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RESEARCH AND DEVELOPMENT DEPARTMENT
Joe L. Browning, Director

Technical Memorandum Report 191

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EFFECT OF GAMMA IRRADIATION FROM A COBALT-60 SOURCE UPON THE SENSITIVITY OF ELECTRIC IGNITION ELEMENTS MK 2, MK 4, and MK 6

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By

Y. K. Roots
T. D. Phillips

U. S. NAVAL PROPELLANT PLANT
Indian Head, Maryland

O. A. WESCHE
Captain, USNavy
Commanding Officer

J. E. DODGEN
Commander, USNR
Technical Director

FOREWORD

The work described in this report was done under Task Assignment 506-925/56035/0204. The original data is reported on laboratory notebook pages 20476 through 20549. Data are as of 18 September 1959.

A. J. Matuszko
Head, Fundamental
Process Division

Approved by:

Bodo Bartocha
Associate Director
for Research

Released by:

O. A. WESCHE
Captain, USNavy
Commanding Officer

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FIGURES

Abstract Unclassified

ABSTRACT

Electric ignition elements Mk 2, Mk 4, and Mk 6 have been exposed to gamma radiation from a cobalt-60 source. Dosages ranged from 1.75×10^5 to 78.23×10^5 roentgens. The effect of this irradiation on the sensitivity of the elements in terms of time-to-ignition was variable. The Mk 6 elements showed a general tendency toward decreased sensitivity; the Mk 2 elements showed less tendency toward decreased sensitivity; and the Mk 4 elements showed an increase in sensitivity.

EFFECT OF GAMMA IRRADIATION FROM A COBALT-60 SOURCE UPON THE SENSITIVITY OF ELECTRIC IGNITION ELEMENTS MK 2, MK 4, AND MK 6

A testing program has been conducted to determine the effect of gamma irradiation on electric explosive devices (EED). This report covers the results of testing irradiated Mk 2, Mk 4, and Mk 6 electric ignition elements. The Mk 2 and Mk 6 elements contain 90 mg of FFFG black powder and an ignition charge of lead styphnate and cellulose nitrate in a 50:1 ratio. The Mk 4 element contains 200 ± 25 mg ignition charge of lead styphnate and graphite in a 96:4 ratio. The balance of this 325-mg element is black powder. The sensitivity of EED's after they had been given dosages of from 1.75×10^5 roentgens to 78.23×10^5 roentgens was compared to that of similar EED's that had received no irradiation. The cobalt-60 source used in this work was obtained from the Brookhaven National Laboratories, Upton, New York, (see Reference 1 for description) and was calibrated April 15, 1957, as 1330 curies, with an intensity of radiation along the central axis of the source of 568,000 roentgens per hour. Assuming the half life of cobalt-60 to be 5.2 years, the dosage rate for the exposure of these EED's was computed from the Radiological Health Handbook.[2] The dosage was then calculated by multiplying the dosage rates so obtained by the time of irradiation.

EXPERIMENTAL

When an explosive is placed in a radiation source, the hazard cannot be predicted in advance. Possibilities exist that the substance might ignite and explode within the source or may become sensitive to handling during subsequent tests. For this reason, preliminary tests were carried out by placing an EED in an iron capsule and giving it an exposure in excess of any contemplated during the series of tests. Such a test having given reasonable assurance of safety, the EED's were packed in cylindrical aluminum canisters in groups of 10 to 30 and in such a way that all would receive equal irradiation when the canisters were lowered by chain hoist into the source. Exposures ranged from a few hours to a few days.

Both the irradiated and the nonirradiated EED's were fired in the ramp-firing equipment devised by Phillips and Klein.[3] The effect of irradiation on the sensitivity of the EED was determined by the increase or decrease of the firing time (t_f) for the various irradiation doses. The firing time (t_f) (see Figure 1) is the time from the moment the current is initiated in the bridge wire (A) until the instant when the blast from the squib takes place (B). The former is determined by the recording galvanometer in the firing circuit and the latter by the time when the photoelectric cell detects the flash from the squib. Time until the squib blast might also be determined by measuring to the instant at which a break (C) is found in the firing line curve, except that the bridge wire of the EED does not always break or fuse at the instant of the explosion of the EED.

Figure 2 shows the arrangement of the essential items of apparatus used in obtaining the firing data. On the table top at left is a C.E.C. Recorder (A) with its attached camera (B) while in the center is the fire control box (C) and at the right, fabricated partly of plexiglass, is the safety firing chamber (S), its door (R), and firing circuit interlock (P,Q). Within the firing chamber is a massive steel and lead firing block (I) with holes drilled to hold the various squibs and other EED's. The white dot (J) is an EED positioned for firing. The EED lead wires are attached to the alligator clips (O), and when the door (R) is closed these are connected by interlocks (P,Q) to the firing line which is energized by the switch (E). In front of the table, supported on a small shelf is a photoelectric cell (L) and its accompanying voltage supply (M). Wires (N) lead from the photoelectric cell to the galvanometer (A). The window of the photoelectric cell (L) faces the EED (J) from outside the transparent front wall of the safety firing chamber (S).

The EED (J) is mounted securely in the vertical member of the massive steel and lead firing block (I). A smaller central hole behind (T) permits the insulated lead wires to be drawn through to make connections with firing-line alligator clips at (O). A safety feature of this firing arrangement is the safety chamber where the firing circuit from (C) terminates at (G); two lines from this point, one leading to the voltmeter (H) and the other to the interlock (P,Q) on the door (R) give indication of the presence of voltage in the door (R) at the interlock (P,Q) which would cause the squib to fire if the door was closed.

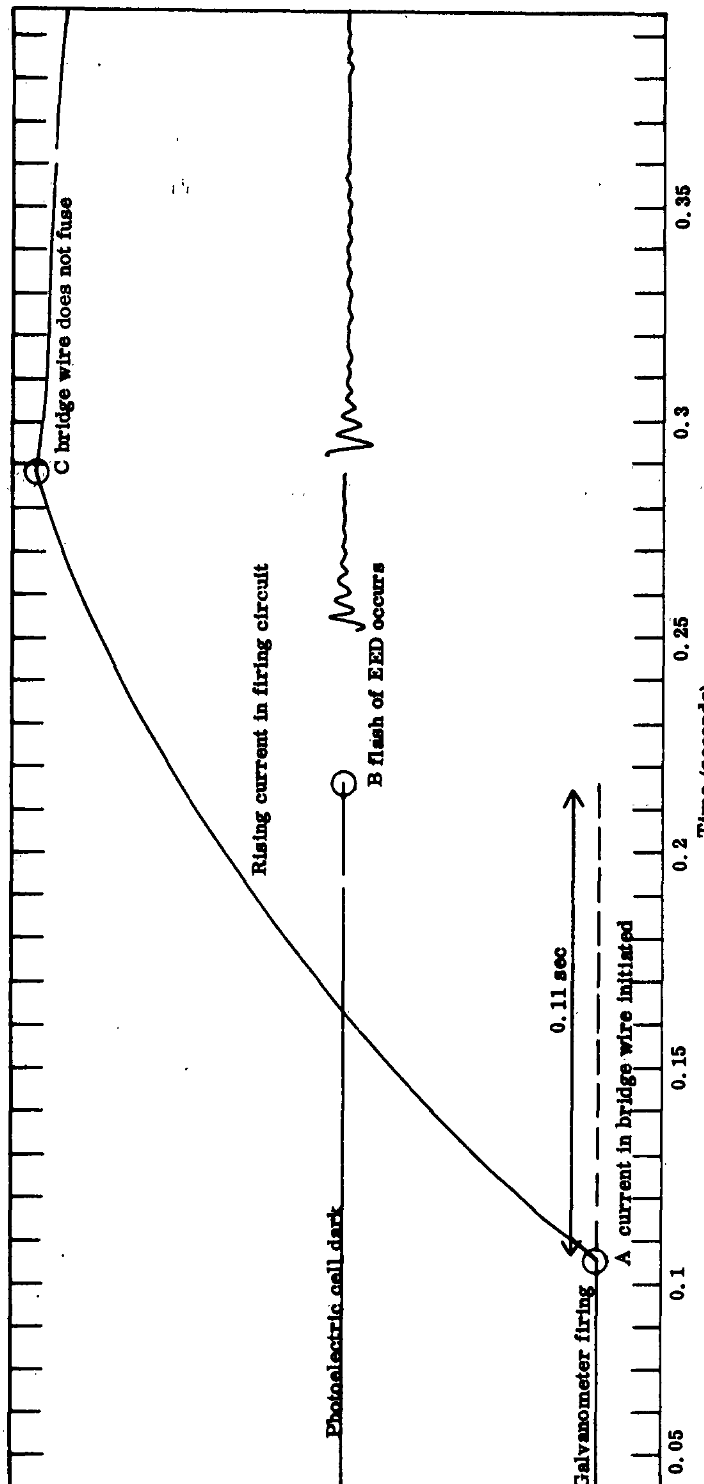


FIGURE 1. SQUIB SAMPLE FIRING RECORD

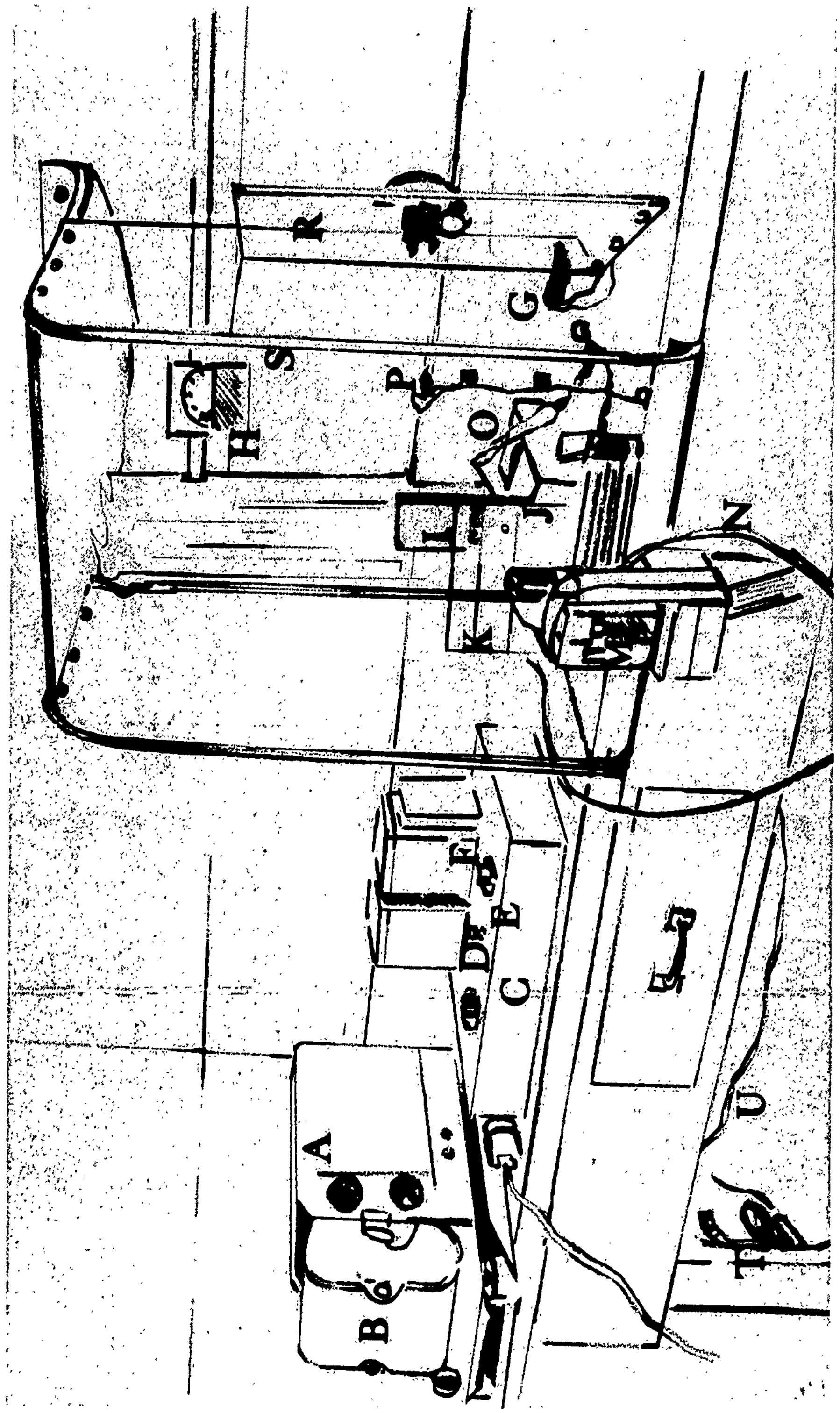


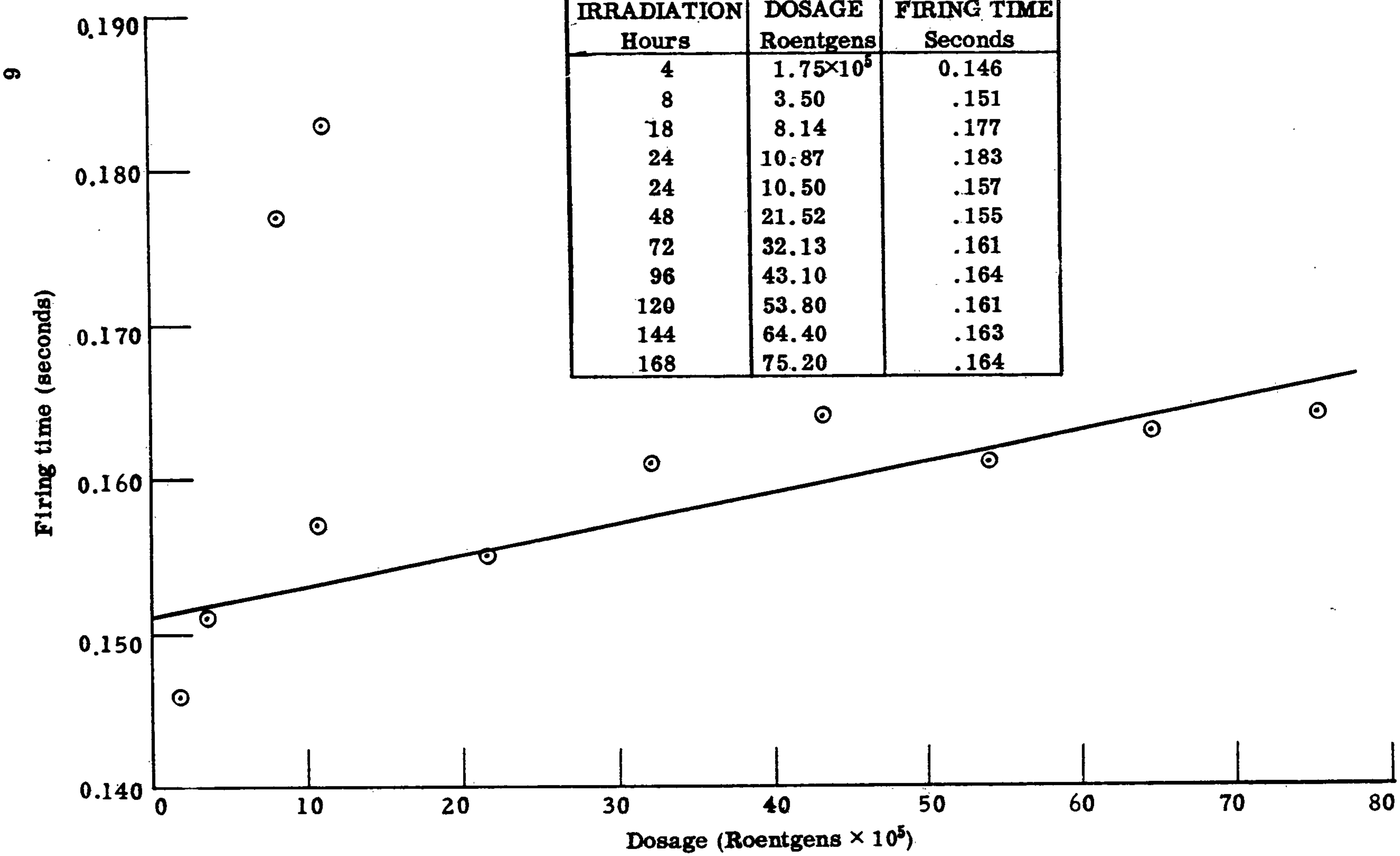
FIGURE 2. SQUIB TEST FIRING APPARATUS

Pressing on the button (D) and pushing switch (E) forward sets the camera into operation and after a millisecond delay applies voltage to the firing line to explode the EED.

On a shelf below the table are storage batteries (T) which supply the following approximate d-c voltages: the recorder, 24 volts; the firing-box relay, 48 volts; the firing line, 68 or more volts. Batteries are kept charged by a selenium recharger (U).

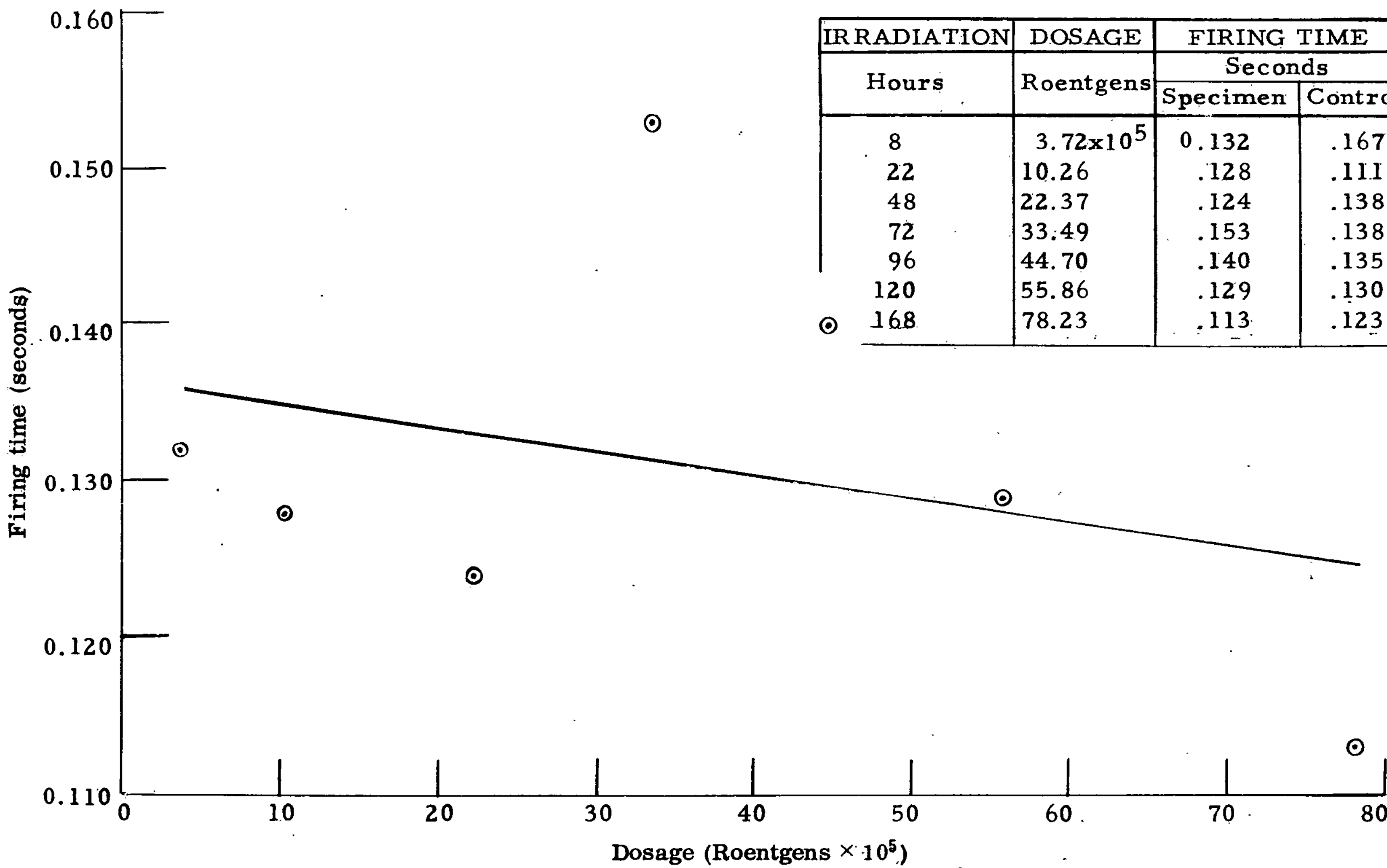
RESULTS AND CONCLUSIONS

From the graphs and the tabulated data given in Figures 3, 4, and 5, it will be observed that the roentgen dosages range from 1.75×10^5 to 78.23×10^5 roentgens and that the effect of these dosages on the firing time of the squibs is extremely variable. The Mk 6 ignition elements show a general tendency toward decreased sensitivity, as shown by the increased time to ignition; the Mk 2 elements show less tendency toward decreased sensitivity. In the case of the Mk 4 ignition elements, however, the sensitivity increases and no explanation for the difference is available. It should be noted that the range over which these elements were exposed exceeds that which they would probably experience in combat conditions save near ground zero in an atomic blast.[4] The data here presented indicate that in so far as hazard due to irradiation of gamma rays from nuclear installations is concerned, any such installation which is sufficiently shielded for safety of personnel would be adequately safe for electric explosive devices such as those here considered. Hence, we can say that there appears to be no hazard in the transport of EED's in atomic-powered craft from the standpoint of gamma irradiation.



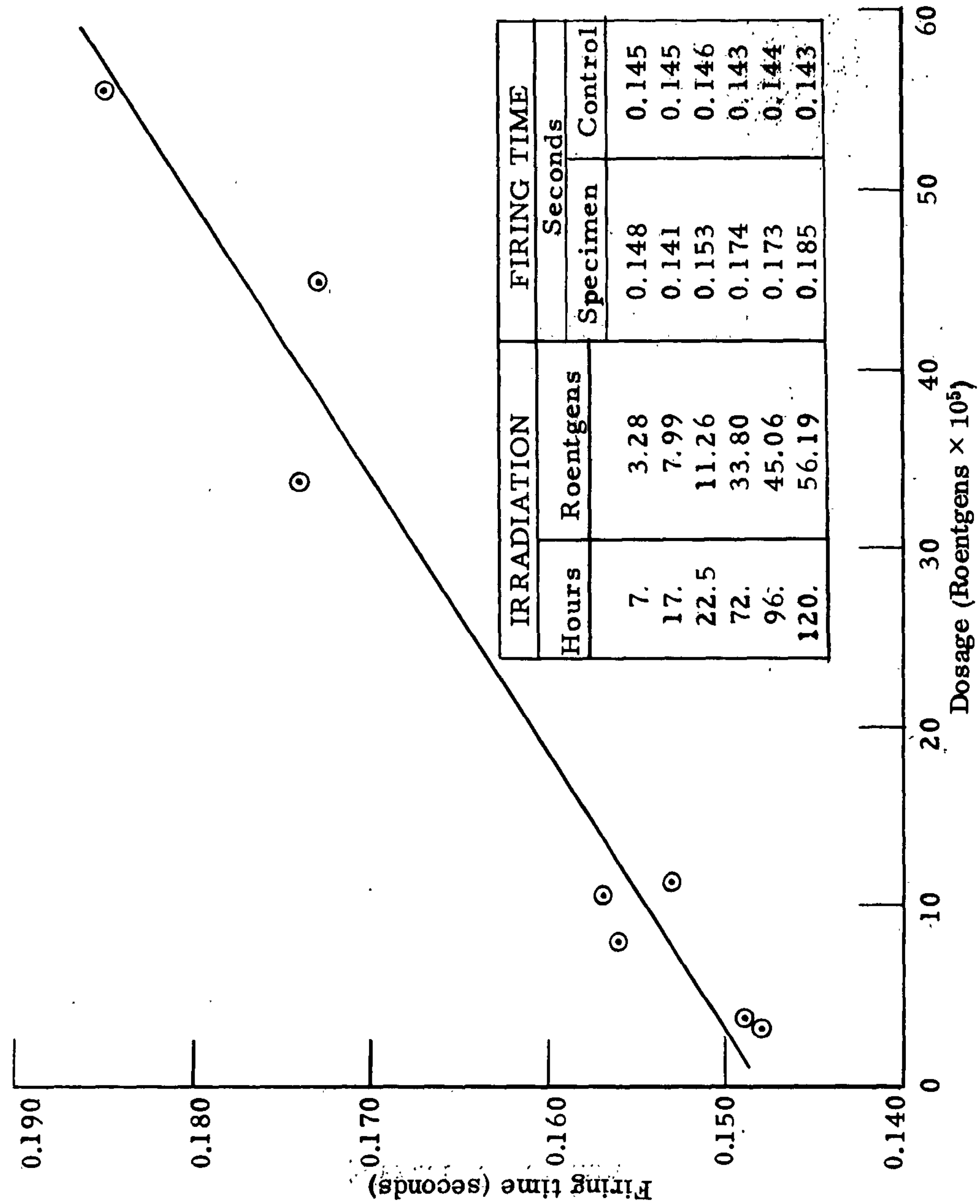
IRRADIATION Hours	DOSAGE Roentgens	FIRING TIME Seconds
4	1.75×10^5	0.146
8	3.50	.151
18	8.14	.177
24	10.87	.183
24	10.50	.157
48	21.52	.155
72	32.13	.161
96	43.10	.164
120	53.80	.161
144	64.40	.163
168	75.20	.164

FIGURE 3. SENSITIVITY OF MK 2 SQUIBS SUBJECTED TO GAMMA IRRADIATION



IRRADIATION	DOSAGE	FIRING TIME	
Hours	Roentgens	Seconds	
		Specimen	Control
8	3.72×10^5	0.132	.167
22	10.26	.128	.111
48	22.37	.124	.138
72	33.49	.153	.138
96	44.70	.140	.135
120	55.86	.129	.130
168	78.23	.113	.123

FIGURE 4. SENSITIVITY OF MK 4 IGNITION ELEMENTS AS AFFECTED BY GAMMA IRRADIATION



IRRADIATION		FIRING TIME Seconds	
Hours	Roentgens	Specimen	Control
7.	3.28	0.148	0.145
17.	7.99	0.141	0.145
22.5	11.26	0.153	0.146
72.	33.80	0.174	0.143
96.	45.06	0.173	0.144
120.	56.19	0.185	0.143

FIGURE 5. SENSITIVITY OF MK 6 IGNITION ELEMENTS AS AFFECTED BY GAMMA IRRADIATION

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(3) U. S. Naval Propellant Plant. A RAMP-TYPE TESTING CIRCUIT FOR ELECTRIC EXPLOSIVES DEVICES. By A. H. Klein and T. D. Phillips. Memorandum Report No. 155. 3 November 1958. UNCLASSIFIED

(4) U. S. Atomic Energy Commission. THE EFFECTS OF NUCLEAR WEAPONS. Washington, D. C.: U. S. Government Printing Office. June 1957.

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(over)

1. Igniters - Effects of radiation
2. EED's - Effects of radiation

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