

G & G
-2013

1711



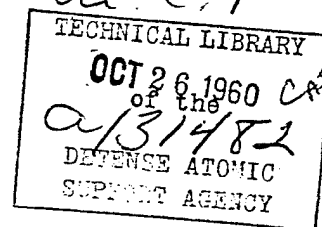
EDGERTON, GERMESHAUSEN & GRIER, INC.

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Distribution Unlimited

FIREBALL CALCULATIONS
SHOT HAMILTON
OPERATION HARDTACK PHASE II
PROJECT 15.1

19960702 073



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Robert B. Rogers DATE *4/25/96*

BOSTON, MASSACHUSETTS • LAS VEGAS, NEVADA
SANTA BARBARA, CALIFORNIA

REPORT NO. B-2013
29 JANUARY 1960

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ISST

Defense Nuclear Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398



29 May 1996

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTENTION: OCD/Mr. Bill Bush

SUBJECT: Documents for DTIC System

There is no record of your office receiving the following reports:

EGG-B-2024 (29 January 1960)
Fireball Calculations Shot Sanford
Operation Hardtack Phase II
Project 15.1

EGG-B-2013 (29 January 1960)
Fireball Calculations Shot Hamilton
Operation Hardtack Phase II
Project 15.1

Both documents are now approved for public release.

Therefore, we are transmitting copies for inclusions into the DTIC system, if not already there.

Enclosure:
A/S

Arndith Jarrett
ARDITH JARRETT
Chief, Technical Support

DTIC QUALITY INSPECTED 4

FIREBALL CALCULATIONS
SHOT HAMILTON
OPERATION HARDTACK, PHASE II
PROJECT 15.1

Report No. B-2013
29 January 1960

Prepared by R. C. Schneiderhan
R. C. Schneiderhan

Approved by D. F. Seacord, Jr.
D. F. Seacord, Jr.

EDGERTON, GERMESHAUSEN & GRIER, INC.
Boston, Mass. Santa Barbara, Calif. Las Vegas, Nev.

FIREBALL CALCULATIONS: SHOT HAMILTON

1.0 INTRODUCTION

Shot Hamilton, a 50-foot tower shot sponsored by LRL, was detonated at 0800 PST, on 15 October 1958 in Area TF-1 of the Nevada Test Site. The fireball yield was $0.43 \text{ ton} \pm 0.09 \text{ ton}$.

2.0 CAMERA INSTRUMENTATION AND OPERATION (Table 1)

Photographic coverage of Hamilton fireball growth was provided by two high-speed Eastman cameras and one high-speed 16 mm Fastax camera at Station 527.01 (6 x 6 No. 2) and a similar camera complement at Station 527.02 (6 x 6 No. 3). In addition, two Rapatronic cameras were located at Station 527.01 to record early fireball growth. The EG&G framing camera, running at an approximate speed of 15,000 frames per second, was located at Station F-732 (6 x 6 No. 1) to record additional early fireball behavior. One Eastman camera from Station 527.02 did not record the complete fireball. All other cameras obtained records suitable for analysis.

The station locations and the burst location are shown in Fig. 1. Figure 2 contains a summary of the survey data.

3.0 RESULTS

Because the yield of Hamilton was well below the range of constant ϕ^5 scaling¹, the ϕ comparison technique as defined in EG&G Report No. B-1869, "Fireball Calculations - Shot Eddy", was employed to determine the yield. A yield of $0.43 \text{ ton} \pm 0.09 \text{ ton}$ is indicated.

¹ ϕ^5 scaling is usually applicable only for yields greater than 2 kt.

An air density of 1.098 grams per liter was used in the yield calculations. The air density value was based upon a pressure of 910 millibars, a temperature of 15.0°C, and a relative humidity of 30 percent at shot time.

The table below gives the comparison shots, and the Hamilton yield obtained by the $\emptyset$ - comparison.

Comparison Shot	Hamilton Yield (tons)
<u>Balloon</u>	
La Place	0.495
Wheeler	0.374
Santa Fe	0.499
Lea	0.452
Hidalgo	0.450
<u>Air Drop</u>	
Buster B	0.404
Wasp'	0.408
Ranger A	0.398
Wasp	0.419
Ranger E	0.423

Comparison Shot	Hamilton Yield (tons)
<u>Tower</u>	
Hornet	0,422
UK-3	0.419
Rio Arriba	0.456
Quay	<u>0.431</u>
	$\overline{W} = 0.432$

Diameter vs time and ϕ vs time plots are shown in Figs. 3, 4, and 5.

The following data sheets are included for each film:

- (a) Photo Plan and Photo Loading Chart
- (b) Camera Data and Calculation Sheet
- (c) Diameter Measurement Sheet
- (d) E102 print-out sheet of D, t, and ϕ .

Selected frames of fireball films are contained in the Appendix.

The zero-frame times of the motion picture camera records were determined by comparing these records with the Rapatronic diameter vs time data.

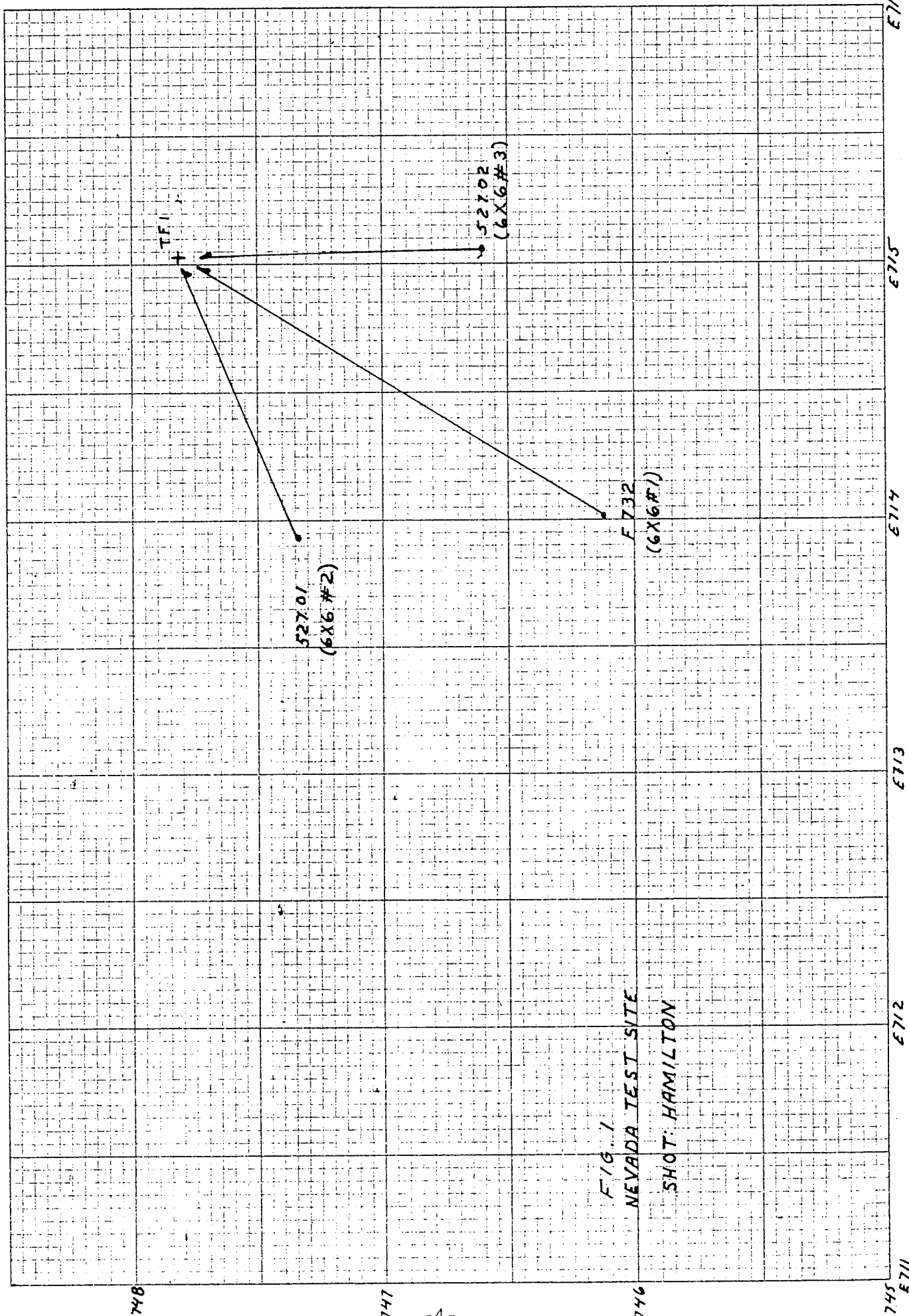


FIG. 2

SURVEY DATA

GZ STA. TF1

[illegible]

FORM E17(1-55 500)

NAME Anderson

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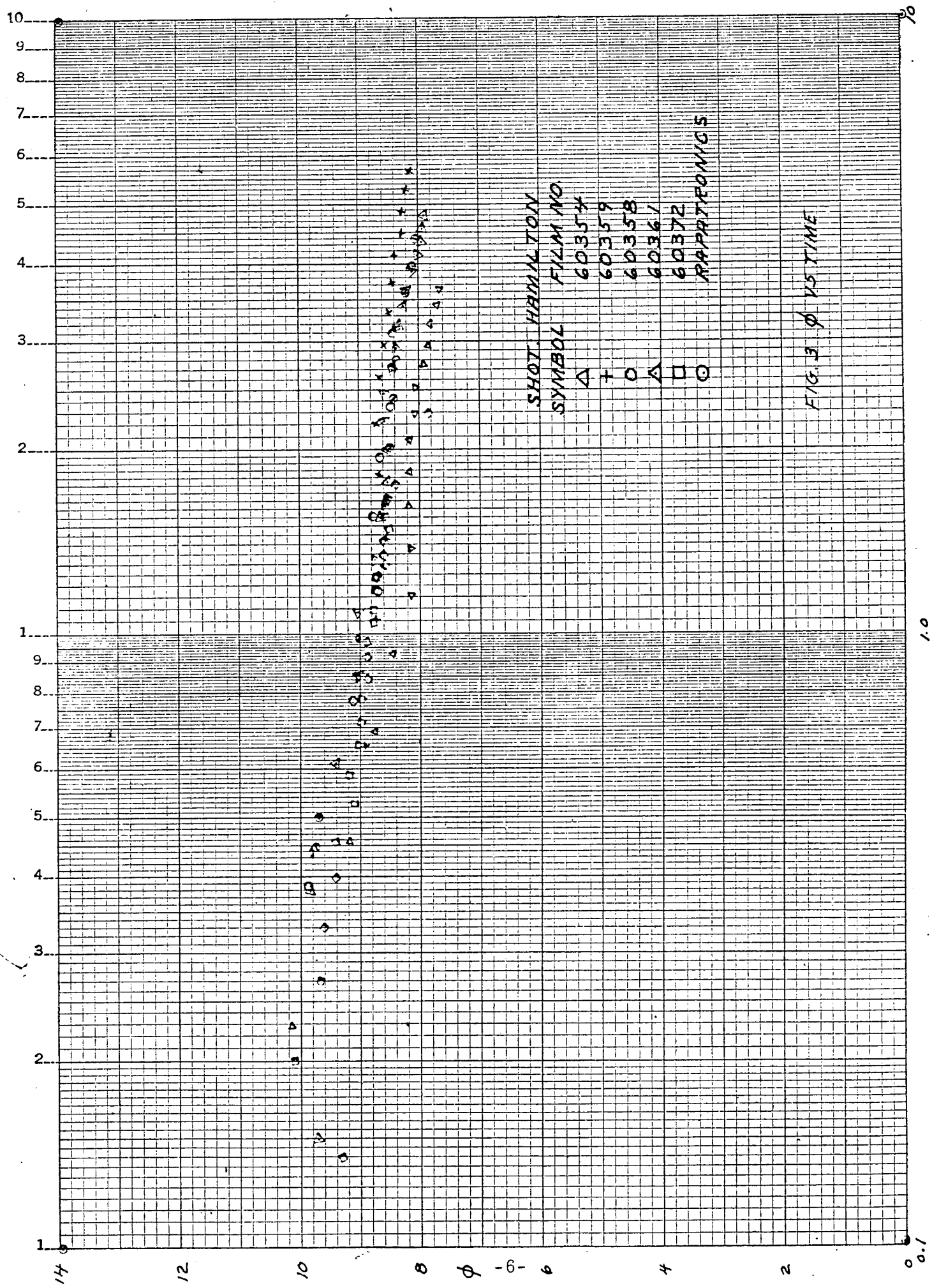
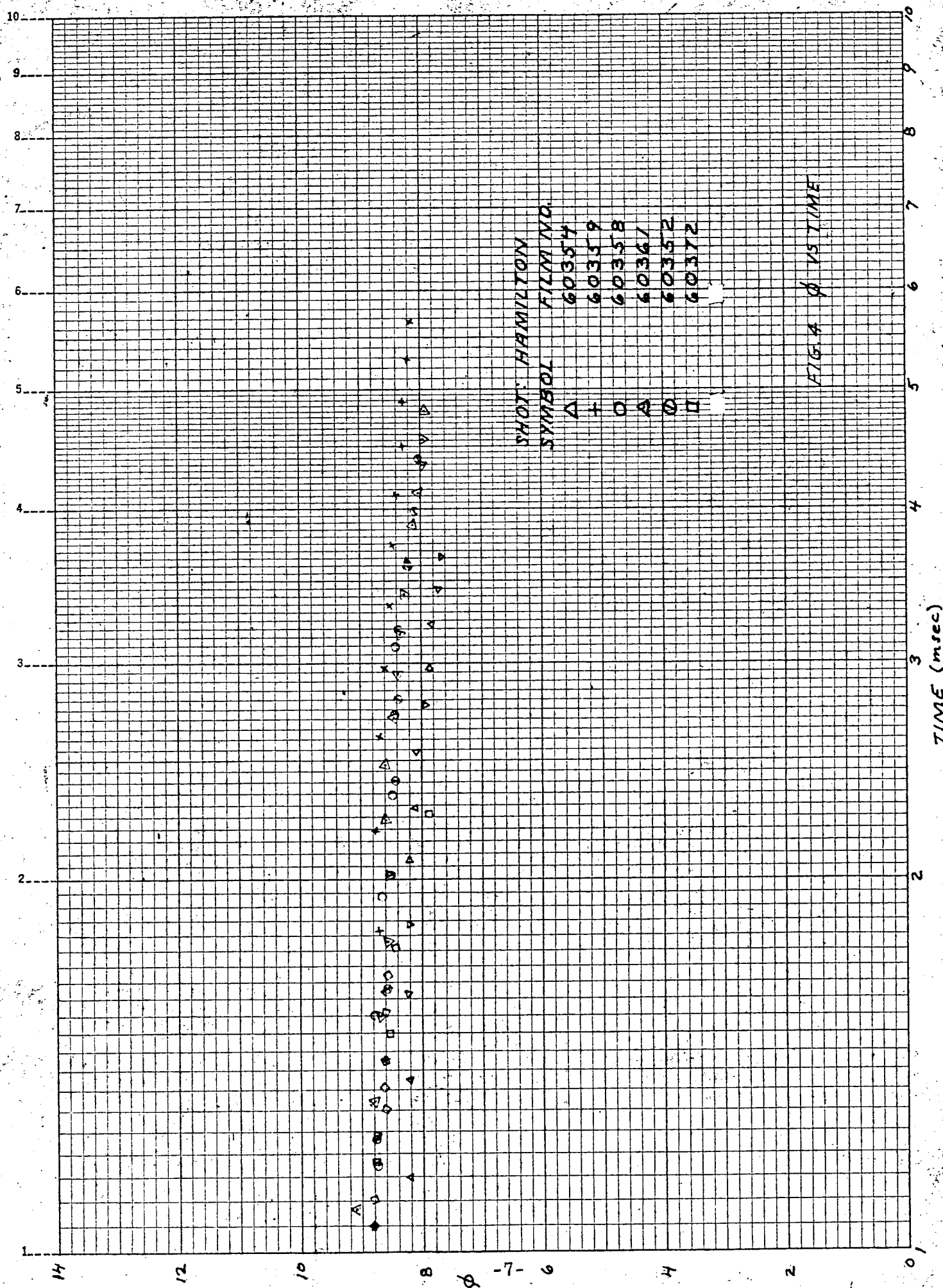


FIG. 3 ϕ VS TIME



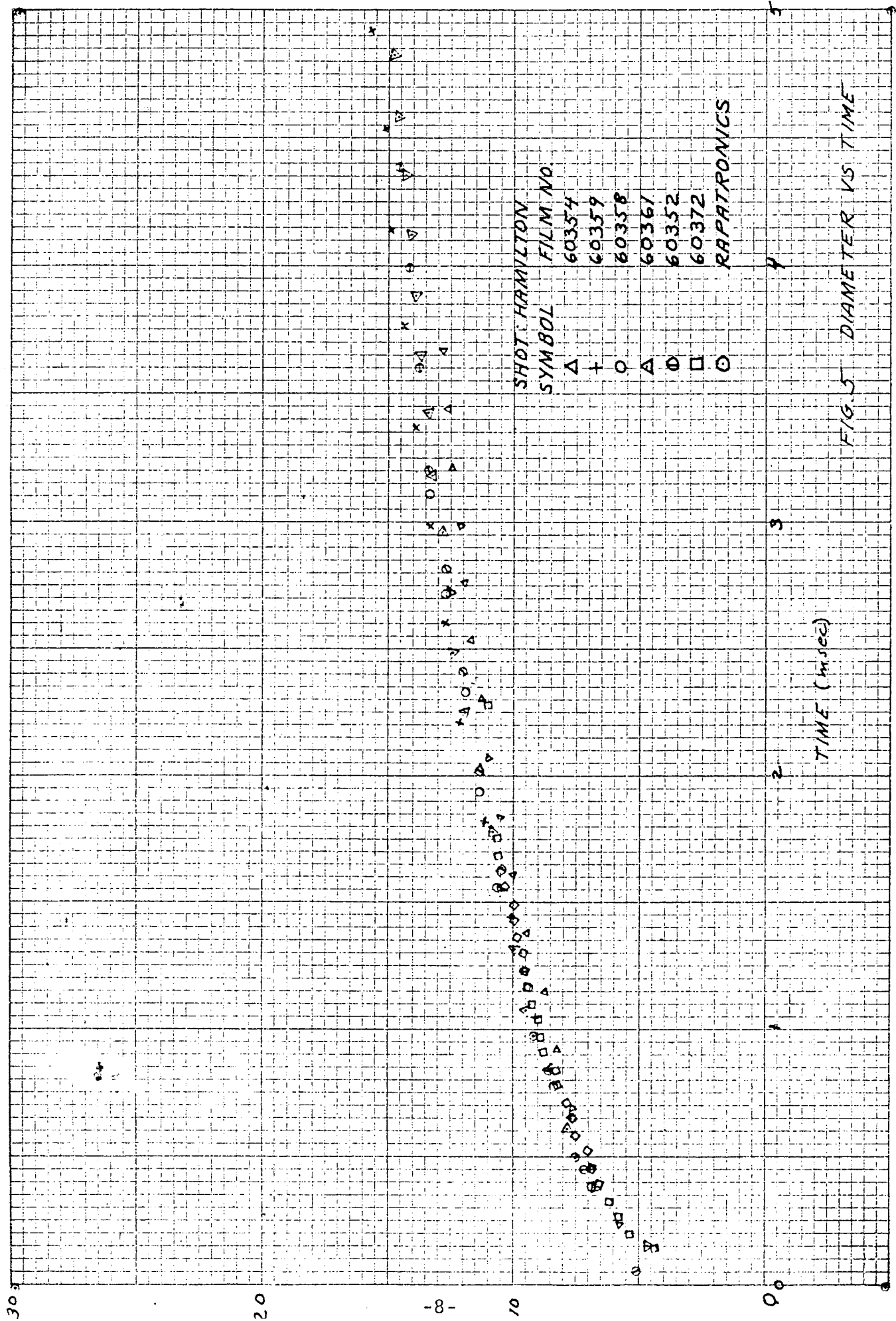


Table I
Hardtack Phase II, Hamilton
Fireball Camera Distribution

Station	Camera	Qualitative Functioning
527.01 (6 x 6 No. 2)	E-34	Record
	E-7	Poor Image
	F-16 No. 2	Record
	R-4	Record
	R-3	Record
527.02 (6 x 6 No. 3)	E-25	Part of F. B. Obscured
	E-6	Record
	F-16 No. 1	Record
F-732 (6 x 6 No. 1)	FR No. 1	Record

Table II
Hardtack Phase II, Hamilton
Average Diameter vs Time

Time (in msec.)	Diameter(meters) as seen from Stations 527.01, 527.02 and F-732
0.5	7.3
1.0	9.0
1.5	10.3
2.0	11.2
2.5	12.2
3.0	12.8
3.5	13.4
4.0	14.2
4.5	14.7

Table III

Hardtack Phase II, Hamilton

Rapatronic Summary

Station	Film No.	Camera	Horizional Range (m)	F. L. (mm)	Diameter(m)	Time(msec)
527.01 (6 x 6 No. 2)	60366	R-4	1196.6	477.39	7.37	0.4995
	60365	R-3	1196.6	477.82	8.99	0.9840

PHOTO LOADING CHART

STATION 527.01 EVENT HAMILTON DATE 10-15-58

6x6 #2

6x6 #2

FILM

CAMERA

LENS

EXPOSURE

REMARKS

TYPE	EMULS. NO.	SIZE	HOLDER	PERF. NO.	NO.	RACK POS.	NOM. SPD.	FOC. MM.	FILTER	APER	SHUTTER RHEO.	W/M ²	REMARKS
MF	1112-9-02	16-100	HS Reel	60358	E-34	C-1	2500	102	ND2+ W-12	f7.5	40/80	3x10 ⁶	
FX	5240 604-02	16-100	HS Reel	60359	E-7	C-2	2500	63	ND-1+ W-12	f5	40/80	1.5x10 ⁵	
FX	5240 624-3	35-200	MIT MAG	60360	M-26	B-2	100	16.5	W-12	f7.5	170°	Weston 700	
MF	1112-9-02	16-400	Daylight SPOOL	60361	#2 F16/4	B-1	4000	75	ND-1 W-12	f5.6	=	1x10 ⁵	
FX	5240-626-2	70-50	Bentley MAG	60414	QL-70	B-3	1/2	105	W-12	f9.0	1/100	Weston 700	
D	263368N	16-50	L-MAG	60363	#22 QSP	B-4	64	9.5	=	f4.5	133°	Weston 700	
KDC	263368N	16-50	A-MAG	60364	#5 GSP	B-4	64	9.5	=	f5.0	133°	Weston 800	
RP	6141-66207	2 1/4 x 3 1/4	RAP Holder	60365	R-4	A-1	40ms Coil	480	=	f11	B	3x10 ⁵	500ms delay
RP	6141-66207	↓	↓	60366	R-3	A-2	40ms Coil	↓	=	f11	B	3x10 ⁵	1000ms delay
					Actual				Delays				
					R-4	479 S.A.			+ 20ms half coil delay				
					R-3	964 ms			+ 20ms half coil delay				

DATE FILM LOADED Rev #1 10-9-58 DATE CAMERA LOADED Rev #2 10-14-58 DATE EXPOSED 10-15-58

REMARKS

FINAL

EDGERTON, GERMESHAUSEN & GRIER, INC.

FORM E-40

STATION NO. 52702
STATION TYPE 6x6 #3
DISTANCE GZ 1220.5'
DISTANCE OBJECT 1221.4'

PHOTO PLAN

BRG 358°21' EVENT HAMILTON
TILT GZ STA. TF 1
GZ -0°10' DATE 10-15-56
OBJ 2°10' POSTED 10-15-56

STATION	TYPE	DISTANCE
N 746600	GZ	1220.5'
E 715' 064'	OBJECT	1221.4'
Z 3 of 3		

GZ
747 820
715 029
3 129

DIFF.
1220
- 35
46

[illegible]

REMARKS	Rev #	Rev #	Rev #
	10-9-58	2	10-14-58

Includes 50' height of Tower

FINAL

PHOTO LOADING CHART

STATION F 732 6x6 #1 EVENT HAMILTON DATE 10-15-58

DATE 10-15-58

[illegible]

	DATE FILM LOADED	DATE CAMERA LOADED	DATE EXPOSED	
			10-15-58	
REMARKS				
	FINA-			

FINAL

FORM E-40

EDGERTON, GERMESHAUSEN & GRIER, INC.

PHOTO PLAN		BRG 30° 15'		EVENT <u>HAMILTON</u>	
GZ	DIFF.	TILT	GZ	STA.	TF
747 820	1701	-0° 3'	10-15-58		
715 029	1017	1023'	POSTED		
3 1297	48				10-15-58

PHOTO PLAN

[illegible]

REMARKS

* Includes 50' height of tower.

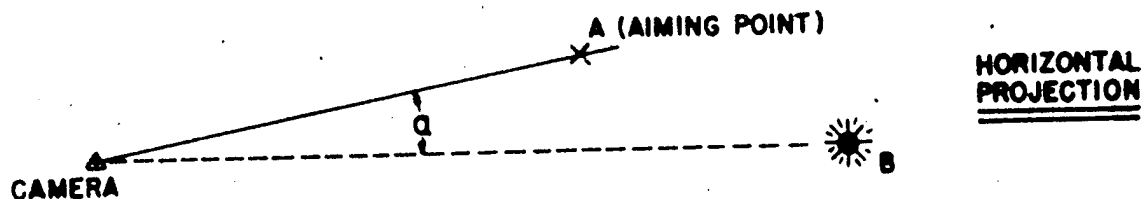
FINA:

AD 1900

EDGERTON, GEMMELHAUSEN & OTHER, INC.

CAMERA DATA & CALCULATIONS

FILM NO. 60366	STATION NO. 527.01 6x6 #2	TEST HAMILTON	CALCULATED BY: 660
CAMERA NO. R3	EQ. AP.		DATE: 10/15/58



A. $R\%_A = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$

$\alpha = 0^\circ 00'$	$\beta = 2^\circ 12'$	$H_B = 3129 \text{ ft}$
$\cos \alpha = 1.0000$	$\cos \beta = 0.99926$	$H_C = 3079 \text{ ft}$
$CB_h = 364.7 \text{ m}$	$\sin \beta = 0.03839$	$\Delta H = 50 \text{ ft} = 15.2 \text{ m}$
$CB_h \cos \alpha \cos \beta = 364.4 \text{ m}$	$\Delta H \sin \beta = 0.6 \text{ m}$	$R\%_A = \boxed{365.0 \text{ m}}$

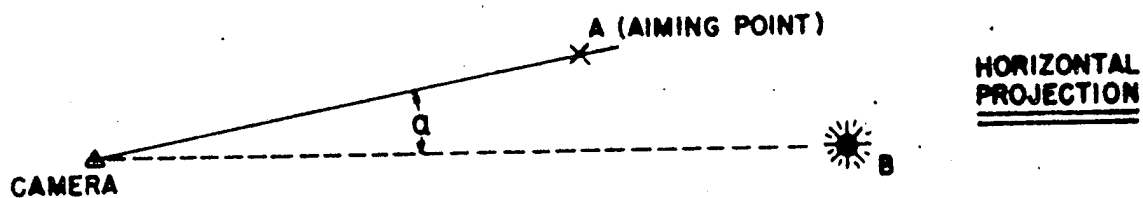
B. FOCAL LENGTH 477.39 mm (774699)

C. MAGNIFICATION FACTOR (meters/in.) 19.43

D. ZERO TIME CORRECTION 0.9840 ms delay

CAMERA DATA & CALCULATIONS

FILM NO. 60365	STATION NO. ^{527.01} 6x6 #2	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. R4	EQ. AP.		DATE: 10/15/58



A. $R^{\circ}/A = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$

$\alpha = 0^{\circ} 00'$	$\beta = 2^{\circ} 12'$	$H_B = 3129 \text{ ft}$
$\cos \alpha = 1.0000$	$\cos \beta = 0.99926$	$H_C = 3079 \text{ ft}$
$CB_h = 364.7 \text{ m}$	$\sin \beta = 0.03839$	$\Delta H = 50 \text{ ft} = 15.2 \text{ m}$
$CB_h \cos \alpha \cos \beta = 364.4 \text{ m}$	$\Delta H \sin \beta = 0.6 \text{ m}$	$R^{\circ}/A = \boxed{365.0 \text{ m}}$

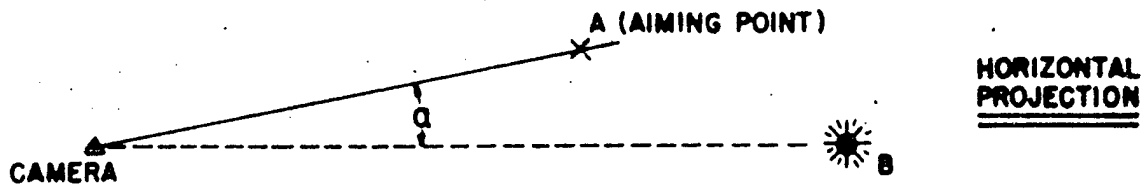
B. FOCAL LENGTH 477.82 mm (773952)

C. MAGNIFICATION FACTOR (meters/in.) 19.41

D. ZERO TIME CORRECTION 0.4995 ms delay

CAMERA DATA & CALCULATIONS

FILM NO. 60359	STATION NO. 527.01 6x6 #2	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. E7	EQ. AP.		DATE: 10/15/58



A. $R^0_A = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$		
$\alpha = 0^\circ 00'$	$\beta = 2^\circ 45'$	$H_B = 3129 \text{ ft}$
$\cos \alpha = 1.0000$	$\cos \beta = 0.99885$	$H_C = 3079 \text{ ft}$
$CB_h = 364.7 \text{ m}$	$\sin \beta = 0.04798$	$\Delta H = 50 \text{ ft} = 15.2 \text{ m}$
$CB_h \cos \alpha \cos \beta = 364.3 \text{ m}$	$\Delta H \sin \beta = 0.7 \text{ m}$	$R^0_A = \boxed{365.0 \text{ m}}$
B. FOCAL LENGTH 64.1 mm (ET-1207)		

C. MAGNIFICATION FACTOR (meters/in.) 144.6
--

D. ZERO TIME CORRECTION 0.28 ms

DIAMETER MEASUREMENTS

SHOT HAMILTON

FILM NO. 60359

[illegible]

READ BY PLW GGO TYPED BY

DATE 10/23/58 DATE _____

REMARKS :

**EDGERTON, GERMESHAUSEN
& GRIER, INC.**

FIREBALL CALCULATIONS

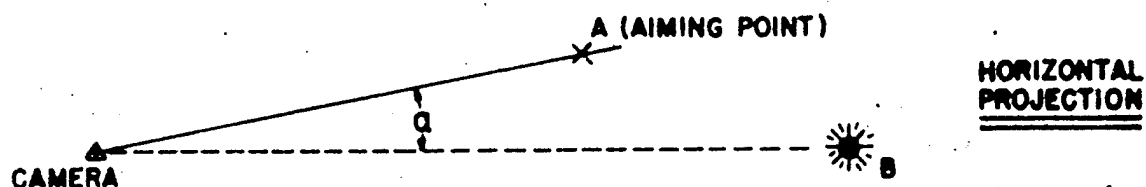
SHOT Hamilton FILM NO. 60359

DATE 1-22-59

D	t	ln D	Int	$t^{2/5}$	ϕ
7.58	.66	2.025 51	415 59 -	.8 468 45	89 50
8.95	1.05	2.191 72	48 76	10.196 97	87 77
9.95	1.44	2.297 50	364 69	11.570 56	85 99
11.10	1.82	2.406 87	598 87	12.706 78	87 35
12.08	2.21	2.491 49	792 93	13.732 43	87 96
12.73	2.60	2.543 94	955 43	14.654 68	86 86
13.33	2.98	2.590 03	1 091 89	15.476 80	86 12
13.88	3.37	2.630 48	1 214 94	16.257 63	85 37
14.40	3.76	2.667 28	1 324 48	16.985 85	84 77
14.88	4.14	2.700 09	1 420 77	17.652 78	84 29
15.23	4.53	2.723 34	1 510 77	18.299 89	83 22
15.73	4.91	2.755 65	1 591 29	18.898 85	83 23
16.05	5.30	2.775 79	1 667 68	19.485 25	82 36
16.40	5.69	2.797 36	1 738 65	20.046 33	81 81

CAMERA DATA & CALCULATIONS

FILM NO. 60358	STATION NO. 527.01 6x6 #2	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. E34	EQ. AP.		DATE: 10/15/58



A. $R\%_A = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$

$\alpha = 0^\circ 00'$	$\beta = 2^\circ 04'$	$H_B = 3129 \text{ ft}$
$\cos \alpha = 1.0000$	$\cos \beta = 0.99935$	$H_C = 3079 \text{ ft}$
$CB_h = 364.7 \text{ m}$	$\sin \beta = 0.03606$	$\Delta H = 50 \text{ ft} = 15.2 \text{ m}$
$CB_h \cos \alpha \cos \beta = 364.5 \text{ m}$	$\Delta H \sin \beta = 0.55 \text{ m}$	$R\%_A = \boxed{365.1 \text{ m}}$

B. FOCAL LENGTH 101.6 mm (RC 128)

C. MAGNIFICATION FACTOR (meters/in.) 91.27

D. ZERO TIME CORRECTION 0.004 ms

E-34

FILM NO. 60358

READ BY 273 350 TYPED BY _____
DATE 10/15/58 DATE 10/15/58
REMARKS:

**EDGERTON, GERMESHAUSEN
& GRIER, INC.**

FIREBALL CALCULATIONS

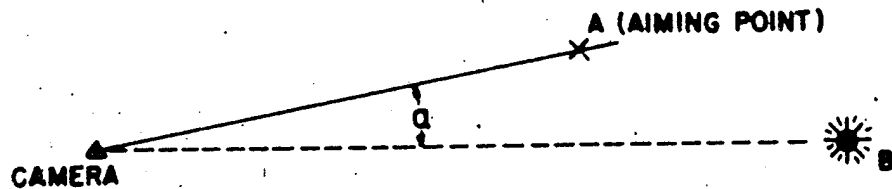
SHOT Hamilton FILM NO. 60358

DATE 1-22-59

D	t	ln D	Int	$t^{2/3}$	ϕ
6.80	.39	1.91685	.94153 -	.686180	99.09
8.32	.78	2.11872	248.44 -	9.05399	91.89
9.32	1.17	2.23221	156.93	10.64784	87.52
10.55	1.56	2.35609	444.75	11.94711	88.30
11.31	1.94	2.42561	662.69	13.03533	86.76
11.94	2.33	2.47983	845.79	14.02588	85.12
12.63	2.72	2.53604	1000.56	14.92163	84.64
13.32	3.11	2.58927	1134.61	15.74355	84.60

CAMERA DATA & CALCULATIONS

FILM NO. 60361	STATION NO. ^{527.01} 6x6 #2	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. F-16 #2	EQ. AP.		DATE: 10/15/58



HORIZONTAL
PROJECTION

A. $R^0_A = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$

$\alpha = 0^\circ 00'$	$\beta = 2^\circ 15'$	$H_B = 3129 \text{ ft}$
$\cos \alpha = 1.0000$	$\cos \beta = 0.99923$	$H_C = 3079 \text{ ft}$
$CB_h = 364.7 \text{ m}$	$\sin \beta = 0.03926$	$\Delta H = 50 \text{ ft} = 15.2 \text{ m}$
$CB_h \cos \alpha \cos \beta = 364.4 \text{ m}$	$\Delta H \sin \beta = 0.6 \text{ m}$	$R^0_A = \boxed{365.0 \text{ m}}$

B. FOCAL LENGTH 78.06 mm (617086)

C. MAGNIFICATION FACTOR (meters/in.) 118.8

D. ZERO TIME CORRECTION 0.15 ms

DIAMETER MEASUREMENTS

SHOT Hamilton

FILM NO. 60361

[illegible]

READ BY GGO LW TYPED BY

DATE 10/28/58 DATE

REMARKS:

**EDGERTON, GERMESHAUSEN
& GRIER, INC.**

FIREBALL CALCULATIONS

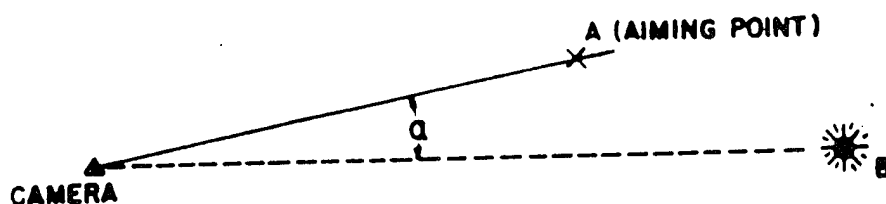
SHOT Hamilton FILM NO. 60361

DATE 1-22-59

D	t	ln D	Int	$t^{2/3}$	ϕ
4.58	.15	1.52174	1.89705 -	.468217	9.781
6.74	.38	1.90799	.96751 -	.679086	99.25
7.79	.61	2.05285	49437 -	.820574	94.93
8.53	.85	2.14366	16245 -	.937085	91.02
9.39	1.08	2.23968	7690	10.31239	91.05
9.86	1.32	2.28844	27763	11.17454	88.23
10.36	1.55	2.33795	43833	11.91642	86.93
10.79	1.78	2.37856	57666	12.59438	85.67
11.34	2.02	2.42826	70308	13.24763	85.60
11.94	2.25	2.47983	81086	13.83128	86.32
12.41	2.48	2.51846	90818	14.38027	86.29
12.64	2.72	2.53684	100056	14.92163	84.70
12.93	2.95	2.55954	108177	15.41426	83.88
13.25	3.18	2.58400	115688	15.88441	83.41
13.54	3.42	2.60567	122967	16.35373	82.79
13.81	3.65	2.62542	129478	16.78525	82.27
14.02	3.88	2.64053	135591	17.20068	81.50
14.18	4.12	2.65188	141592	17.61863	80.48
14.39	4.35	2.66659	147024	18.00558	79.91
14.67	4.58	2.68587	152174	18.38039	79.81
14.94	4.82	2.70411	157280	18.75959	79.63

CAMERA DATA & CALCULATIONS

FILM NO. 60352	STATION NO. 527.02 6x6 #3	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. E 6	EQ. AP.		DATE: 10/15/58



HORIZONTAL
PROJECTION

A. $R^0/A = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$			
$\alpha = 0^\circ 00'$	$\beta = 2^\circ 10'$	$H_B = 3129 \text{ ft}$	
$\cos \alpha = 1.0000$	$\cos \beta = 0.99929$	$H_C = 3083 \text{ ft}$	
$CB_h = 372.0 \text{ m}$	$\sin \beta = 0.03781$	$\Delta H = 46 \text{ ft} = 14 \text{ m}$	
$CB_h \cos \alpha \cos \beta = 371.7 \text{ m}$	$\Delta H \sin \beta = 0.5 \text{ m}$	$R^0/A = $	372.2 m
FOCAL LENGTH 63.91 mm (ET 1254)			

MAGNIFICATION FACTOR (meters/in.) 147.9

ZERO TIME CORRECTION 0.05 ms

FIREBALL CALCULATIONS

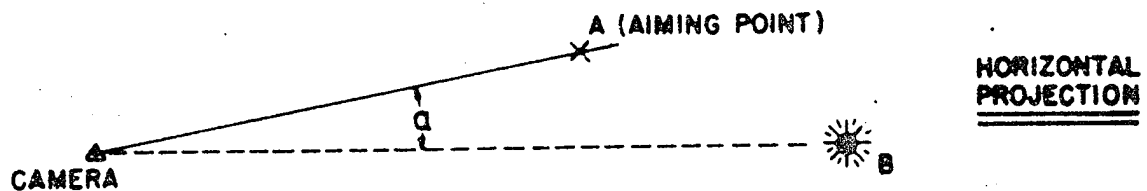
SHOT Hamilton FILM NO. 60352

DATE 1-22-59

t	ln D	Int	$t^{2/3}$	ϕ
.05	1.61343	2.09572 -	.301722	16637
45	1.96286	79845 -	7.26597	9799
84	2.14248	17429 -	9.32657	9135
123	2.25342	20696	10.86309	8763
163	2.34563	48865	12.15873	8586
202	2.42384	70308	13.24763	8522
241	2.48568	87955	14.21653	8447
281	2.54158	103313	15.11726	8400
320	2.59452	116315	15.92432	8408
360	2.62252	128099	16.69287	8249
399	2.65047	138386	17.39412	8140
438	2.68040	147711	18.05514	8080

CAMERA DATA & CALCULATIONS

FILM NO. 60354	STATION NO. ^{527.02} 6x6 #3	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. F16 #1	EQ. AP.		DATE: 10/15/58



A. $R\%_A = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$

$\alpha = 0^\circ 00'$	$\beta = 2^\circ 10'$	$H_B = 3129 \text{ ft}$
$\cos \alpha = 1.0000$	$\cos \beta = 0.99929$	$H_C = 3083 \text{ ft}$
$CB_h = 372.0 \text{ m}$	$\sin \beta = 0.03781$	$\Delta H = 46 \text{ ft} = 14 \text{ m}$
$CB_h \cos \alpha \cos \beta = 371.7 \text{ m}$	$\Delta H \sin \beta = 0.5 \text{ m}$	$R\%_A = \boxed{372.2 \text{ m}}$

B. FOCAL LENGTH 77.96 mm (617071)

C. MAGNIFICATION FACTOR (meters/in.) 121.3

D. ZERO TIME CORRECTION 0.002 ms

DIAMETER MEASUREMENTS

FILM NO. 60354

Milton

[illegible]

BY GGG JEC TYPED BY

10/28/58 _____ DATE _____

LINKS:

**EDGERTON, GERMESHAUSEN
& GRIER, INC.**

FIREBALL CALCULATIONS

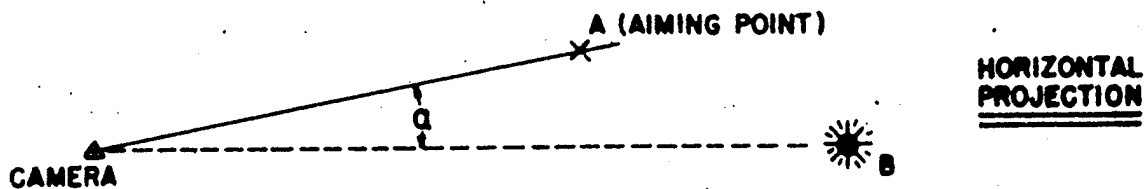
607 FILM NO. 60354

DATE 1-22-59

ln D	Int	$t^{2/5}$	ϕ
233 36	1.469 74 -	.5 554 93	10.1 89
112 43	776 48 -	7 330 11	92 35
128 14	371 12 -	8 620 42	88 16
06 62	83 32 -	9 672 19	84 98
59 94	139 68	10 574 64	81 98
35 42	322 11	11 375 14	82 19
02 66	476 31	12 098 84	82 65
47 54	609 80	12 762 43	81 95
96 01	727 52	13 377 76	82 07
26 49	832 84	13 953 38	81 12
62 93	928 14	14 495 55	80 99
80 67	1 015 17	15 009 04	79 61
01 38	1 091 89	15 476 80	78 82
25 69	1 166 27	15 944 22	78 39
40 00	1 235 51	16 391 94	77 35
60 31	1 300 25	16 821 99	76 92

CAMERA DATA & CALCULATIONS

NO. 60372	STATION NO. F-732 6x6 #1	TEST HAMILTON	CALCULATED BY: GGO
ERA NO. FR #1	EQ. AP.		DATE: 10/15/58



$$R^0/A = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$$

$0^\circ 00'$	$\beta = 1^\circ 23'$	$H_B = 3129 \text{ ft}$
$\alpha = 1.0000$	$\cos \beta = 0.99971$	$H_C = 3081 \text{ ft}$
$= 604.1 \text{ m}$	$\sin \beta = 0.02414$	$\Delta H = 48 \text{ ft} = 14.6 \text{ m}$
$\cos \alpha \cos \beta = 603.9 \text{ m}$	$\Delta H \sin \beta = 0.4 \text{ M}$	$R^0/A = \boxed{604.3 \text{ m}}$

FOCAL LENGTH

MAGNIFICATION FACTOR (meters/in.)

ZERO TIME CORRECTION 0.006 ms

DIAMETER MEASUREMENTS

~~SECRET~~ Hamilton

FILM NO. 60372

Fr. No.	Mag.	D ₁	D ₂	D ₃	D _{avg} (m)	FLEXOWRITER	
						D _{avg} (m)	t (ms)
0	19.33	XXXX	XXXX		—		—
1		XXXX	XXXX		—		—
2		0134	0139		4.26		0.14
3		0169	0176		5.31		0.20
4		0182	0190		5.77		0.27
5		0198	0200		6.19		0.33
6		0212	0211		6.56		0.40
7		0222	0230		6.94		0.46
8		0235	0235		7.10		0.53
9		0249	0249		7.49		0.59
10		0253	0255		7.67		0.66
11		0257	0259		7.89		0.72
12		0267	0265		8.19		0.79
13		0273	0276		8.34		0.85
14		0279	0283		8.65		0.92
15		0281	0286		8.87		0.98
16		0288	0289		8.97		1.05
17		0297	0301		9.18		1.11
18		0300	0304		9.36		1.18
19		0306	0307		9.53		1.24
20		0312	0314		9.58		1.31
21		0317	0320		9.81		1.37
22		0325	0326		9.96		1.44
23		0329	0330		10.02		1.50
24		0335	0336		10.33		1.57
25		0336	0341		10.46		1.63
26		0342	0343		10.55		1.69
27		0348	0349		10.56		1.76
35		0354	0355		10.99		2.28

READ BY JEC RCS

TYPED BY JEC

DATE 1/14/59

DATE 1/14/59

REMARKS:

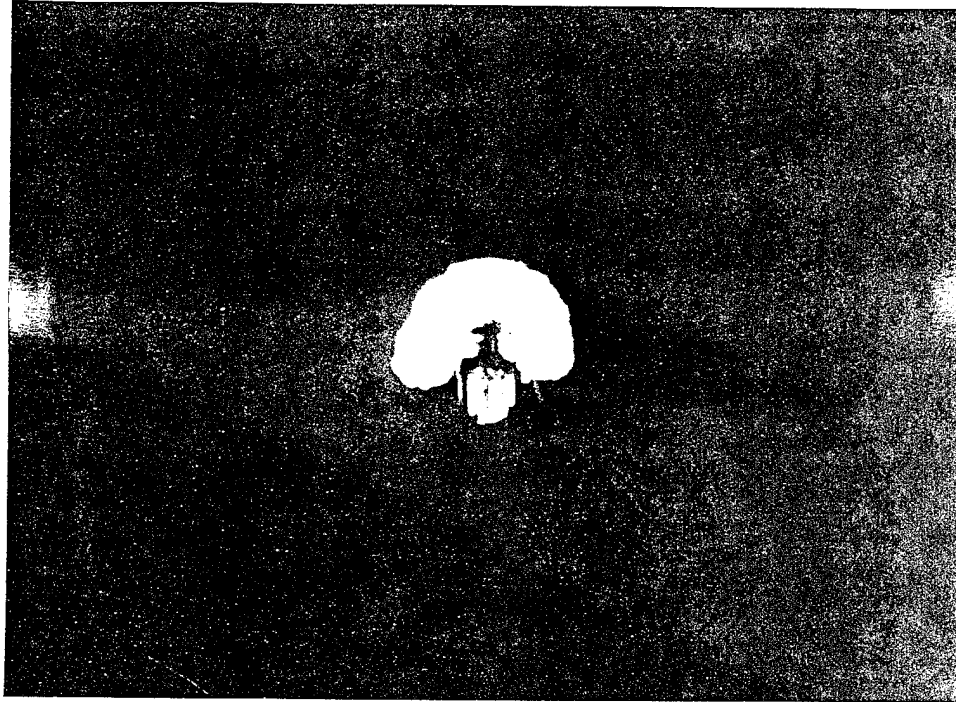
FIREBALL CALCULATIONS

SHOT Hamilton FILM NO. 60372

DATE 1-22-59

D	t	ln D	Int	$t^{2/5}$	ϕ
4.26	.14	1.44934	1.96607 -	.455467	93.53
5.31	.20	1.66956	1.60945 -	5.25303	101.08
5.77	.27	1.75260	1.30940 -	5.92288	97.41
6.19	.33	1.82285	1.10864 -	6.41812	96.44
6.56	.40	1.88091	.91621 -	6.93164	94.63
6.94	.46	1.93724	.77648 -	7.33011	94.67
7.10	.53	1.96005	.63490 -	7.75720	91.52
7.49	.59	2.01355	.52770 -	8.09707	92.50
7.67	.66	2.03732	.41559 -	8.46845	90.57
7.89	.72	2.06562	.32854 -	8.76851	89.98
8.19	.79	2.10296	.23569 -	9.10028	89.99
8.34	.85	2.12112	.16245 -	9.37085	88.99
8.65	.92	2.15763	.8332 -	9.67219	89.43
8.87	.98	2.18275	.2023 -	9.91939	89.42
8.97	1.05	2.19396	.4876	10.19697	87.96
9.18	1.11	2.21709	104.28	10.42596	88.04
9.36	1.18	2.23649	165.44	10.68416	87.60
9.53	1.24	2.25446	215.06	10.89836	87.44
9.58	1.31	2.25969	270.02	11.14057	85.99
9.81	1.37	2.28337	314.83	11.34208	86.49
9.96	1.44	2.29851	364.69	11.57056	86.08
10.02	1.50	2.30465	405.53	11.76111	85.19
10.33	1.57	2.33505	451.15	11.97769	86.24
10.46	1.63	2.34754	488.65	12.15873	86.02
10.55	1.69	2.35609	524.79	12.33578	85.52
10.56	1.76	2.35704	565.37	12.53761	84.22
10.99	2.28	2.39692	824.11	13.90473	79.03

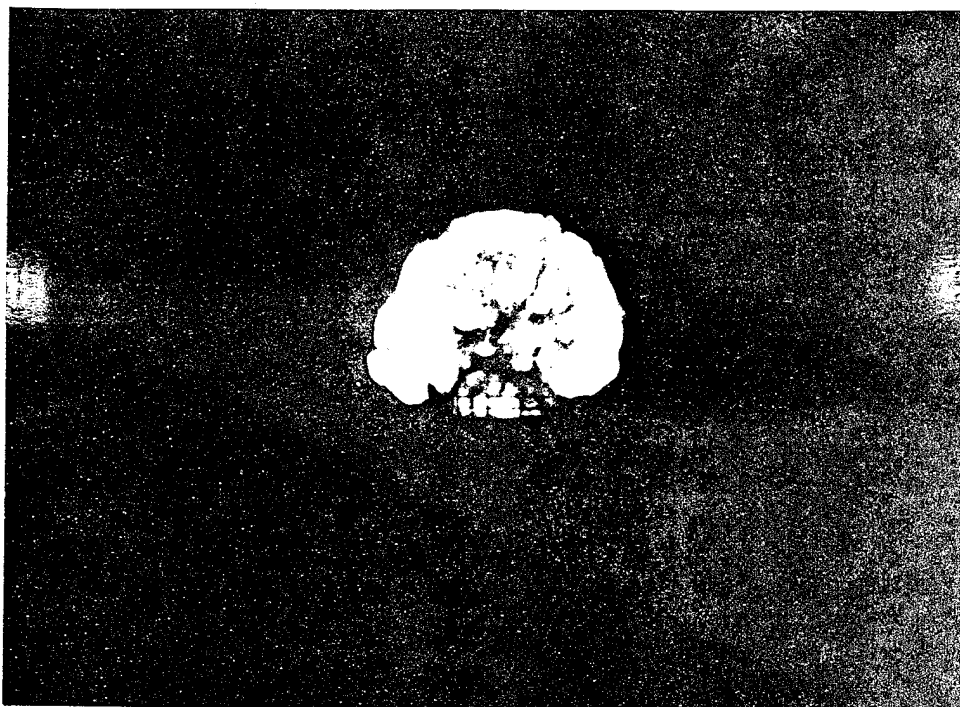
APPENDIX
HARDTACK PHASE II, HAMILTON
PHOTOGRAPHIC EXAMPLES



Camera: F-16 No. 2

Station: 527.01

Time: 0.38 msec



Camera: F-16 No. 2

Station: 527.01

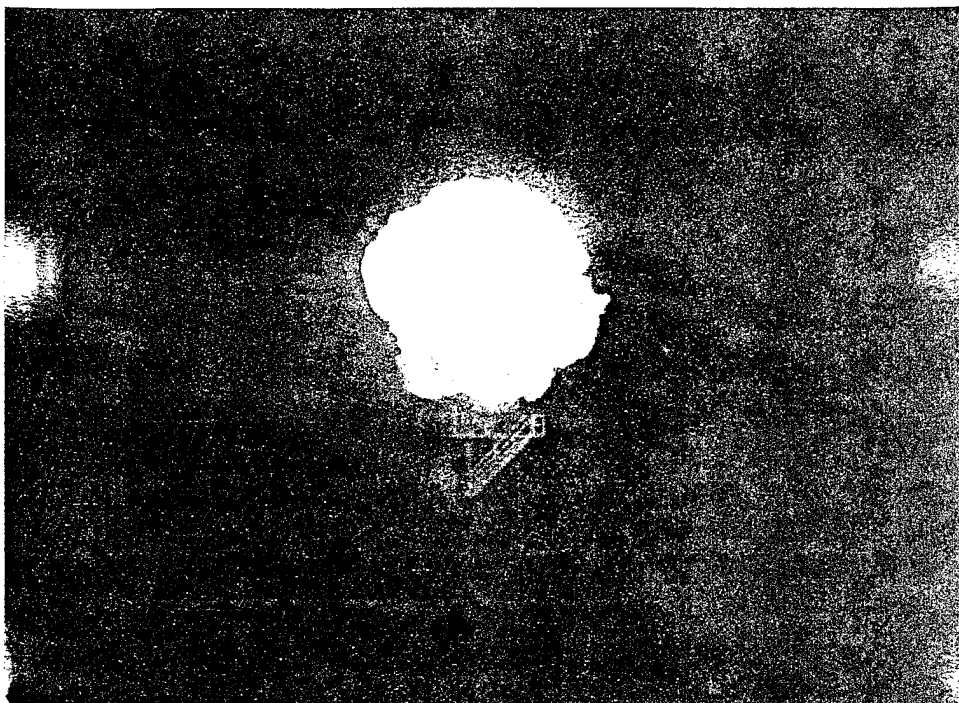
Time: 1.08 msec



Camera: F-16 No. 2

Station: 527.01

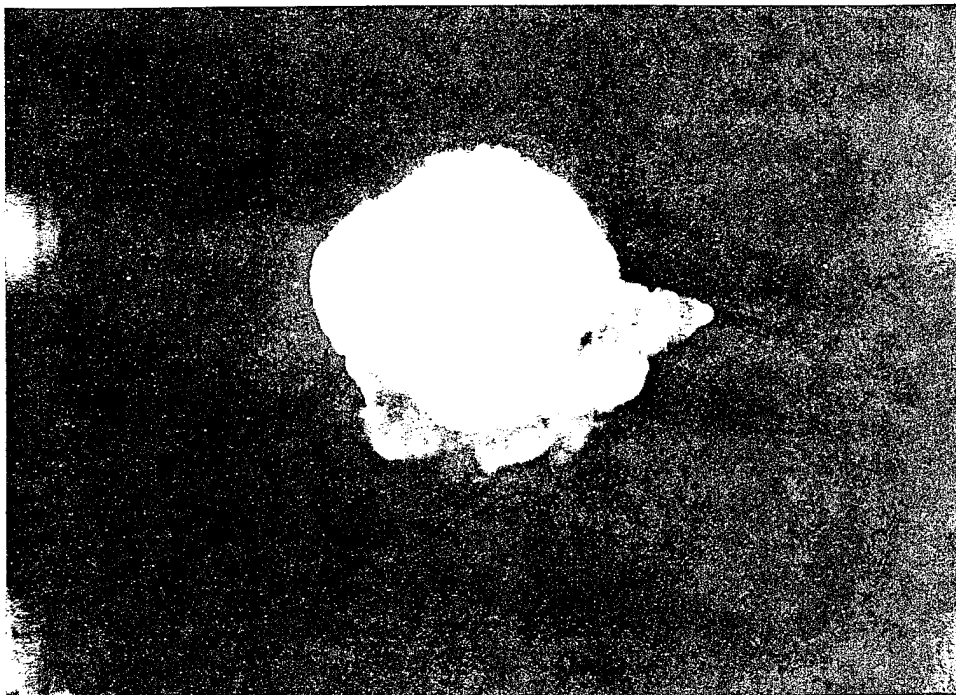
Time: 2.02 msec



Camera: E-6

Station: 527.02

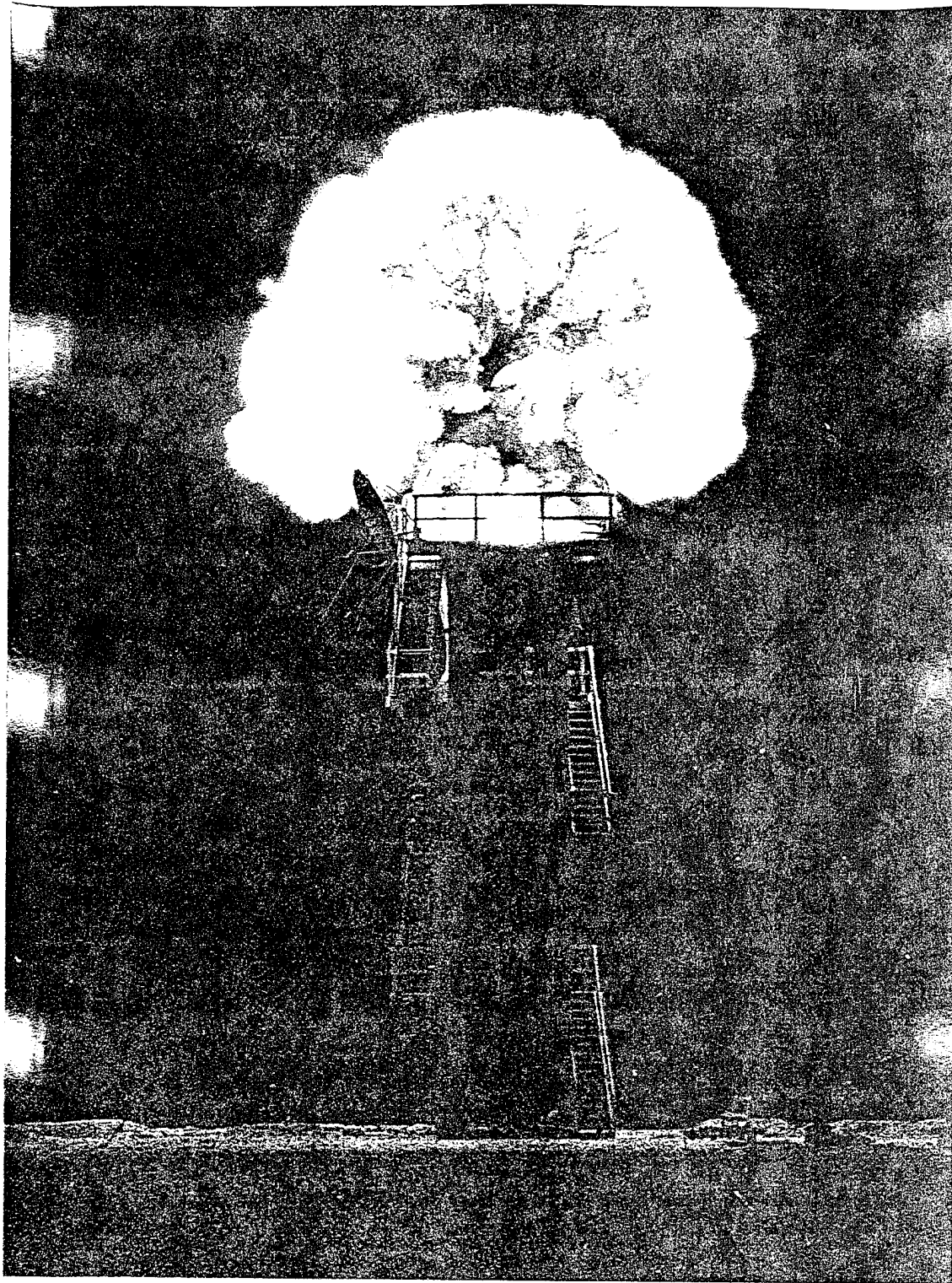
Time: 2.02 msec



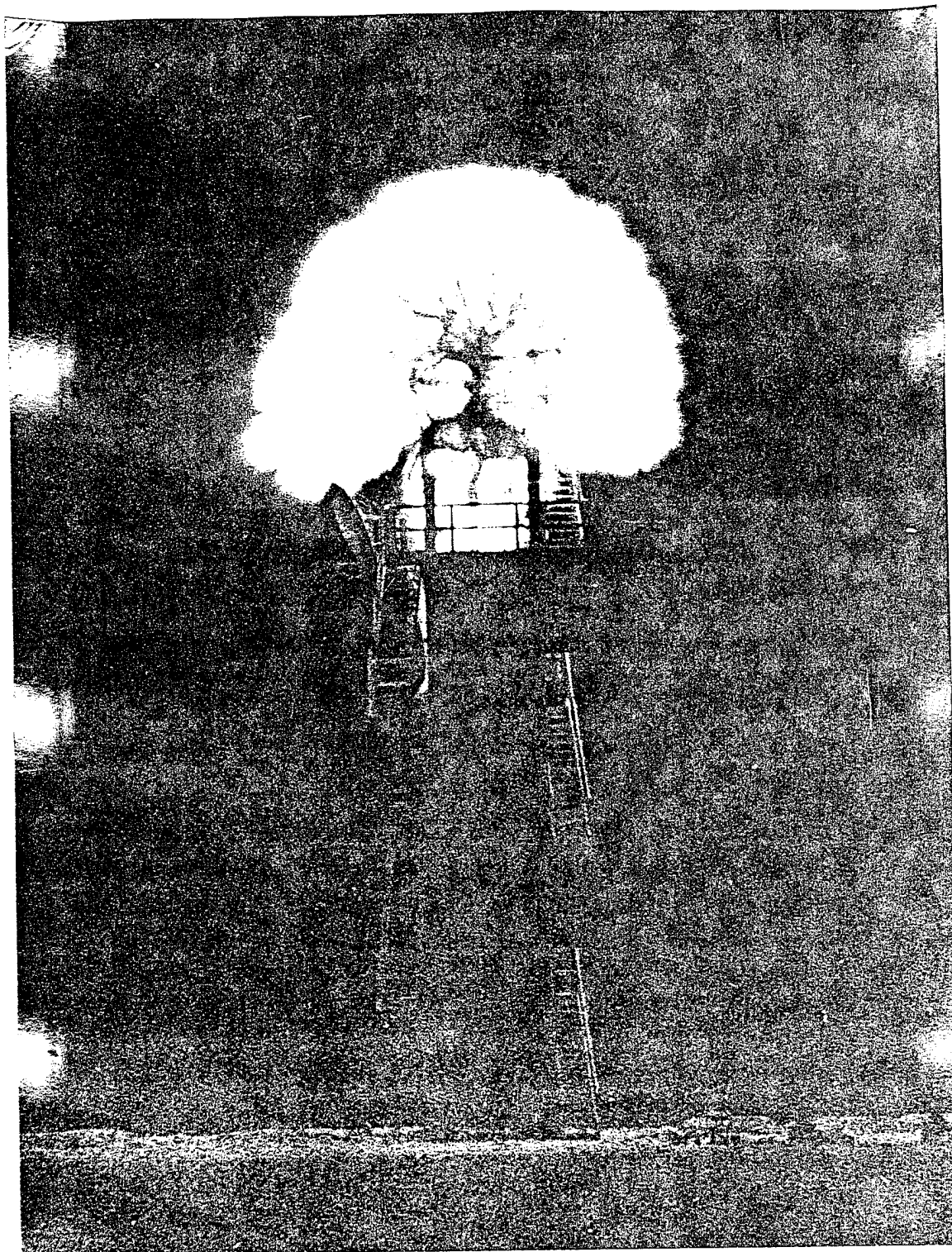
Camera: E-6

Station: 527.02

Time: 6.74 msec



Camera: R-4
Station: 527.01
Time: 0.4995 msec



Camera: R-3
Station: 527.01
Time: 0.9840 msec

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