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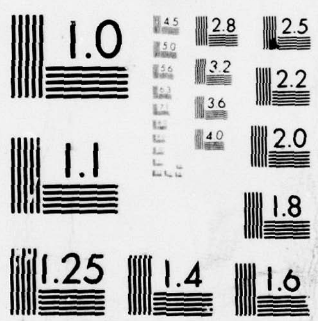

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Operation UPSHOT-KNOTHOLE

NEVADA PROVING GROUNDS

March - June 1953

Project 6.4

EVALUATION OF CHEMICAL DOSIMETERS

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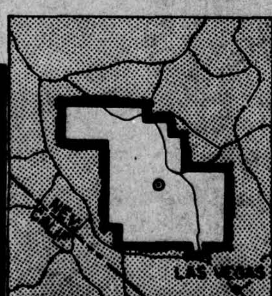

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OPERATION UPSHOT-KNOTHOLE

Project 6.4

EVALUATION OF CHEMICAL DOSIMETERS

REPORT TO THE TEST DIRECTOR

by

John E. Chaney

January 1955

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Chemical Corps
Chemical and Radiological Laboratories
Army Chemical Center, Maryland

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ABSTRACT

The developmental type tactical dosimeter, Type E-1, was tested during Operation UPSHOT-KNOTHOLE. Two experimental dosimeters, the Tracerlab Tactical Dosimeter and the Consolidated Vacuum Dosimeter, were also evaluated. Along with laboratory findings and detailed data gathered under Project 29.1, the test results indicate that the tactical dosimeter, Type E-1, is rate independent and, with the exception of the 50 r tube, records exposures in accordance with accepted film standards within the expected reading accuracy of step-type dosimeters. Recalibration studies accomplished at the Chemical Corps Chemical and Radiological Laboratories indicated that the 50 r tubes were poorly manufactured, being sensitive to only 80 r. This recalibrated value of 80 r for the 50 r tubes correlates with field test results. The two experimental dosimeters need redesigning to withstand rugged field use, must be modified to include improved color standards, and require modification of their basic composition to record more satisfactorily gamma radiation exposure.

ACKNOWLEDGMENTS

The work on this project was performed in close coordination and cooperation with personnel of Projects 6.8 and 29.1.

[redacted]

FOREWORD

This report is one of the reports presenting the results of the 78 projects participating in the Military Effects Tests Program of Operation UPSHOT-KNOTHOLE, which included 11 test detonations. For readers interested in other pertinent test information, reference is made to WT-782, Summary Report of the Technical Director, Military Effects Program. This summary report includes the following information of possible general interest.

a. An over-all description of each detonation, including yield, height of burst, ground zero location, time of detonation, ambient atmospheric conditions at detonation, etc. for the 11 shots.

b. Compilation and correlation of all project results on the basic measurements of blast and shock, thermal radiation, and nuclear radiation.

c. Compilation and correlation of the various project results on weapons effects.

d. A summary of each project, including objectives and results.

e. A complete listing of all reports covering the Military Effects Tests Program.

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CHAPTER 1

GENERAL

1.1 OBJECTIVE

This project was conducted to evaluate existing chemical-type dosimeters against the high initial gamma radiation exposure rates and the energy spectrum encountered in the detonation of a nuclear device.

The purpose of this project was to provide practical field test information to substantiate conclusions drawn from laboratory testing of chemical-type dosimeters. Furthermore, this project was intended to determine if the tactical dosimeter, Type E-1, read within the proper step ranges when compared to the standard exposure values obtained by photographic methods, and to establish the consistency of readings among dosimeters of the same type when tested in the field. Other chemical dosimeters were exposed for rate-dependence studies only, and it was not intended that they be subjected to full-scale field testing.

1.2 HISTORICAL

The program reported herein is a continuation of similar programs conducted at GREENHOUSE, Project 5.1, WT-63, BUSTER, Project 6.1, WT-317, and SNAPPER, Project 6.1, WT-532. The dosimeters discussed are representative of the current research and development program of the U. S. Army Chemical Corps.

1.3 THEORY OF INSTRUMENTS

1.3.1 Tactical Dosimeter, Type E-1

The tactical dosimeter, Type E-1, operates on the basic principle that water-saturated chloroform exposed to X-ray or gamma radiation is partially decomposed, one of the products of decomposition being hydrochloric acid. This decomposition is directly proportional to the amount of radiation received. By extracting the hydrochloric acid from the chloroform with an aqueous solution of an acid indicating dye (bromcresol purple), the pH of the aqueous solution is changed, causing the dye to undergo a color change from purple to yellow. The degree of color variation is controlled by varying the ratio of chloroform to aqueous-dye solution, varying the dye concentration, or changing the pH of the aqueous solution.

The decomposition of the chloroform to acid by X-ray or gamma radiation is a rate dependent process. The addition of a small quantity of resorcinol has minimized this problem of rate dependence within the range of gamma exposure rates obtained in the laboratory (0.5 r/min to 1200 r/min). (1)

1.3.2 Tracerlab Tactical Dosimeter

This dosimeter operates on the same basic principle as the tactical dosimeter, Type E-1. Carbon tetrachloride, like chloroform, decomposes on exposure to gamma radiation to form hydrochloric acid. Carbon tetrachloride sensitized with dimethylaniline produces the acid which is detected by an indicator consisting of the imino base of diphenylamine dissolved in benzene. This acid indicator goes through a gradient color change from yellow to deep blue.

1.3.3 Consolidated Vacuum Dosimeter

This dosimeter also operates on the same basic principle as the tactical dosimeter, Type E-1. The formation of the hydrochloric acid is accomplished by the decomposition of water-saturated chloroform. The dye used to indicate the acid production is neutral red, which goes through a gradient color change from yellow to red. Anhydrous ethyl alcohol has been added to the system to increase the solubility of the neutral red hydrochloride formed during the reaction.

1.4 DESCRIPTION AND CHARACTERISTICS OF INSTRUMENTS

1.4.1 Tactical Dosimeter, Type E-1

The tactical dosimeter, Type E-1, consists of four flame-sealed glass ampoules filled with chloroform overlayed with an aqueous dye solution. The ampoules are made of neutral glass and are internally coated with silicone. The wall thickness is 0.5 mm, the average diameter 10 mm, and the average length of a sealed tube is 73 mm. The contents of each tube are given in Table 1.1. The four ampoules are encased in a white rubber insert for shock protection. This entire unit is covered by 0.5 mm of lead and is contained in an olive drab painted steel case with a hinged cover. To protect against light, shock, and tampering while the case cover is open, a metal insert is provided to cover the rubber encased tubes. Figure A.1 shows this instrument with the hinged cover opened and Fig. A.2 shows a disassembled unit. The external dimensions of the case are approximately 3-3/4 in. x 2-1/4 in. x 1/2 in. The total weight of the dosimeter is 7 oz.

The chloroform used is triple-distilled and contains 0,2 per cent resorcinol as a stabilizer. The concentration of the aqueous dye

(1) Chaney, J.E., Santilli, A., Heck, J., CRLR 360, Development of the E1R1 Tactical Radiation Dosimeter, 20 December 1953.

solution is 5.28 mg of bromcresol purple per 100 ml of triple distilled water.

TABLE 1.1 - Contents of the Ampoules in the Tactical Dosimeter, Type E-1

Tube No.* (r)	Volume of Chloroform (ml)	Volume of Aqueous Dye Solution (ml)	pH of Aqueous Dye Solution
50	2.5	0.1	6.0
200	2.3	0.2	6.2
400	2.15	0.3	6.3
600	2.1	0.4	6.3+

* Calibrated against Co^{60} source.

The tactical dosimeter, Type E-1, has a thermal stability of two weeks in accelerated storage at 50°C; shelf-life at normal room temperatures will exceed one year. Light stability of the instrument is estimated to be better than 12 hours when the case cover is open and the tubes, seen through the metal insert, are exposed to the direct rays of a midday sun. When the outside cover is closed and the device is carried in its intended manner, with the exception of brief reading periods, it will have almost indefinite light stability. The above conclusions are the findings of laboratory investigations. The above durations of stability are those times after which the dosimeter will no longer be accurate to within 80-120 per cent of one or more step value.

It has been determined in the laboratory that mass produced tactical dosimeters, Type E-1, which are properly aged, calibrated and color graded can be expected to have a spread of deviation of no more than 90 to 110 per cent for any given step value. (1),(2) For example, the 50 r tube of a properly prepared dosimeter will respond (show a complete color change) to 45-55 r, the 200 r tube will respond to 180-220 r, etc. Most of the time the higher range tubes (200-600 r) will respond to radiation between 95 to 105 per cent of their calibrated values.

A typical sample of 10 devices from a lot of tactical dosimeters, Type E-1, including properly mass-produced 50 r tubes, and their response to X-ray is shown in Table 1.2. Other laboratory data (2) have shown this dosimeter to respond equally well in all portions of the energy range from 80 kev to 1.3 Mev.

(2) Rochkind, J.M., Lieberman, D.S., Gatoff, H.L., CRLR 260, Final Engineering Test No. 57, "Dosimeter, Tactical, E1R1," 28 Sept. 1953

TABLE 1.2 - Response* of Mass-Produced Tactical Dosimeters, Type E-1, to X-Ray** Radiation

DOSIMETER NUMBER	TUBE NUMBER (r)***			
	50	200	400	600
1	55	185	375	580
2	50	205	415	590
3	50	190	400	640
4	50	200	420	590
5	55	215	380	560
6	50	200	410	625
7	45	215	370	610
8	55	200	390	580
9	50	195	385	580
10	55	210	420	630

* Complete color change from purple to yellow.
** 225 kev.
*** Calibrated against Co^{60} source.

In order to have a sufficient quantity of Tactical Dosimeters, Type E-1, ready for testing during the UPSHOT-KNOTHOLE series, certain steps in their manufacture were hurriedly performed or skipped entirely. Performing the tube color grading process too rapidly resulted in slight inconsistencies of response among dosimeters exposed within the same station (see Tables 3.1 and 3.2). When properly color graded, 95-100 per cent of a lot of dosimeters can be expected to indicate the same dose range when exposed under identical conditions. Unfortunately, because the 50 r tubes were the last to be produced, a time consuming aging process was entirely eliminated and resulted in tubes labeled as 50 r not responding to as much as 76 r at station 7, Shot 8 (Table 3.2). The 200, 400, and 600 r tubes, made at an earlier date, were properly aged. After manufacture, the chemical components of the tubes require an equilibration period. Color grading for a specific dose response prior to the completion of this process, results in tubes which respond to dosages somewhat higher than their calibrated values when exposed to radiation several weeks after their manufacture. No such changes occur if tubes are given an accelerated aging treatment prior to color grading and final calibration. The 50 r tubes, prepared without benefit of aging and used during the UPSHOT-KNOTHOLE series, were found to be responsive to 80-90 r when recalibrated against cobalt-60. Further information concerning corrected values and the testing of accurate 50 r dosimeter tubes by Project 29.1 will be found in Chapter 3.

1.4.2 Tracerlab Tactical Dosimeter

This dosimeter consists of two screw-cap vials housed in a lead lined plastic case. The color standards are painted strips, graduated from yellow to deep blue and corresponding to dose steps of 0, 50, 100,

[redacted]

and 200 r for the lower range vial, and 300, 400, 500, and 600 r for the higher range vial. A composite view of this dosimeter is shown on the left of Fig. A.3.

Formulation of Solution in the 0 to 200 r Range Vial

83 g Dow Corning Silicone 200 (250,000 c.s. viscosity)
166 ml Carbon Tetrachloride
10 ml 10^{-3} M solution of imino base of diphenylamine in benzene
0.06 ml Dimethylaniline per 2.5 ml of benzene

Formulation of Solution in the 300 to 600 r Range Vial

83 g Dow Corning Silicone 200 (250,000 c.s. viscosity)
166 ml Carbon Tetrachloride
20 ml 10^{-3} M solution of imino base of diphenylamine in benzene
0.06 ml Dimethylaniline per 2.5 ml of benzene

1.4.3 Consolidated Vacuum Dosimeter

This dosimeter consists of a flame-sealed glass ampoule filled with water-saturated chloroform containing 2.5×10^{-5} M neutral red and 1.5 per cent of anhydrous ethyl alcohol. The ampoule is housed in a spun aluminum container measuring 2-5/8 in. in length and 9/16 in. in diameter. The inside of the container is lined with 0.5 mm-thick lead. Short transparent plastic rods serve as color standards for visual comparison with the dosimeter. The plastic rods are a thermosetting polyester resin tinted various shades from yellow to red, corresponding to the colors produced in the dosimeter by doses of 0, 50, 150, 250, 375, and 600 r. The dosimeter case, ampoule, and color standards are shown on the right of Fig. A.3.

1.5 EXPOSURE STANDARD

To determine the integrated gamma exposure to which the dosimeters were exposed, conventional film badges in National Bureau of Standards holders were used as standards. More detailed information on these standards is contained in the SNAPPER, Project 6.1 report, WT-532.

[redacted]

CHAPTER 2

EXPERIMENTAL PROCEDURE

2.1 MOUNTING METHODS

The exposures of tactical dosimeter, Type E-1, Tracerlab tactical dosimeter, and the Consolidated Vacuum dosimeter, were effected by the use of aluminum stations. A station consisted of a frame as shown in Fig. A.4, to which was affixed a plate as shown in Fig. A.5, covered by a thermal and shock shield shown in Fig. A.6. More detailed information on the station can be found in the Operation SNAPPER, Project 6.1 report, WT-532. The dosimeters were attached to the exposure plate with masking tape and then covered by the thermal and shock shield. A number of Type E-1 devices were attached to the outside of the thermal and shock shield by the use of masking tape. This latter method of mounting proved inadequate and only a few of the instruments, thus exposed, were found.

2.2 EXPOSURE TECHNIQUES

Eight stations, positioned to cover the entire range of the instruments, were used for participation in Shots 7 and 8. For Shot 7, fifteen tactical dosimeters, Type E-1, five Tracerlab tactical dosimeters and five Consolidated Vacuum dosimeters were exposed behind the thermal and shock shield. For Shot 8, fourteen tactical dosimeters, Type E-1, were exposed behind the thermal and shock shield and four additional ones were located outside the shield at each of the eight stations.

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CHAPTER 3

RESULTS

3.1 GENERAL

Dosimeters exposed during Shot 7 were not retrieved until 30 hr after H-hour, while those tested at Shot 8 were recovered between 2 and 3 hr after H-hour. A number of dosimeters, particularly those located at the positions nearest to ground zero, were slightly damaged or lost. However, at these positions the radiation exposure was well above the range of the dosimeters.

3.2 TACTICAL DOSIMETER, TYPE E-1

Almost all of the tactical dosimeters, Type E-1, exposed at Shots 7 and 8 indicated within the correct step range, particularly when the recalibration value of 80 r for the 50 r tube is applied to the appropriate stations such as station 7, Shot 8. The dosimeters were found to have good consistency in response and were quite rugged when carried by participating troops simulating actual field use. A number of devices withstood the full impact of shock and thermal effects. To obtain unbiased results, the dosimeters were read by a group of individuals, the greater portion of whom were unfamiliar with the dosimeter.

3.2.1 Participation in Shot 7 (25 April)

Approximately 90 per cent of the tactical dosimeters, Type E-1, were recovered after the detonation. These were given to each of eight persons to read. Almost all of the eight readings for any one instrument were in complete agreement. The results were averaged and are combined in Table 3.1. Table 3.2 is a listing of those instruments which were not read identically by all eight readers. In a particular range covered by the dosimeter, over 95 per cent of the recorded exposure ranges agreed with the film standards to the accuracy required by the military characteristics. At each station 87 per cent or more of the dosimeters indicated the same exposure range.

[redacted]

3.2.2 Participation in Shot 8 (19 May)

Eighteen dosimeters were placed at each of eight stations. Dosimeters Nos. 15 to 18 inclusive at each station were placed outside the thermal and shock shield. All dosimeters within the shields and 44 per cent of those outside the shields were recovered. The sensitivity and readability of all units were unaffected although the units outside the shields were externally scorched. It is considered that many of the items exposed outside the shields were lost as a result of poor mounting techniques. The dosimeters were read by four persons and the readings for any one instrument agreed. In a particular range covered by the dosimeter, 100 per cent indicated the correct exposure to the accuracy required by the military characteristics. At each station, except Station 4, 83 per cent or more of the dosimeters indicated the same exposure range. The standard exposure value at Station 4 was on the borderline between two step ranges, and readings in both step ranges were obtained. Table 3.3 gives detailed information on the dosimeter readings and compares them with values of the standards.

3.2.3 Testing under Project 29.1

Evaluation testing of the present Tactical Dosimeter, Type E-1, as well as developmental testing of other chemical dosimeters (variations of Type E-1) were conducted under AEC Project 29.1.

A large number of Type E-1 dosimeters were tested during several shots and the results substantiate the findings in this report. The dosimeters responded in the correct step ranges, (except for the 50 r tube), and were consistent and quite rugged. The 50 r tubes were shown to be insensitive in the 40 to 60 r range. Upon recalibration on cobalt-60, a similar batch of 50 r tubes was found to consist mainly of tubes responsive to 80 r.

A number of Type E-1 dosimeters containing 50 r tubes properly aged and color graded (see para. 1.4.1) were tested at Shot 11. Three test stations were in the critical range of the 50 r tubes, having standard dose values of 84 r, 63 r, and 49 r respectively. At all these stations the properly prepared 50 r tubes registered a distinct color change from purple to yellow and in all cases the dose range was read as 50-200 r. This recorded dose range for all three test stations is within the accuracy required by the military characteristics. Thus, it is shown that the chemical system employed in the Type E-1 dosimeter is capable of registering prompt gamma exposures in the 0-50 r and 50-200 r dose ranges.

Further information on similar tests can be found in the report of Project 29.1, WT-802.

3.2.4 Use by Troops Participating in Shot 7

Twelve tactical dosimeters, Type E-1, were distributed to troops at Camp Desert Rock in connection with Exercise Desert Rock V during Shot 7. About half were carried in pants pockets while the other half were carried in shirt pockets. Interrogation of the troops following

[redacted]

the exercise indicated that they found no difficulty with regard to size and weight. Difficulty in opening the case was experienced and it was found impossible to open the case while wearing gloves. Another difficulty experienced was the fact that dust and dirt seeped under the lid of the case, covering the tubes with a dust film and making it almost impossible to read the instrument without first wiping off the viewing portion of the tubes.

3.3 TRACERLAB TACTICAL DOSIMETER

Five dosimeters were placed under thermal and shock shields at each of eight stations during Shot 7. It was found that in most cases the instrument was damaged to some extent by the shock wave. This, however, is attributed to the fact that this particular instrument is a laboratory model and not intended for field use. Difficulty was experienced in reading the instruments since it is difficult to match a colored liquid against colored strips of paper. The readings obtained on these dosimeters were not in good agreement with film standard values as shown in Table 3.4. Results indicated that at Stations 5 through 8 the dosimeters recorded a dose range one step higher than the range in which the film values were located.

3.4 CONSOLIDATED VACUUM DOSIMETER

This dosimeter, like the Tracerlab tactical dosimeter, presented a reading problem in that it was difficult to distinguish the 0, 50, and 150 r colors of the plastic standards from one another. Likewise, a number of breakages were encountered because the instrument was not built for rugged field use. By referring to Table 3.5, it can be seen that from Stations 6 through 8 the dosimeters generally read one range lower than the range in which the film values were located. This is the exact opposite of the condition encountered with the Tracerlab tactical dosimeter. An additional failing of the dosimeter is its inconsistency of response as shown in Stations 4, 6, 7, and 8. (Ref. Table 3.5.) Four instruments at Station 6 recorded different ranges of exposures and only one covered the film standard exposure. There is a possibility that the disagreement may be attributed to the difficult visual comparison of dosimeter to standard. It should be noted that this and the Tracerlab tactical dosimeters were read by five separate individuals and the tables reported herein are the averages of these readings.

[redacted]

TABLE 3.1 - Readings of Tactical Dosimeter, Type E-1, Exposed at Shot 7

DOSIMETER NUMBER	STATIONS AND STANDARD VALUES IN ROENTGENS							
	1 Over 1000 r	2 Over 1000 r	3 Over 1000 r	4 800 r	5 570 r	6 300 r	7 162 r	8 112 r
1	(A)	Over 600 r	Over 600 r	(C)	400-600 r	200-400 r	*80-200r	*80-200 r
2	Over 600 r	"	"	Over 600r	"	"	"	"
3	(A)	"	"	"	"	"	"	"
4	(B) Over 600 r	"	"	"	"	"	"	"
5	(A)	"	"	"	"	"	"	"
6	Over 600 r	"	"	"	200-400 r	"	"	"
7	(A)	"	"	(A)	400-600 r	"	"	"
8	(A)	"	"	Over 600r	"	"	"	"
9	(A)	"	"	"	"	"	"	"
10	(A)	"	"	"	200-400 r	"	200-400r	"
11	Over 600 r	"	"	"	400-600 r	"	*80-200r	"
12	(A)	"	"	"	"	*80-200 r	"	"
13	(A)	"	(C)	"	"	200-400 r	"	"
14	(A)	"	Over 600 r	"	"	"	200-400r	"
15	(A)	(B) Over 600 r	"	"	"	"	*80-200r	"

Note: Those dosimeters which were not read identically by all 8 readers are shown in Table 3.2.
(A) Dosimeter not recovered
(B) 50 r tube broken
(C) 600 r tube broken
* 50 r tubes recalibrated against cobalt-60 and found to be responsive to 80 r.

[redacted]

TABLE 3.2 - Tactical Dosimeters, Type E-1, with Varying Readings After Exposure at Shot 7

STATION NUMBER	STANDARD VALUES IN ROENTGENS	DOSIMETER NUMBER	READINGS
4	800 r	15	7 read Over 600 r
			1 " 400-600 r
5	570 r	1	7 " 400-600 r
			1 " 200-400 r
5	"	4	7 " 400-600 r
			1 " 200-400 r
5	"	6	6 " 200-400 r
			2 " 400-600 r
5	"	11	7 " 400-600 r
			1 " 200-400 r
5	"	13	6 " 400-600 r
			2 " 200-400 r
6	300 r	1	7 " 200-400 r
			1 " *80-200 r
6	"	12	7 " *80-200 r
			1 " 200-400 r
7	162 r	4	6 " *80-200 r
			2 " 200-400 r
7	"	6	7 " *80-200 r
			1 " 200-400 r
7	"	10	6 " 200-400 r
			2 " *80-200 r
8	112 r	2	7 " *80-200 r
			1 " *0- 80 r
8	"	11	6 " *80-200 r
			2 " *0- 80 r

* 50 r tubes recalibrated against cobalt-60 and found to be responsive to 80 r.

[redacted]

TABLE 3.3 - Readings of Tactical Dosimeter, Type E-1, Exposed at Shot 8

DOSIMETER NUMBER	STATIONS AND STANDARD VALUES IN ROENTGENS 1 1500 r	2 1200 r	3 850 r	4 588 r	5 432 r	6 210 r	7 76 r	8 42 r
1	Over 600 r	Over 600 r	Over 600 r	400-600 r	200-400 r	200-400 r	*Under 80 r	*Under 80 r
2	"	"	"	Over 600 r	"	"	"	"
3	"	"	"	"	"	"	"	"
4	"	"	"	400-600 r	"	"	"	"
5	"	"	"	Over 600 r	"	"	"	"
6	"	"	"	"	"	"	"	"
7	"	"	"	400-600 r	"	"	"	"
8	"	"	"	"	"	"	"	"
9	"	"	"	Over 600 r	"	*80-200 r	"	"
10	"	"	"	400-600 r	"	200-400 r	"	"
11	"	"	"	"	"	"	"	"
12	"	"	"	"	"	"	"	"
13	"	"	"	Over 600 r	400-600 r	*80-200 r	"	"
14	"	"	"	400-600 r	200-400 r	200-400 r	"	"
15	"	(A)	(A)	(A)	"	"	"	(A)
16	(A)	(A)	(A)	400-600 r	"	*80-200 r	(A)	*Under 80 r
17	(A)	Over 600 r	Over 600 r	(A)	(A)	200-400 r	*Under 80 r	(A)
18	(A)	(A)	(A)	400-600 r	200-400 r	(A)	(A)	(A)

Note: Reading, made by all 4 persons, for any one instrument were in complete agreement
Dosimeters 15 - 18 were exposed outside of the aluminum stations
(A) Dosimeter not recovered
* 50 r tubes recalibrated against cobalt-60 and found to be responsive to 80 r.

[redacted]

TABLE 3.4 - Readings of Tracerlab Tactical Dosimeter Exposed at Shot 7

DOSIMETER NUMBER	STATIONS AND STANDARD VALUES IN ROENTGENS							
	1 Over 1000 r	2 Over 1000 r	3 Over 1000 r	4 800 r	5 570 r	6 300 r	7 162 r	8 112 r
1	Over 600 r	Over 600 r	Over 600 r	*	Over 600 r	400-500 r	300-400 r	200-300 r
2	"	"	"	Over 600 r	"	"	"	"
3	**Over 600 r	"	"	"	"	"	"	"
4	Over 600 r	"	"	"	"	"	"	"
5	""	"	"	"	"	"	"	"

* Dosimeter not recovered.
** Lower range tube broken.

TABLE 3.5 - Readings of Consolidated Vacuum Dosimeter Exposed at Shot 7

DOSIMETER NUMBER	STATIONS AND STANDARD VALUES IN ROENTGENS							
	1 Over 1000 r	2 Over 1000 r	3 Over 1000 r	4 800 r	5 570 r	6 300 r	7 162 r	8 112 r
1	Over 600 r	Over 600 r	Over 600 r	Over 600 r	375-600 r	50-150 r	**	0-50 r
2	"	"	"	"	"	250-375 r	**	"
3	*	"	"	"	"	50-150 r	50-150 r	"
4	**	*	"	50-150 r	"	Over 600 r	0-50 r	"
5	*	Over 600 r	"	375-600 r	"	50-150 r	150-250 r	50-150 r

* Dosimeter not recovered.
** Tube broken.

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CHAPTER 4

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

4.1 DISCUSSION AND CONCLUSIONS

The chemical dosimeter, as a step-type dosimeter, is designed primarily as a go, no-go device. The military characteristics (1) state that this type of dosimeter should be accurate within 20 per cent of the step values. By these standards a dosimeter may indicate a change at 80 per cent of its rated value and must indicate a change at 120 per cent of its rated value. Laboratory experimentation (2)(3) has already shown the Type E-1 dosimeter to satisfy these requirements. It is well to point out at this time that the field test data presented in this report are not intended as the sole source of information for the conclusions made herein. The data that were gathered in no way contradict the results of laboratory tests made under controlled conditions. Limitation such as the lack of accurate dose-distance data before testing, prevented the exposure of dosimeters to exactly 80 per cent and 120 per cent of each dose step value. Therefore a dosimeter was considered satisfactory if the reading on a dosimeter tube indicated a change when exposed in a location where the standard exposure value was 80 per cent of the minimum of a step range or 120 per cent of the maximum of a step range. It is not intended that it indicate any exposure closer than that lying between two step ranges. One of the basic problems encountered in the previous development of the two-phase chloroform-water dosimeter system has been its inherent property of rate dependence. In the evaluation of the new tactical dosimeter, Type E-1, this problem has been satisfactorily minimized, as shown by laboratory testing (2)(3) and the results obtained in this project. By the addition of resorcinol to the chloroform-water system, this dosimeter now indicates exposures within the appropriate step ranges.

The present step ranges of 50, 200, 400, and 600 r do not meet the present military characteristics (1) for a dosimeter of this type.

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(1) Army Field Forces Board No. 1, Project CE-3752

(2) Chaney, J.E., Santilli, A., Heck, J., CRLR 360, Development of the E1R1 Tactical Radiation Dosimeter, 20 December 1953

(3) Rochkind, J.M., Lieberman, D.S., Gatoff, H.L., CRLR 260, Final Engineering Test No. 57, Dosimeter, Tactical, E1R1, 28 Sept 1953

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However, it is believed that when the present system is modified to step ranges of 50, 125, 175, 300, and 450 r, this dosimeter will more closely satisfy military characteristics.

As a result of laboratory findings and this evaluation it is concluded that:

1. By the addition of resorcinol to the two-phase chloroform-water system, the tactical dosimeter, Type E-1, is now rate independent over the range required.

2. The tactical dosimeter, Type E-1, satisfactorily records the total gamma radiation exposure within the accuracy limitations of step-type dosimeters.

3. The tactical dosimeter, Type E-1, requires modification of the packaging to provide additional dust-proofing and provide a more satisfactory closure.

4. The tactical dosimeter, Type E-1, is satisfactory under rough field usage.

5. The Tracerlab tactical dosimeter and the Consolidated Vacuum dosimeter show improvement over former single-phase chlorinated hydrocarbon systems, but are not rugged enough for field use in their present design, are difficult to read against their color standards, and may require modification of their basic composition to function more satisfactorily.

4.2 RECOMMENDATIONS

It is recommended that:

1. The tactical dosimeter, Type E-1, be modified to include step ranges of 50, 125, 175, 300, and 450 r and redesigned to provide a more satisfactory case closure.

2. After revision, the tactical dosimeter, Type E-1, be submitted to the Services for service testing for possible adoption as an end-item.

3. No recommendations are made on the Tracerlab and Consolidated dosimeters since they were subjected to informative tests only for the interested Service laboratory.

APPENDIX A

PHOTOGRAPHS

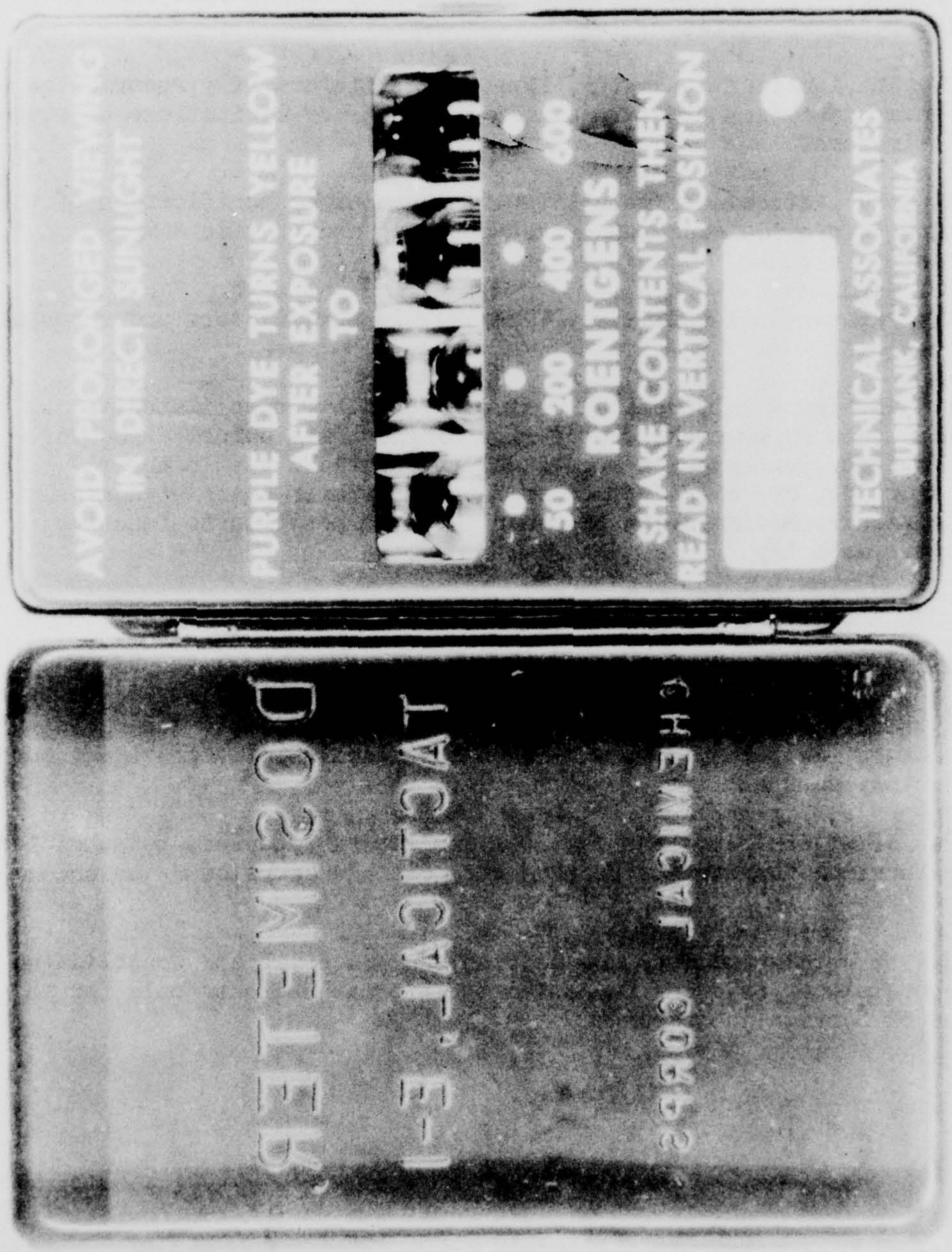

Fig. A.1 Tactical Dosimeter, Type E-1

Fig. A.2 Tactical Dosimeter, Type E-1, Disassembled

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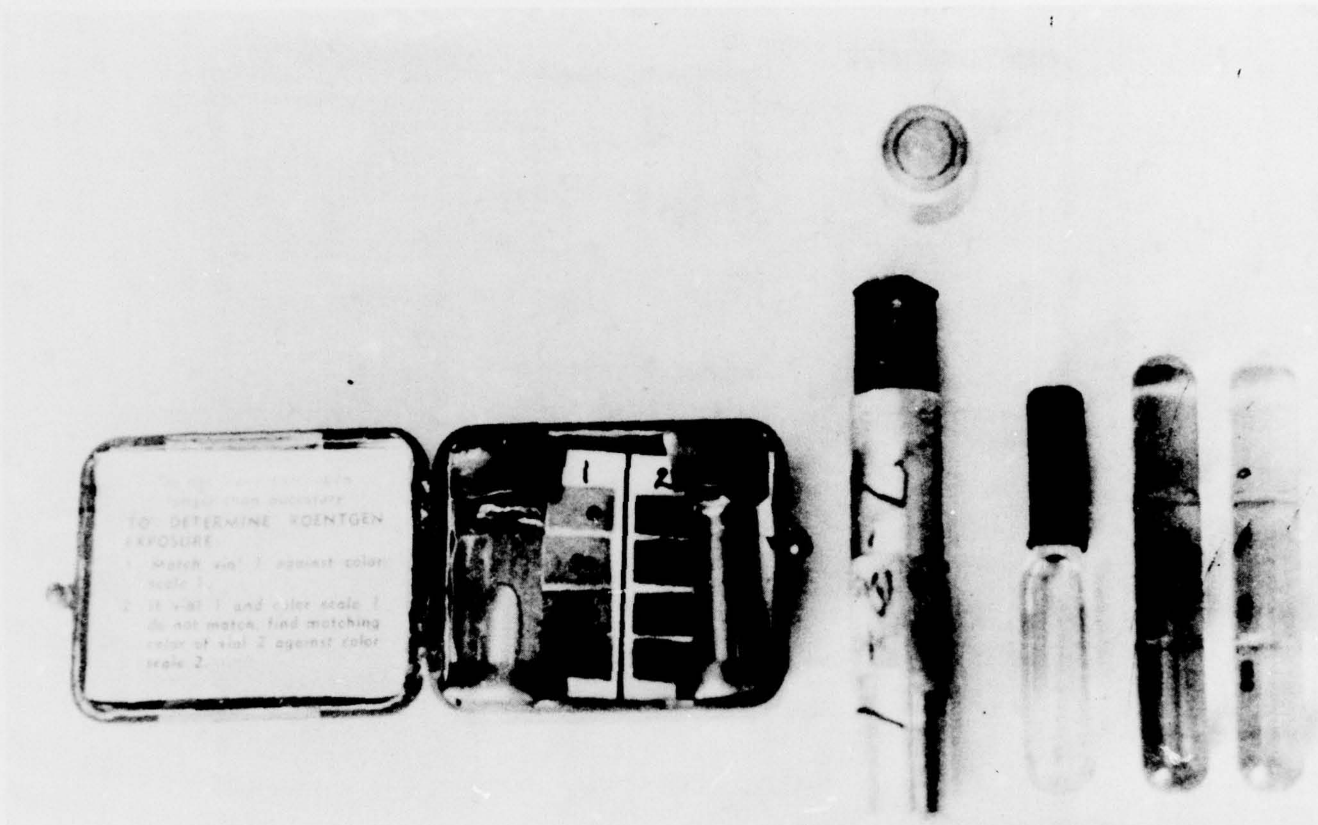

Fig. A.3 Tracerlab Tactical Dosimeter (left)
Consolidated Vacuum Dosimeter and Color Standards (right)

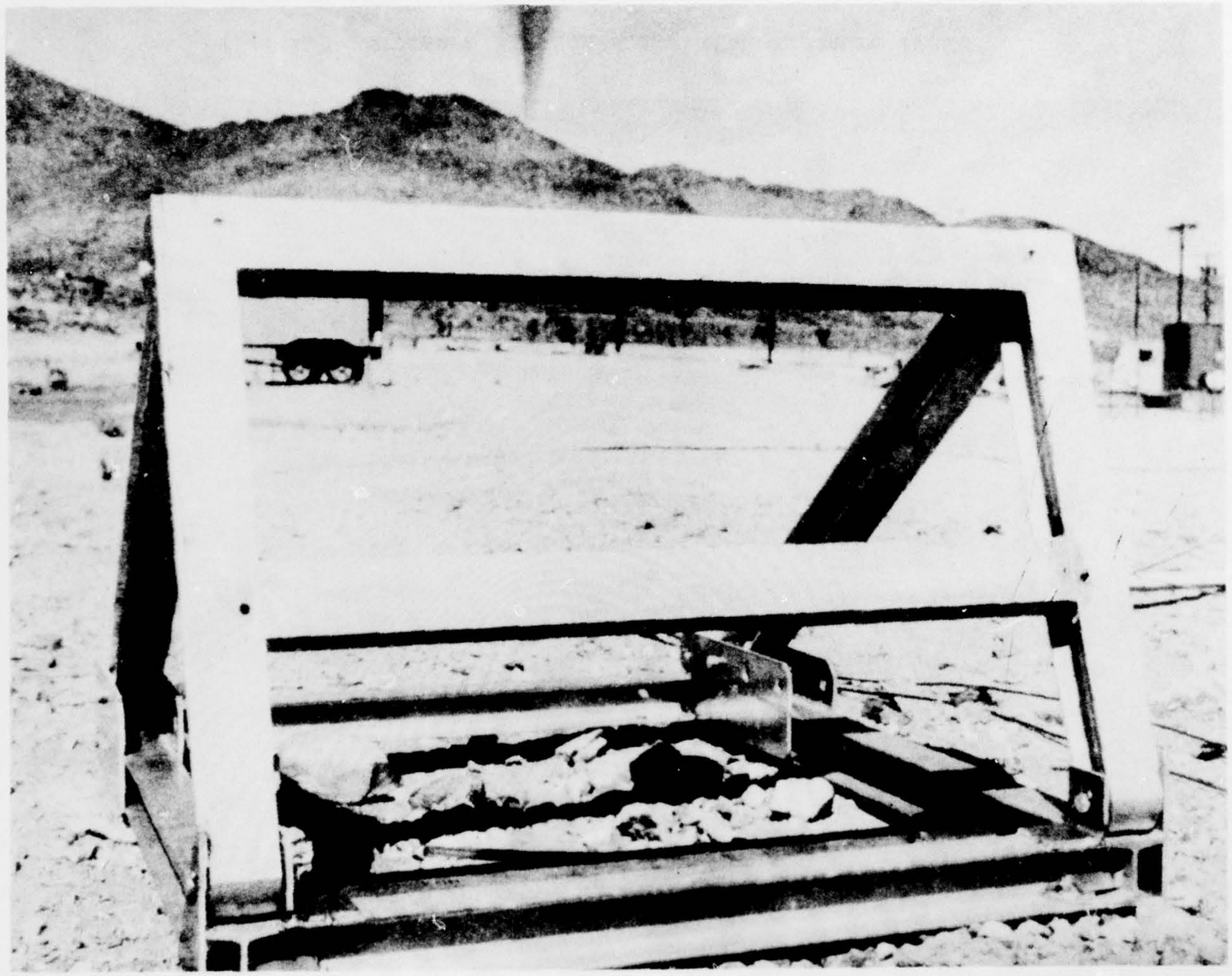

Fig. A.4 Exposure Station Frame

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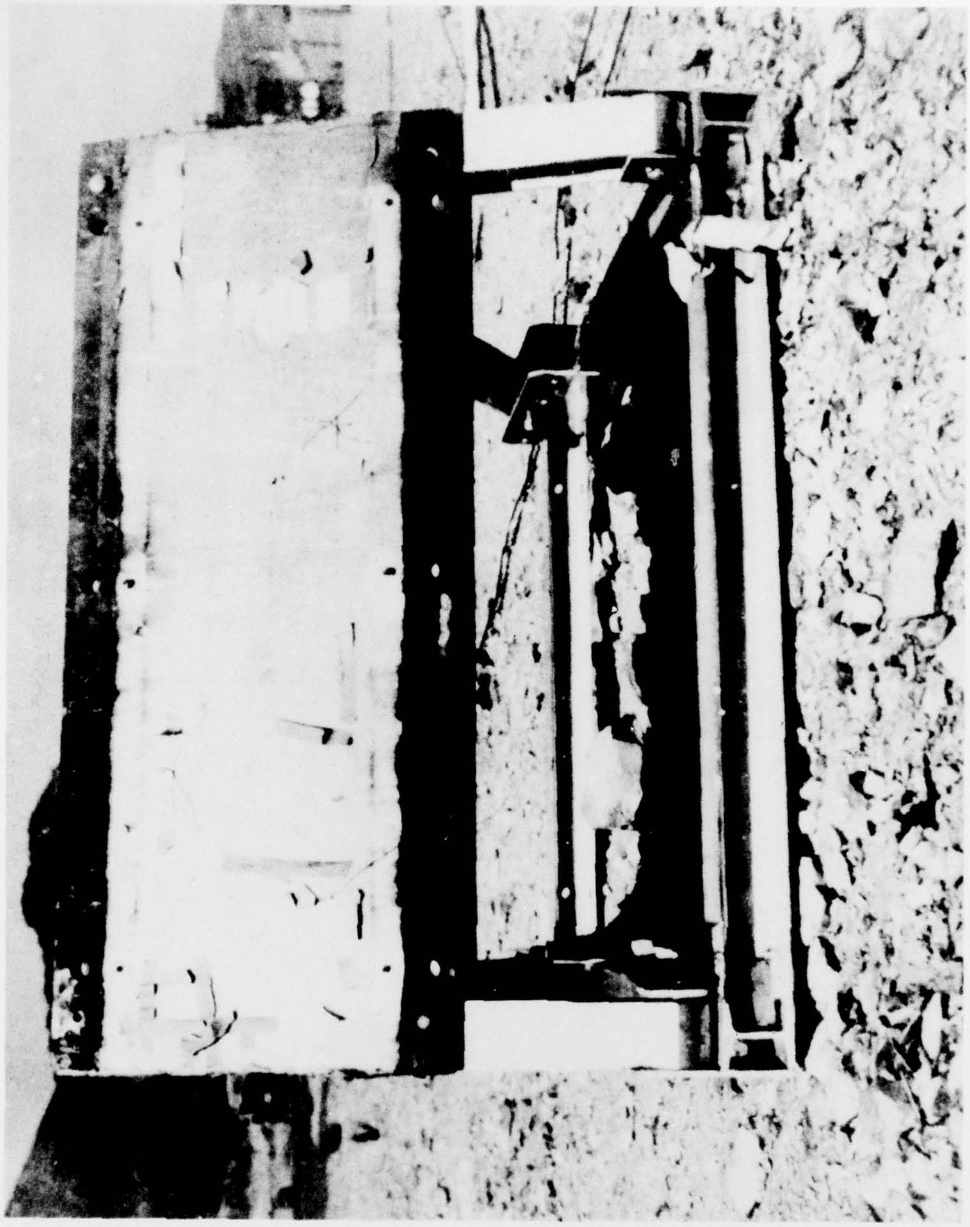

Fig. A.5 Exposure Station Frame With Exposure Plate

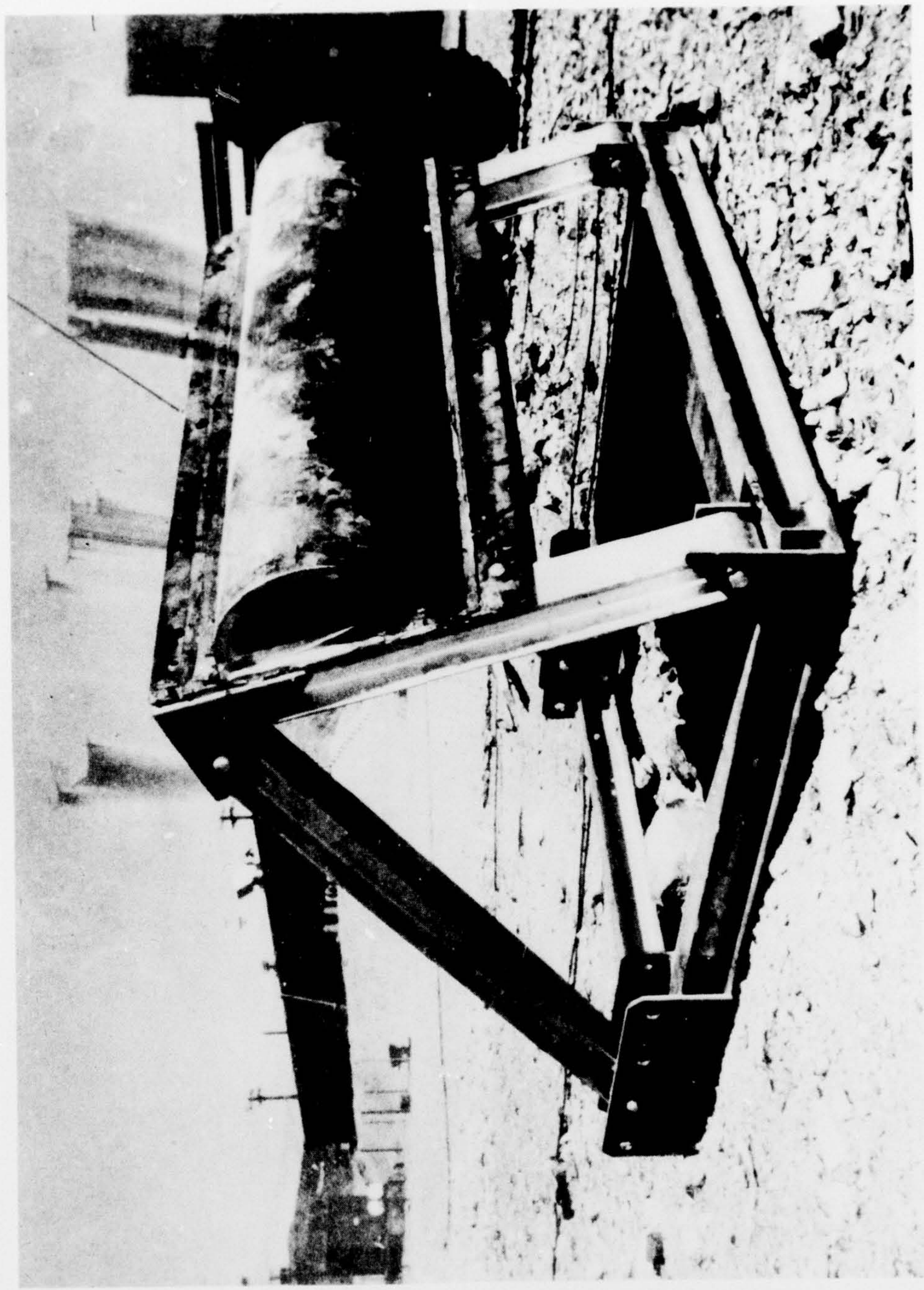

Fig. A.6 Exposure Station Frame With Exposure Plate Covered by Shock and Thermal Shield

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