with a central area between pins masked by 0.020-in. dia aluminum wire, was formed with the evaporation of 0.288 gm of gold to give a calculated film thickness of 0.36 μ . The central mask was removed, and

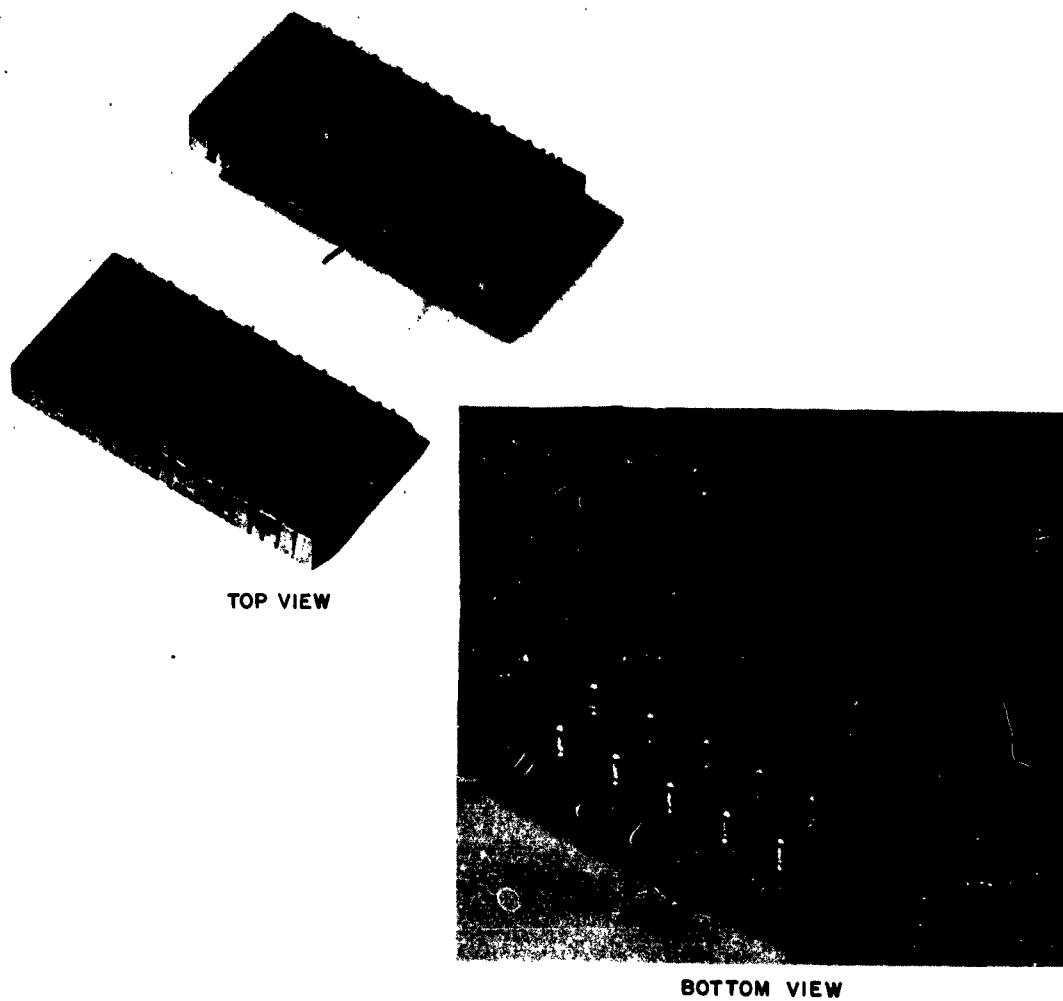


Figure 1. Header Holding Fixture for Film Bridge Deposition.

a second deposit made over the first with half the original amount of gold to provide a total film thickness in the area of the connecting pins of 0.54μ and a narrow thin central region between pins of 0.18μ . The film resistance measured from pin to pin with a Kelvin bridge ranged from 0.081 ohms to 0.186 ohms. This wide variation of resistance is the result of not having each of the four holding block fixtures normal to the path from the evaporating source with a consequent variation in film deposit.

3.3 TESTING

Pulse and continuous current heating tests of the bare films were conducted on 9 glass units and 11 BeO units. The units were tested in the camera holding fixture as shown in Figure 2, except for unit II BeO-6.

The continuous current tests were performed by applying a current from a 12 v battery with series resistance for controlling the current level. The initial current was applied and then gradually increased until film burnout occurred. The data from these tests are presented in Table 1 and a photomicrograph of unit II BeO-1 in Figure 3. Unit II BeO-5 was not placed in the camera holding fixture but was positioned in line with the lens and hole in the fixture so as not to make contact with the aluminum strip.

The pulse current tests were performed by discharging a 1- μ f capacitor through the film bridge. The capacitor was charged with batteries and the voltage measured with a high impedance voltmeter. If the bridge did not burn out on the first pulse, additional pulses were applied at the same or higher voltage levels until burnout did occur. The data from these tests are presented in Table 2. Unit I BeO-5, Figure 4, burned at the edge of one pin as well as in the central area. This may be the result of the pin surface being slightly above the ceramic surface. All of the other units tested heated only in the central thinner film area.

4. WORK PLANNED FOR NEXT MONTH

- a. Prepare test chamber and filter systems for BeO explosive firing tests.
- b. Continue gold film depositions.
- c. Continue pulse and steady current tests.



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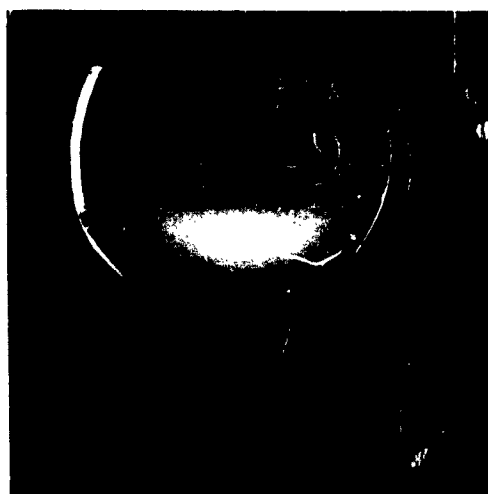
Figure 2. Header in Camera Fixture.

Table 1. Continuous Current Tests.

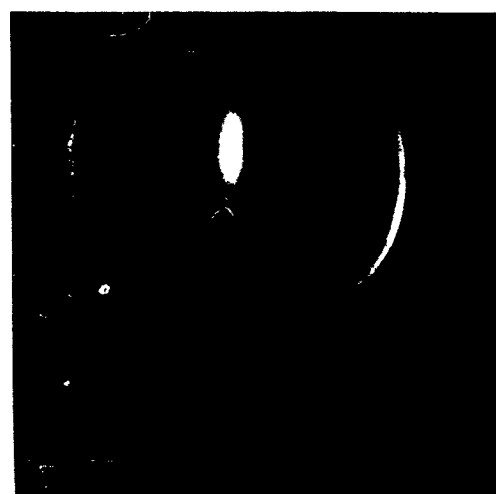
Unit	Approximate Heating Time (sec)		Current (Amp)		Initial Resistance (ohms)		Resistance At Burnout (ohms)		Remarks
	Initial	At Burnout	Initial	Kelvin Bridge	Oscilloscope	At Burnout			
	(Amp)	(Amp)	(ohms)	(ohms)	(ohms)	(ohms)			
<u>Glass Units</u>									
I G-1	65	1.93	3.35	0.185	0.197	0.32	Estimated value. Voltage exceeded scope range		
I G-3	90	2.06	3.35	0.143	0.170	(0.28)			
I G-7	90	2.42	3.80	0.116	0.136	0.25	Estimated value. Voltage exceeded scope range		
II G-2	105	2.45	4.01	0.138	0.163	0.23			
II G-3	100	2.85	4.7	0.095	0.109	0.19			
<u>BeO Units</u>									
I BeO-2	225	2.60		0.136	0.135		Film did not burnout. Stopped heating to change ammeter to higher range. Voltage exceeded scope range. Voltage exceeded scope range.		
I BeO-2	35	10.0	15.0	0.136					
I BeO-4	42	8.0	14.0	0.144	0.138				
I BeO-6	73	8.0	14.2	0.108	0.112	0.24			
II BeO-1	220	8.2	15.0	0.092	0.089				
II BeO-4	140	8.2	15.0	0.086	0.850	0.23			
II BeO-6*	55	8.2	9.9	0.096	0.098	0.23			

*Note: This unit supported only by connecting pins with no heat sink. All other units were inserted into a central hole in a 1/16-in. thick aluminum strip 1-1/2 in. wide and about 12 in. long.

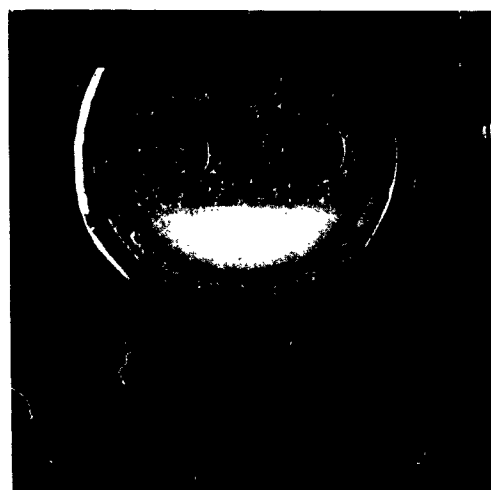
*Note: This unit supported only by connecting pins with no heat sink. All other units were inserted into a central hole in a 1/16-in. thick aluminum strip 1-1/2 in. wide and about 12 in. long.



BEFORE PULSE



DURING PULSE

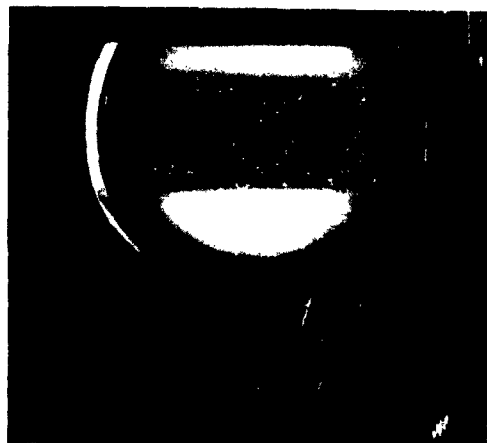


AFTER PULSE

Figure 3. Continuous Current Test Unit II BeO-1.

Table 2. Pulse Current Tests.

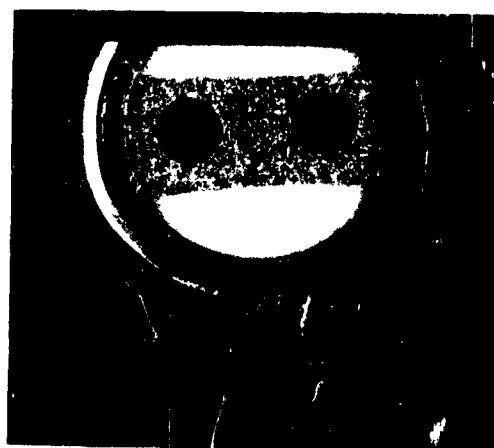
Glass Unit	Time to Burnout in μ sec	Peak Current (amperes)	Capacitor Voltage (volts)	Initial Resistance (Kelvin Bridge) (ohms)	Resistance at Burnout (oscilloscope) (ohms)	Remarks
II G-7	1	80 92	90 100	0.104	0.326	1st pulse 2nd pulse
II G-10	1	90 90 88	100 100 100	0.112	0.205	1st pulse 2nd pulse 3rd pulse
III G-7	0.8	100 110 110	105 117 117	0.090	0.170	1st pulse 2nd pulse 3rd pulse
III G-9	1.2	90 105	102 114	0.125	0.240	1st pulse 2nd pulse
<u>BeO Units</u>						
I BeO-8	1	92 120 160 155	100 123 157 157	0.112	0.160	1st pulse 2nd pulse 3rd pulse 4th pulse
I BeO-5	1	145	157	0.157		voltage trace exceeded range (burned at edge of pin)
II BeO-8	1	170 200 225	157 181 204	0.083	0.120	1st pulse 2nd pulse 3rd pulse
II BeO-5	1	200 190	180 180	0.081	0.126	1st pulse 2nd pulse
III BeO-8	1.5	195	180	0.085	0.091	1st pulse (Burnout occurred after current peak)



BEFORE PULSE



DURING PULSE



AFTER PULSE

Figure 4. Unit I BeO-5 Capacitor Discharge Pulse.

REFERENCES

1. U. S. Naval Weapons Laboratory, Contract N178-8107, dated 30 June 1962.