URS 654-2

EXPLOSION-GENERATED WAVE TESTS
MONO LAKE, CALIFORNIA

GROUND AND AERIAL PHOTOGRAPHY

January 1966

Sponsored by

OFFICE OF NAVAL RESEARCH
Washington, D.C. 20360
Contract No. Nonr-4959(00)
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by

D. Walter
URS CORPORATION
1811 Trousdale Drive
Burlingame, California

Approved by

K. Kaplan,
Project Leader

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ABSTRACT

In the summer of 1965, a series of ten spherical cast TNT charges, each weighing approximately 10,000 lb were exploded at Mono Lake, California. As part of that program, URS Corporation conducted a project to acquire ground-based, high- and normal-speed, motion picture photography of base surge, plume, and wave run-up characteristics on all shots, and another to acquire aerial photography of wave refraction on two shots.

The high-speed and normal-speed motion pictures show excellent detail of base surge and plume. Run-up information is good; on many films waves within waves can be seen near the shore. The aerial photography obtained is good, and wave generation, refraction, and run-up can readily be seen.

ACKNOWLEDGEMENTS

The work was done under the technical guidance of Mr. K. Kaplan, Manager of the Fluid Dynamics Division of URS Corporation. Special thanks go to Mr. J. R. Bertram for his assistance in the field. The cooperation and assistance of the U.S. Army Engineer Waterways Experiment Station field test crew, expecially Mr. Murray Pinkson, Field Supervisor, is gratefully acknowledged.

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Section 1
INTRODUCTION

In the summer of 1965, a series of ten spherical, cast TNT charges, each weighing approximately 10,000 lb, were exploded at Mono Lake, California. The study is part of a program to broaden and extend the present knowledge of wave generation, propagation, and run-up over variable-depth hydrography. The purposes of the portion of the study described in this report were to acquire ground-based motion picture photography of base surge, plume, and run-up characteristics on all tests and to acquire aerial photography of two tests suitable for later wave-refraction analysis.

Section 2
INSTRUMENTATION

TOWERS

All ground-based photography was conducted from towers positioned at strategic points along the beach front. Elevated camera positions were chosen in order to improve the view of the detonation and run-up phenomena and to eliminate heat-wave distortion, which is a problem at ground level when taking motion pictures at a considerable distance from a subject.

Figure 1 shows the tower locations in relationship to the overall test facility. Towers 1 and 2, located adjacent to Run-Up Ramps 1 and 2, were of a scaffold type, 50 ft high, with 5- by 5-ft work platforms; Tower No. 3, also with a work platform, was 20 ft high and of a standard communications-type configuration.

CAMERAS

During the test, two high-speed and five normal-speed cameras were utilized. One high-speed camera (500 frames/sec Fastax WF3 with a 152-mm lens) was located on Tower No. 1, approximately 1 mile from ground zero. Another high-speed camera (500 frames/sec Red Lake Hycam with a 152-mm lens) was located on Tower No. 3, approximately 2.8 miles from ground zero. These high-speed cameras were mounted on tripods and secured to the work platforms with cables and turnbuckles. Normal-speed (16 frames/sec) Gun Sight Aiming Point (GSAP) cameras were also located on Towers 1, 2, and 3. On Tower No. 1, two GSAP cameras monitored run-up information and a third camera was directed toward the point of detonation. The GSAP camera on Tower No. 2 was positioned toward Run-Up Ramp No. 2; the GSAP camera on Tower No. 3 was pointed toward ground zero. Figure 2 shows a typical GSAP camera mount used during the tests.

At the base of Towers 1 and 3, F-56 Fairchild aerial-type cameras (provided URS at no cost by the U.S. Naval Ordnance Laboratory) with 8.25-in. and 20-in. lenses, respectively, were mounted and focused on ground zero. These cameras were operated at an exposure rate of approximately one picture every 3 sec for a 4-min duration in order to gather supplementary data on base surge and plume formation.

All the cameras were activated either manually or by hard wire trips to relays. High-speed cameras were started one second before detonation by a trip signal from the firing console. GSAP cameras directed toward ground zero were also started automatically 10 sec before the detonation. All other cameras were started manually at different times.

The timing lights for high-speed cameras were operated through a DC-to-AC converter, which was activated 10 sec before detonation to allow the timing lights to stabilize. Figure 3 shows the camera circuit used for the high-speed cameras.

LENSES

During pre-test preparations, calculations were made, using information from previous studies on cavity and plume sizes, to determine the lenses required to achieve optimum data coverage. Optical qualities of certain lens types were also considered at that time. (Lenses with focal lengths of 2 in. or greater, when used in conjunction with rotary prism cameras, give high-quality pictures because light passes through the prism in a more parallel beam.) The 152-mm lens selected, satisfied both the optical qualities desired and provided sufficient detail for plume and base-surge information. The field of view provided by the 152-mm lens at 1 mile was 350 ft high by 500 ft wide. At 2.8 miles it was 980 ft high by 1,400 ft wide. The focal lengths of the lenses used on the GSAP cameras were 35 mm for run-up and 78 mm for base surge and plume.

FILM

The film used in the high-speed cameras was selected during pre-test exposures taken at the test facility. Two different types of high-speed

16-mm color film (Ektachrome MS and Ektachrome ER) were tried. Lens speed, aperture settings, and camera voltages were varied during these tests. It was found that Ektachrome MS was a very fine-grained film with good color contrast. It also proved to be excellent for making copies. Ektachrome ER was found to be very grainy, had less contrast, and produced copies of poor quality.

The most important factor in the film selection was the exposure rate at which the cameras were to operate. Ektachrome ER is suited for very high-speed camera operation; Ektachrome MS is designed for slower camera speeds. Since 500 frames/sec is a relatively slow framing rate in high-speed photography, the high light-sensitivity of Ektachrome ER was not required, and the higher quality Ektachrome MS was chosen.

Standard Kodak Kodachrome II magazines were used in the GSAP cameras.

POWER SOURCE

All cameras were operated from DC sources. (When operating the Fastax at framing rates lower than 1,000 frames/sec, DC is required because of the torque characteristics of the motors.) Heavy-duty storage batteries were used and recharged between each test. These batteries were not removed from the towers after installation; therefore the same batteries were used with the same cameras for the entire series. A small portable generator and a series-type battery charger were transported from tower to tower to recharge batteries.

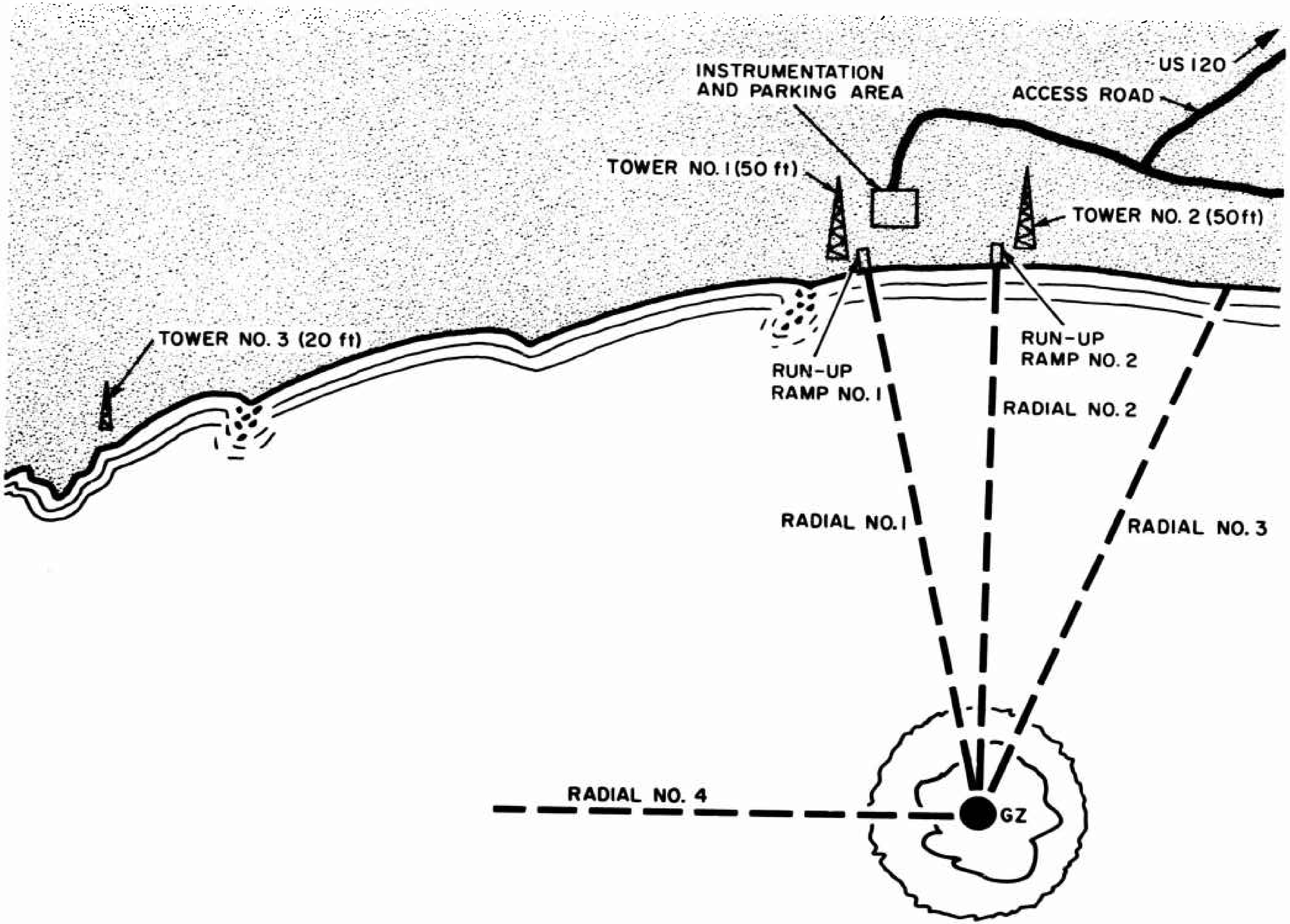

Fig. 1. Tower Locations

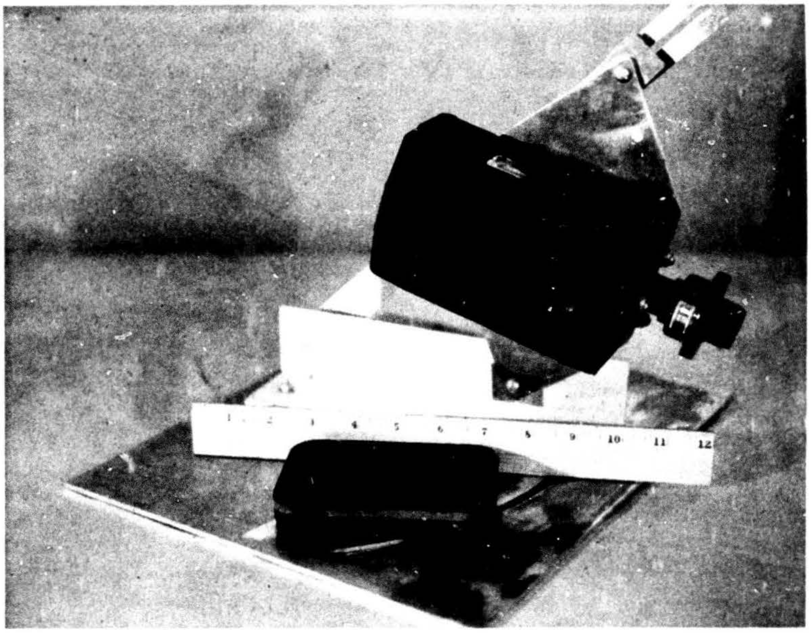

Fig. 2a. GSAP Camera 75-mm Lens

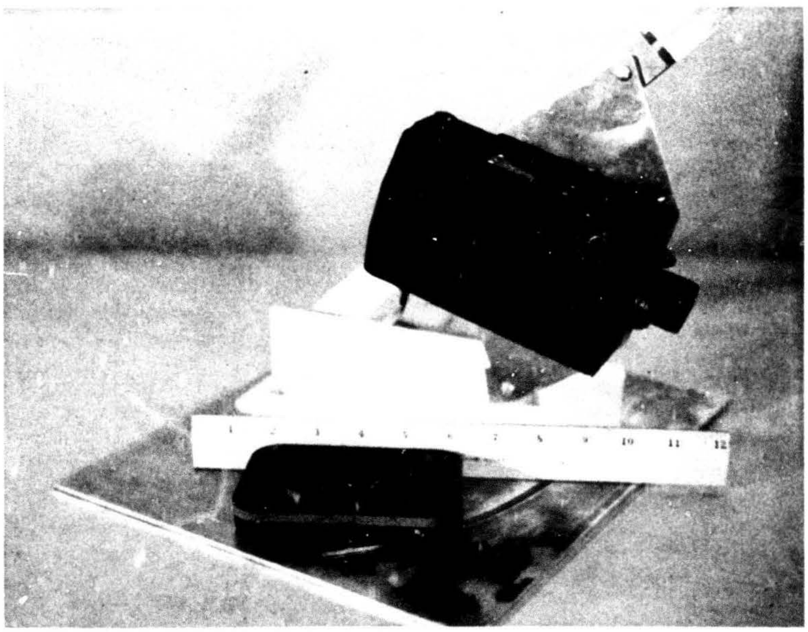

Fig. 2b. GSAP Camera 35-mm Lens

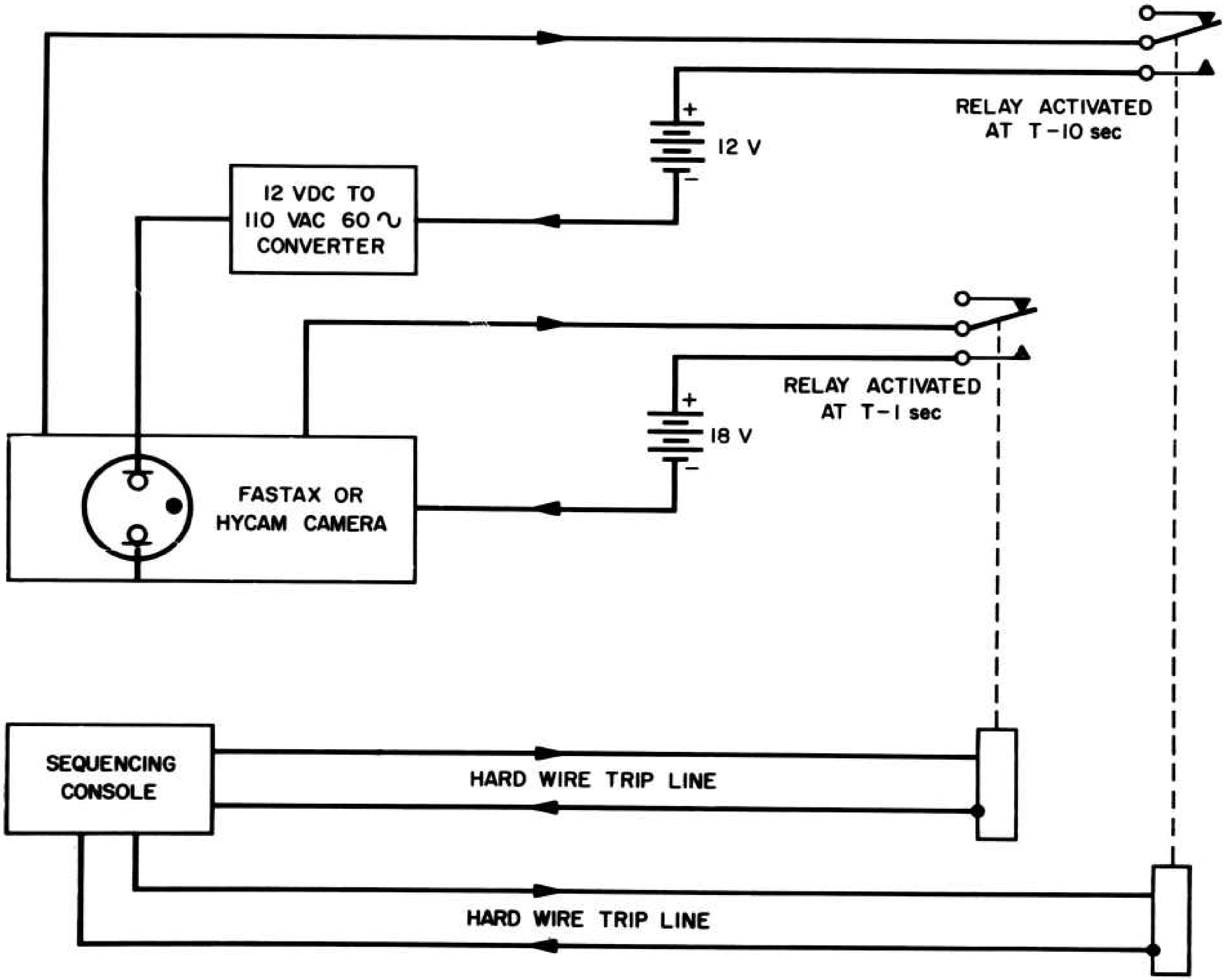

Fig. 3. Camera Circuit

Section 3
RESULTS

Tests were completed on the Mono Lake Project on September 9, 1965. A table showing shot sequence, data, and charge position is presented in Table 1. The high-speed motion pictures taken of base surge and plume show excellent detail, and information can readily be obtained from these films. The run-up information obtained is good, and on many films, waves within waves can be seen near the shore. With the aerial photography, fine coverage was obtained on one shot, and there is a possibility that additional information might be gleaned from the other shots covered.

Table 2 shows camera performance of all ground- and tower-based cameras for the entire test series. As can be seen, the majority of information loss occurred during the first two shots of the series; after the second shot, field operations were perfected and there was little subsequent loss of data. On shots one and two, certain relays malfunctioned, a gun-camera motor and gun-camera magazine failed, and the manual control (initially established for Tower No. 3) proved unsatisfactory.*

Data reductions made since the test series ended are given in Appendixes A and B. In Appendix A, tracings of plume and base surge taken from the projected films are shown. Time increments and a scale (in feet) are presented along with each tracing. In Appendix B, the run-up data in tabular form is shown. Note that the entries for wave heights and distances between waves are approximations since these phenomenon were measured from oblique photography.

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* Initially, Tower No. 3 was to be controlled manually since its location was quite remote from the test area. Since radio silence was deemed necessary at that time, a telephone line was installed to Tower No. 3 to signal the operator the precise time to start the cameras. When this method of starting cameras proved unsatisfactory, a relay was installed at Tower No. 3 and the telephone line was converted to a trip-line to improve timing. Also, radio silence was withdrawn.

Table 1

TEST SEQUENCE

SHOT NO.	DATE	CHARGE POSITION (ft)
1	081365	0
2	081765	-0.67
3	082365	-1.4
4	082465	-1.04
5	082665	-8.2
6	082665	0
7	082765	-41
8	083065	-51.5
9	080765	-21
10*	090865	-1.04

* Different ground zero — approximately 2,000 ft closer to the beach.

Table 2

SUMMARY OF CAMERA PERFORMANCE

CAMERA	LOCATION OF CAMERA	ORIENTATION	SHOT NO.										REMARKS
			1	2	3	4	5	6	7	8	9	10	
Fastax WF3	Tower No. 1	Blast	*	*	*	*	*	*	*	*	*	*	
Hycam	Tower No. 3	Blast	—	—	*	*	*	*	*	*	*	*	Timing & Relay Problems
Gun Camera	Tower No. 1	Blast	—	—	*	*	*	*	*	*	*	*	Magazine Failure
Gun Camera	Tower No. 1	Ramp No. 1 Run-Up	—	—	*	—	*	*	*	*	*	*	Magazine Failure
Gun Camera	Tower No. 2	Ramp No. 2 Run-Up	—	—	*	*	*	*	*	*	*	*	Magazine Failure
Gun Camera	Tower No. 3	Blast	—	—	*	*	*	—	*	*	*	—	Magazine Failure
F-56 Fairchild	Tower No. 1	Blast	+	+	*	*	*	*	—	—	*	*	Film Bound Up in Magazine
F-56 Fairchild	Tower No. 3	Blast	+	+	*	*	*	*	*	*	*	*	

* Operated

— No data

\+ No camera for these tests

A brief review of the type of data acquired from each type of camera station is given on the following pages.

BASE SURGE AND PLUME

High-Speed Photography

Good correlation between measurements made from Tower 1 (Fastax) and Tower 3 (Hycam) photography was the general rule; Figs. 4 and 5 typify this. Since these cameras viewed the detonation from different angles (see Fig. 1), this good correlation indicates that the columns expanded uniformly, with little or no radial asymmetrics. The slight differences in column diameter reductions are well within the accuracies attainable with the resolving power of the lenses used.

In the shallow-depth charge-placement tests, the column is obscured initially by the fireball and then by vapor condensation. Figure 6 shows this occurrence, along with the column development to maximum size before collapse and the beginning of base surge. Although it is not obvious on Fig. 6, the films themselves also clearly show the shock wave propagating in air away from ground zero.

For the deeper shots (-8.2 ft to -51.5 ft) a different type of column forms (Figs. 7 and 8). The outer edge of the dome, initially formed by the underwater shock wave, slows appreciably, while the inner part, driven by the expansion of the underwater bubble, travels at high velocity. This creates a skirt effect at the base of the column. This skirt becomes more pronounced with increased placement depth of the explosive. The air shock wave from these shots can also clearly be seen on the films.

Figure 9 is a plot of column diameter at its maximum point of expansion vs depth of charge.*

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* Note especially the large changes in diameter that occur for surface and near-surface bursts. These are the first measurements of which we are aware, that show such differences for surface effects other than waves. Small variations in measurements from the four cameras (two high-speed and two normal-speed) were found. Figure 9 shows averages of the four separate measurements.

Normal-Speed Photography

Normal-speed cameras provided additional plume data from Towers 1 and 3 to supplement the high-speed data; excellent agreement between the normal- and high-speed photography was obtained. Tracings of the plume and base surge are presented in Appendix A for further analysis.

Base surge information (Fig. 10) was obtained for shots at the upper charge placements. At the lower charge placements the bubble created by the detonation rose to the surface and interacted with the column above, causing too much turbulence. This turbulence extended beyond the field of view of the camera lenses used, and therefore, base-surge information could not be obtained from these films.

The F-56 Fairchild cameras used during the program provided still further coverage on plume and base surge. In Figs. 11 and 12, the cameras from Towers 1 and 3 have caught the column at the start of its downward movement and the beginning of the base surge.

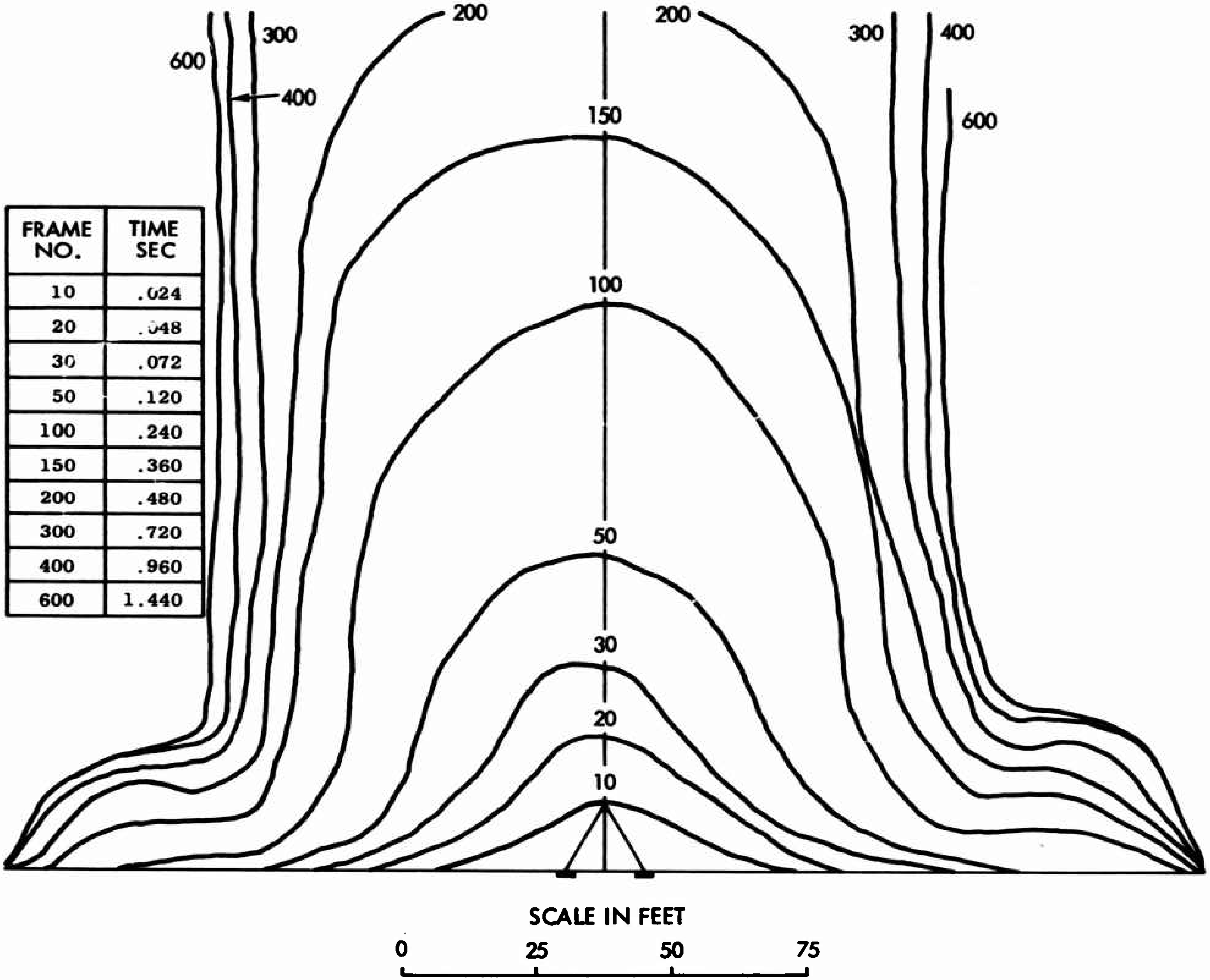
RUN-UP

Normal-Speed Photography

Run-up data was monitored at Ramp No. 1 (1 on 50 slope) and No. 2 (1 on 30 slope). The first wave approached the ramps in groups of three — one large wave and two smaller ones riding behind. After the oscillation at ground zero had subsided, one of the two smaller waves was no longer visible. This three-wave group can readily be seen in Fig. 13. The later, two-move pattern, can be seen in Fig. 14. All reduced data from wave run-up is available in tabular form in Appendix B.

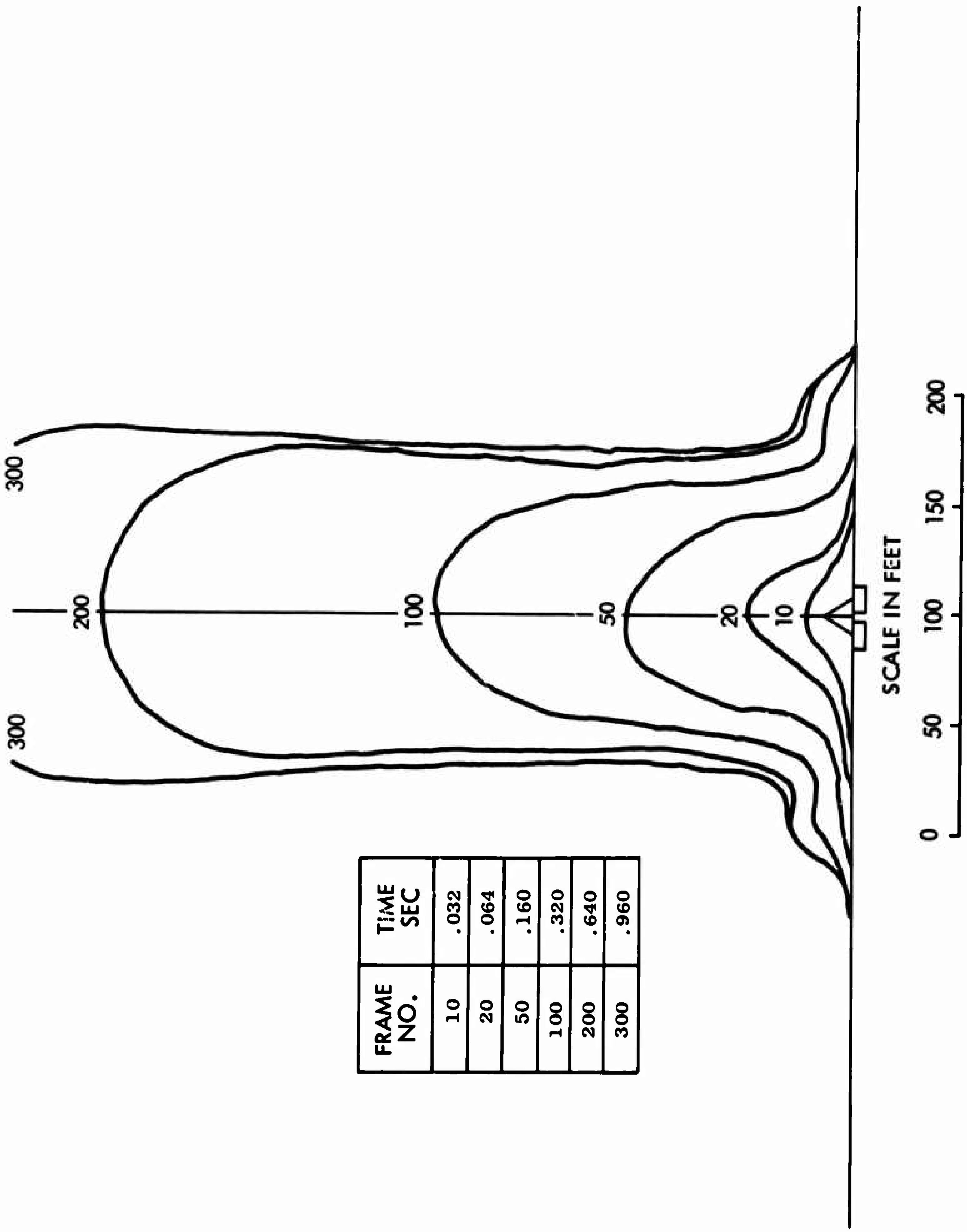
AERIAL

Wave refraction information was gathered on Shots 4 and 8. An Itek Hyac Panoramic camera (which sweeps a 120-deg arc) with colored film was used with excellent results. Figures 15, 16, and 17 are typical aerial photographs obtained during the program. Figure 15 was obtained during Shot 4; Figs. 16 and 17 during Shot 8. In these photos, wave generation can clearly be seen along with the overall wave pattern being formed. Very definite wave run-up can be observed in Fig. 15b.



FRAME NO.	TIME SEC
10	.024
20	.048
30	.072
50	.120
100	.240
150	.360
200	.480
300	.720
400	.960
600	1.440

Fig. 4. Tracing of Plume, Fastax, Shot 9



FRAME NO.	TIME SEC
10	.032
20	.064
50	.160
100	.320
200	.640
300	.960

Fig. 5. Tracing of Plume, Hycam, Shot 9

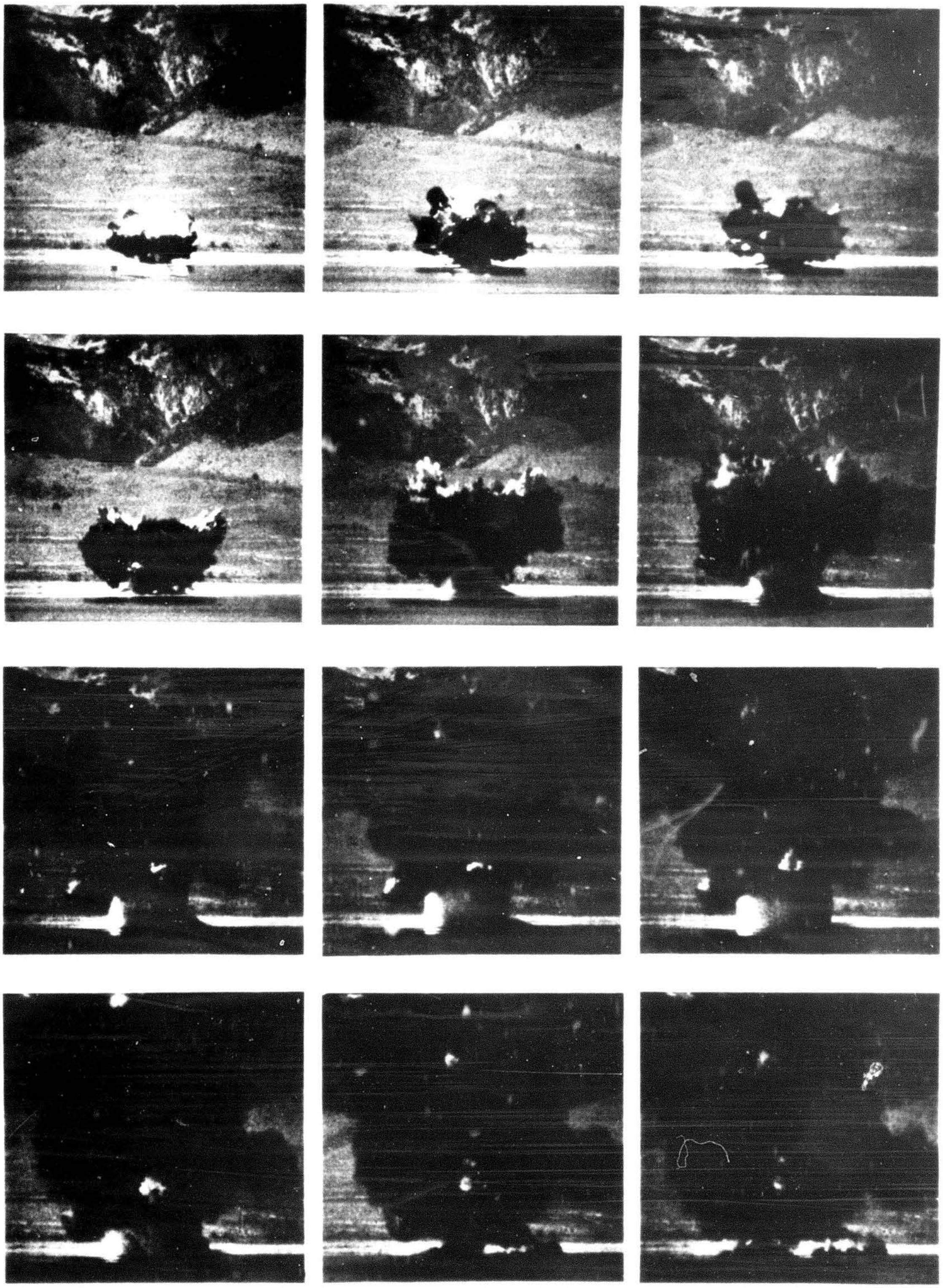


Fig. 6. 16-mm Frame Sequence, Shot 10 (Tower No. 3, -1.04 ft, Hycam)

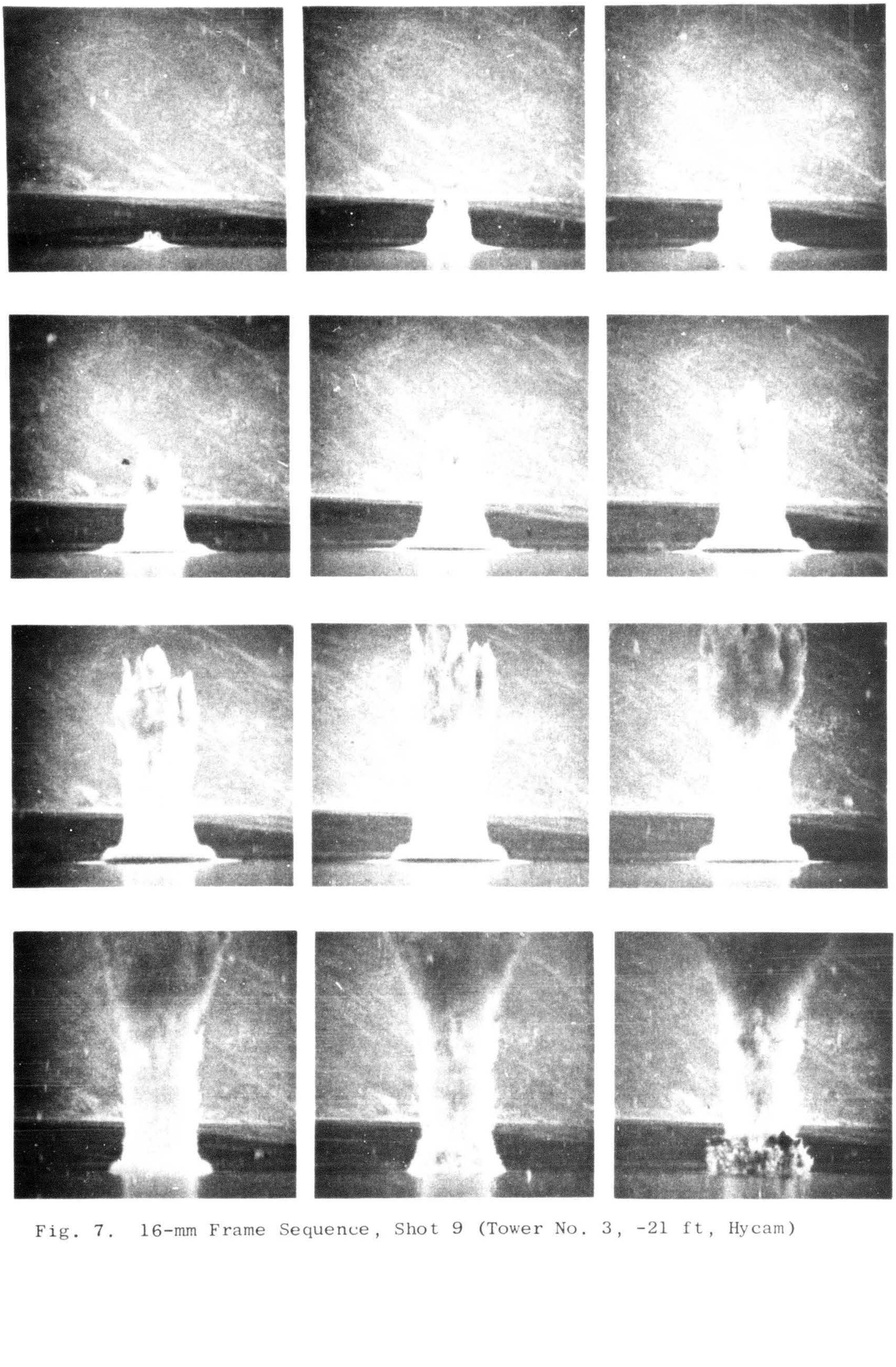


Fig. 7. 16-mm Frame Sequence, Shot 9 (Tower No. 3, -21 ft, Hycam)

FRAME NO.	TIME SEC
40	.090
60	.112
80	.180
100	.225
150	.338
200	.450
250	.566
300	.676
400	.900
500	1.132
600	1.350
700	1.602

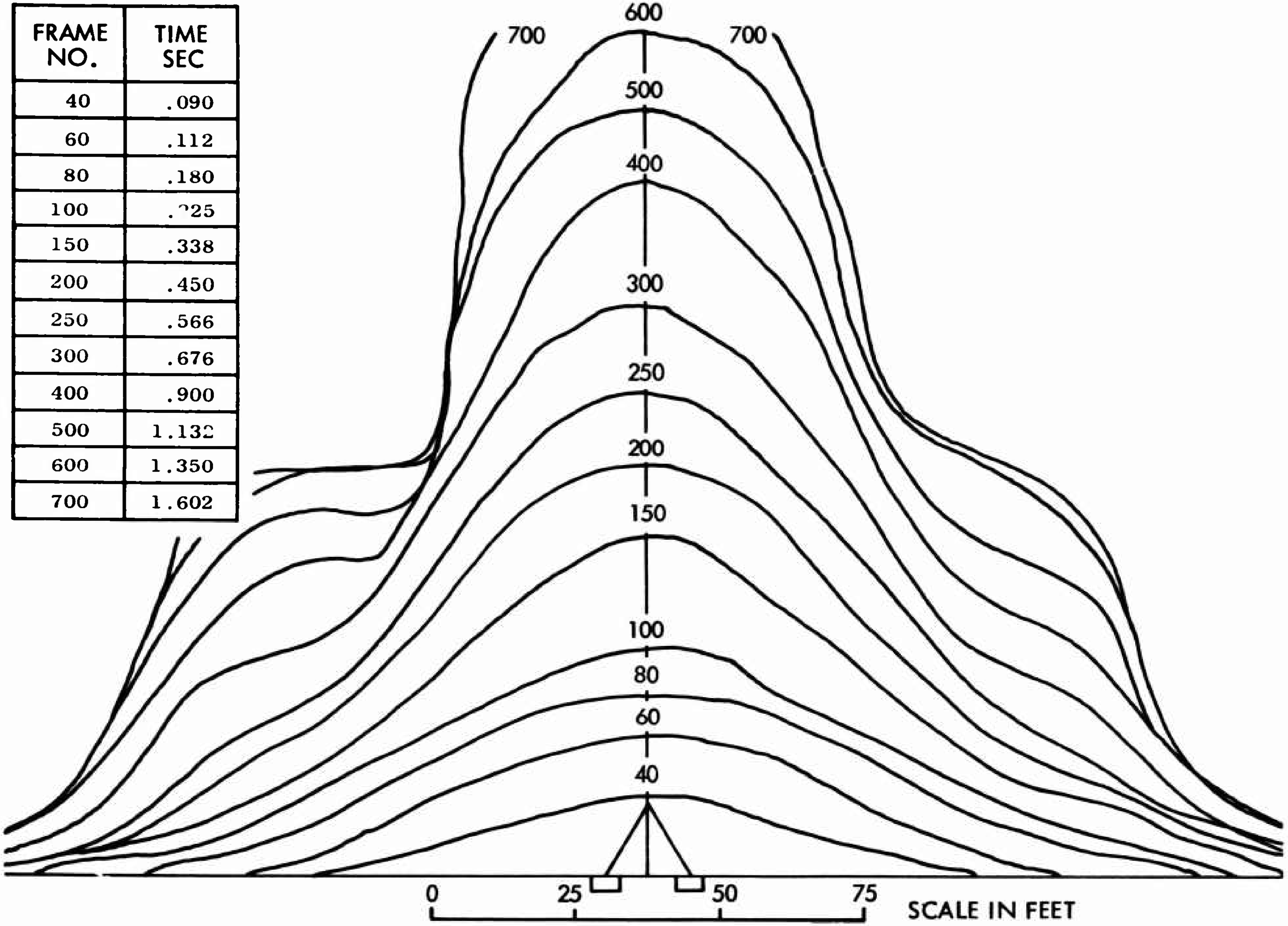


Fig. 8. Tracing of Plume, Fastax, Shot 8

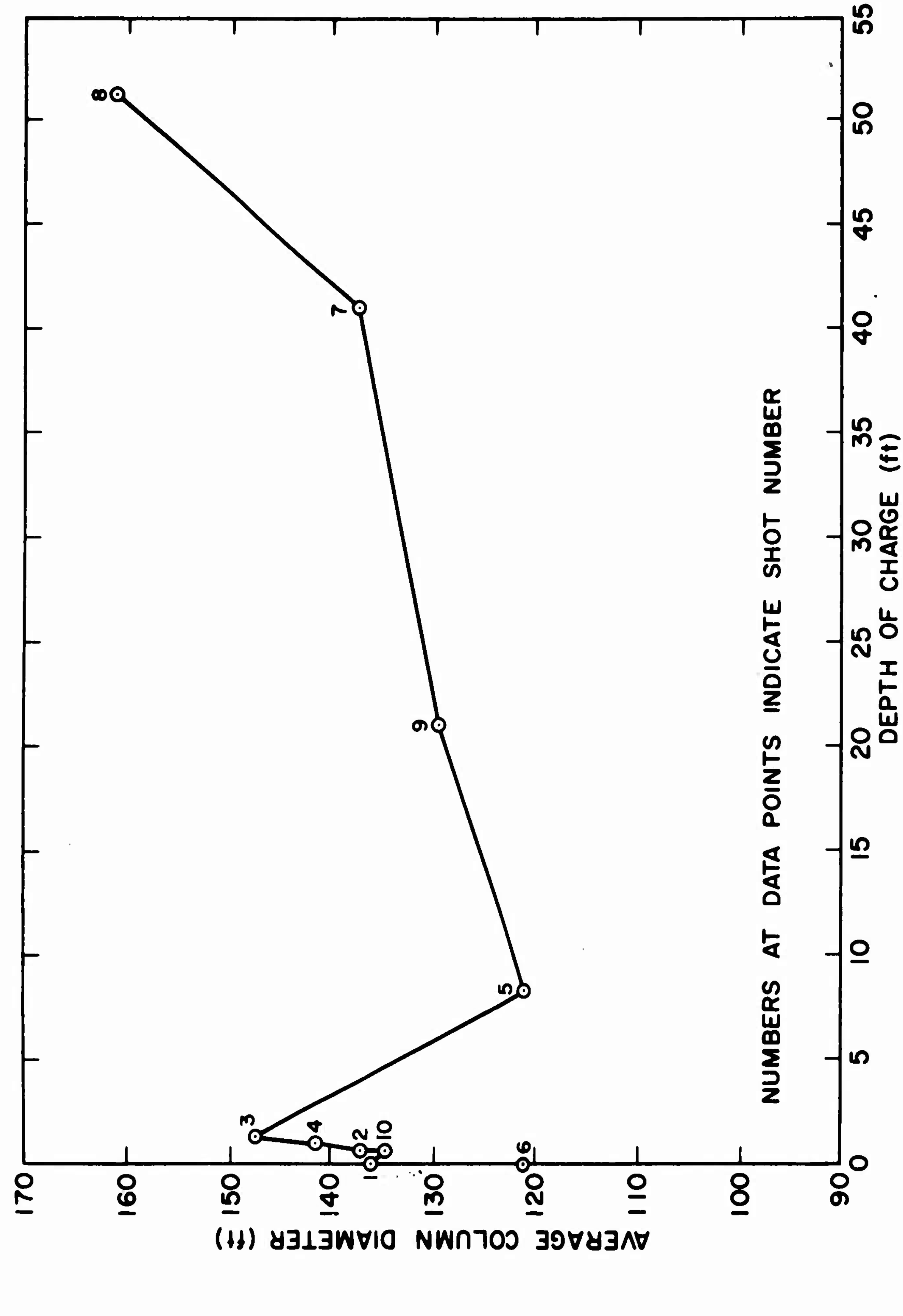


Fig. 9. Plot of Average Column Diameter vs Depth of Charge

FRAME NO.	TIME SEC
2	.148
3	.222
4	.296
5	.370
7	.518
9	.667
12	.889
20	1.48
97	7.21
102	7.6
110	8.1
125	9.3
140	10.4

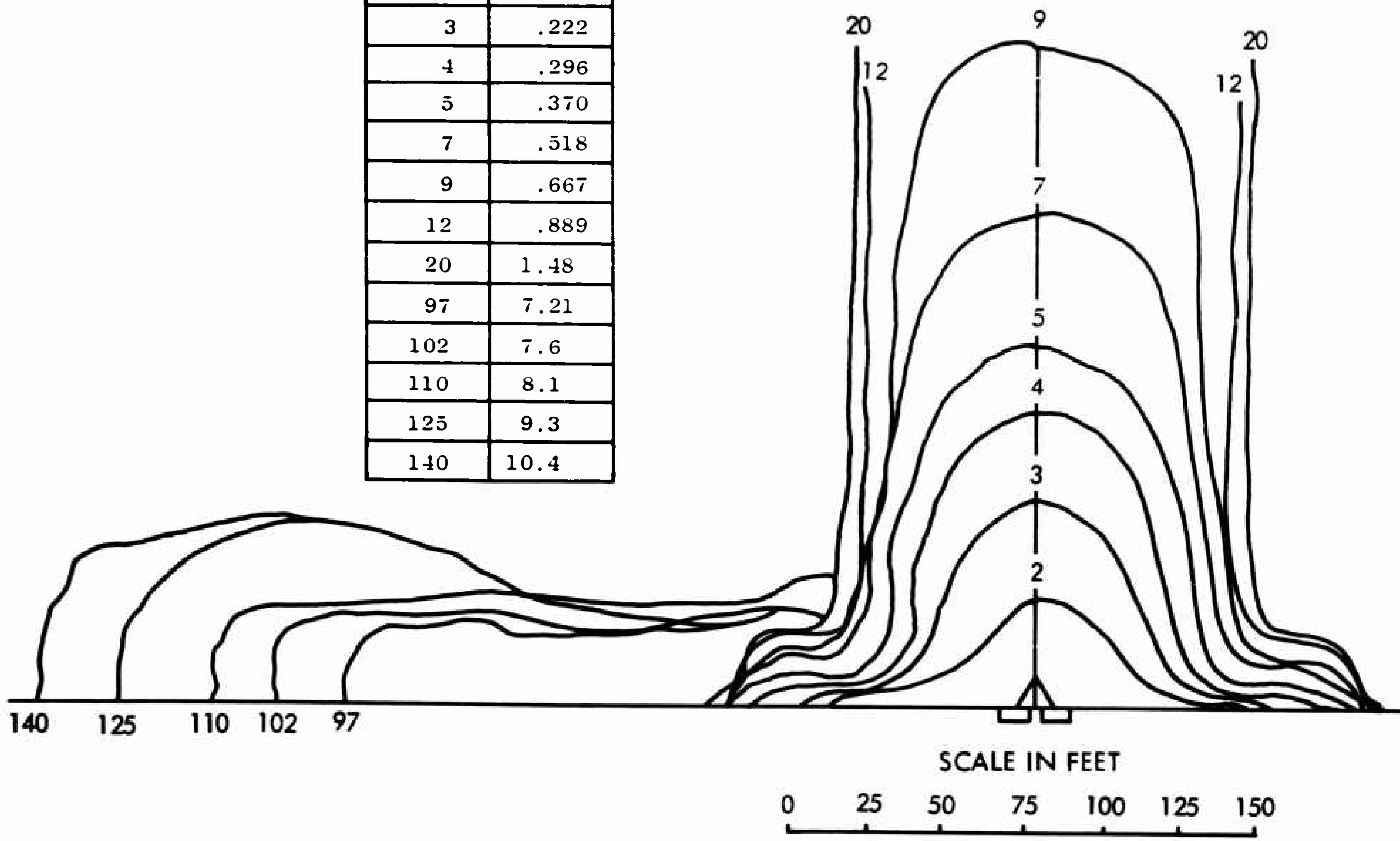


Fig. 10. Tracing of Plume and Base Surge, Gun Camera, Shot 9

Fig. 11. Photo of Plume and Base Surge, Shot 4 (Tower No. 1, -1.04 ft, F-56 Fairchild Camera, 8.25-in. Lense, T_0 + ~1.5 sec)

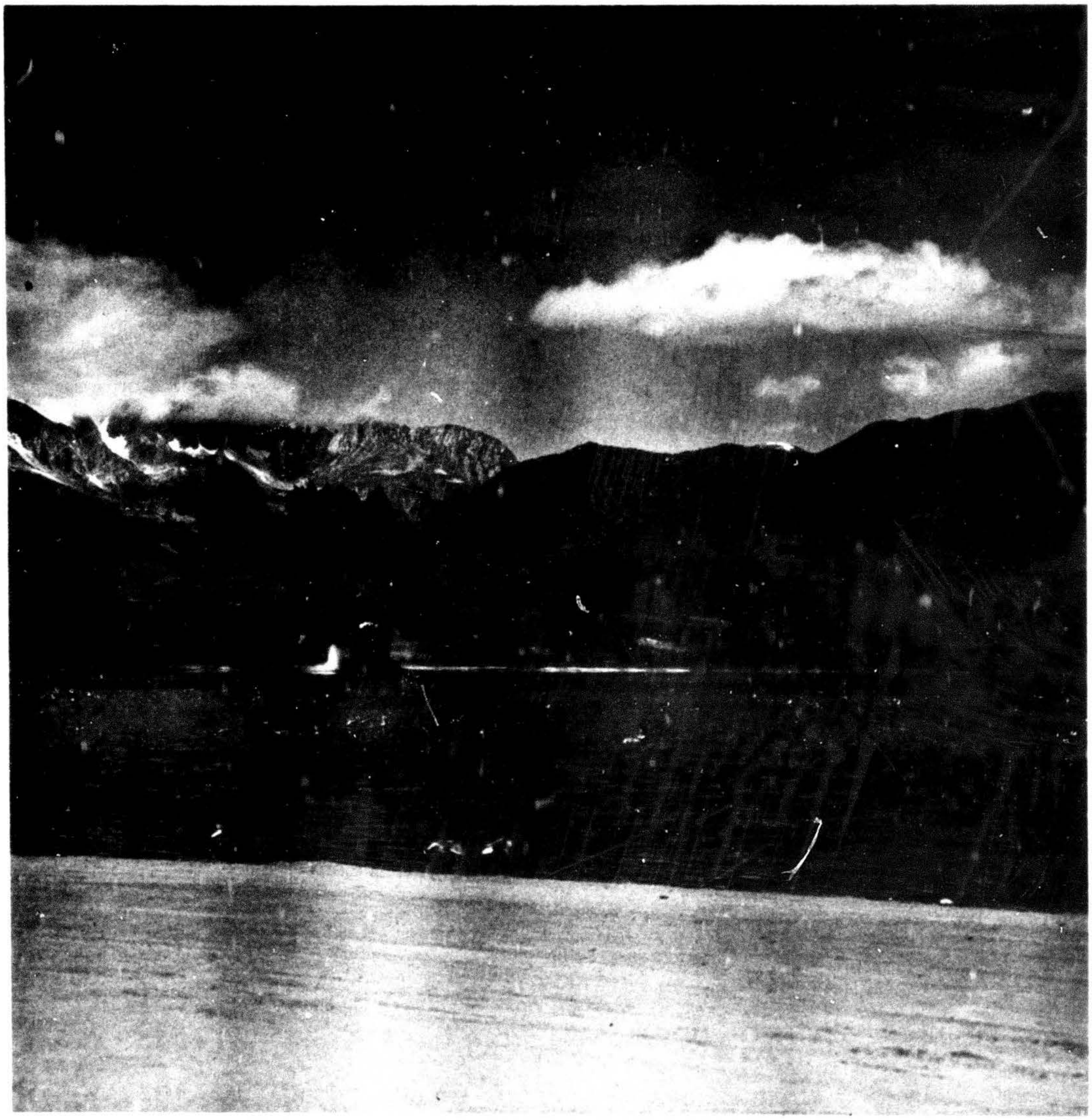


Fig. 12. Photo of Plume and Base Surge, Shot 10 (Tower No. 3, -1.04 ft, F-56 Fairchild Camera, 20-in. Lense, T_o + ~1.5 sec)

Fig. 13. Photo of Run-Up, Three-Wave Pattern, Shot 4 (Tower No. 1, -1.04 ft, F-56 Fairchild Camera, 8.25-in. Lense, T_o + ~2.75 min)

Fig. 14. Photo of Run-Up, Two-Wave Pattern, Shot 10 (Tower No. 3, -1.04 ft, F-56 Fairchild Camera, 20-in. Lense, T_o + ~2.45 min)

Fig. 15a. Photo of Wave Generation, Shot 4 (T_o + ~42 sec)

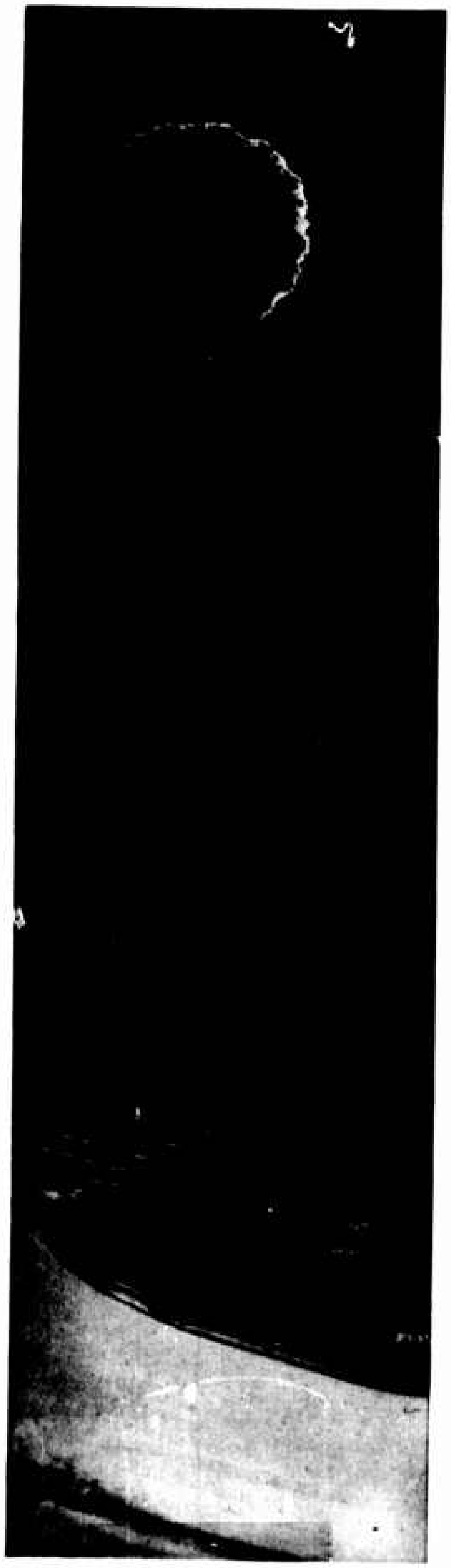


Fig. 15b. Photo of Wave Run-Up, Shot 4 (T_o + ~4.1 min)

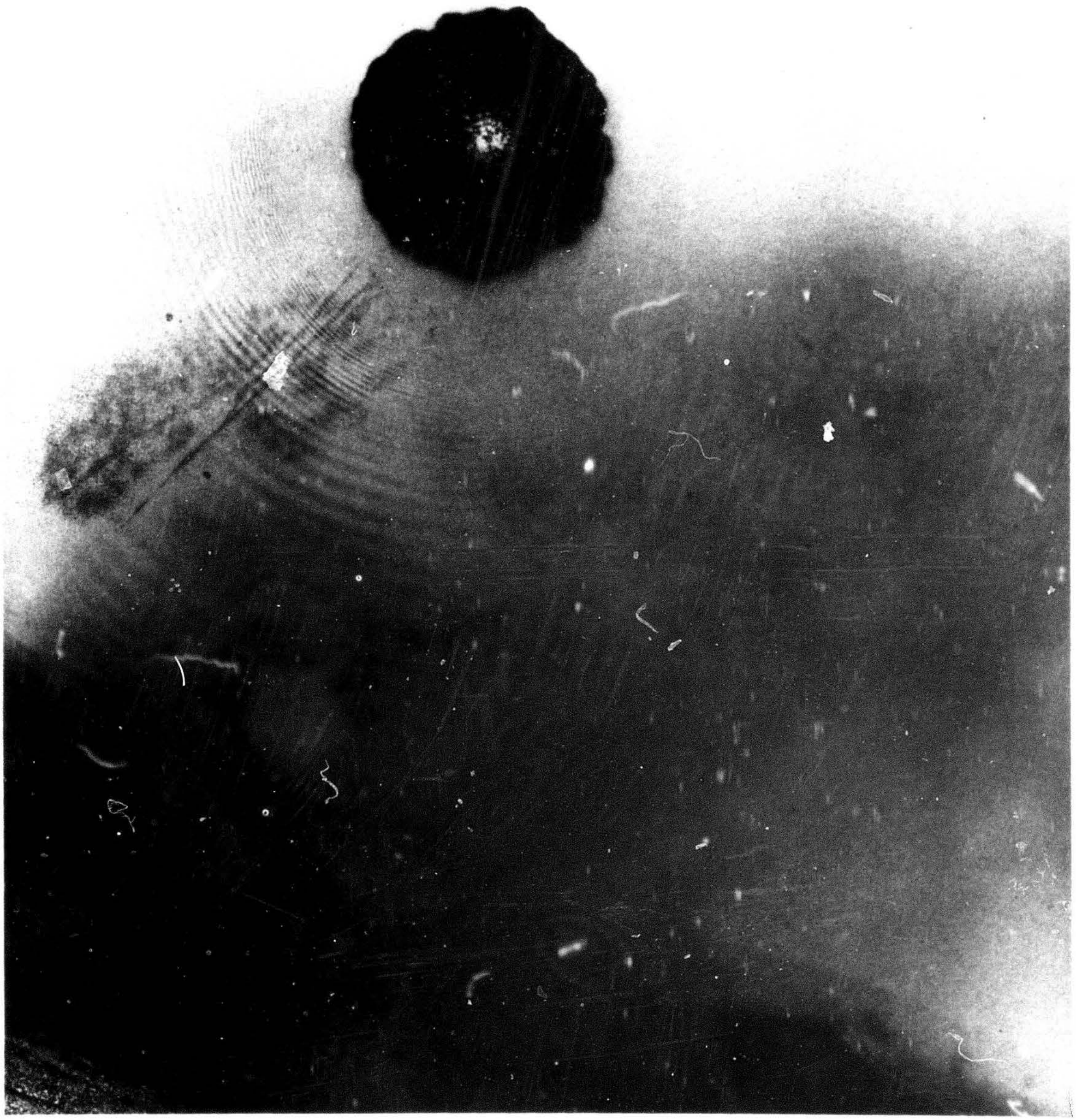
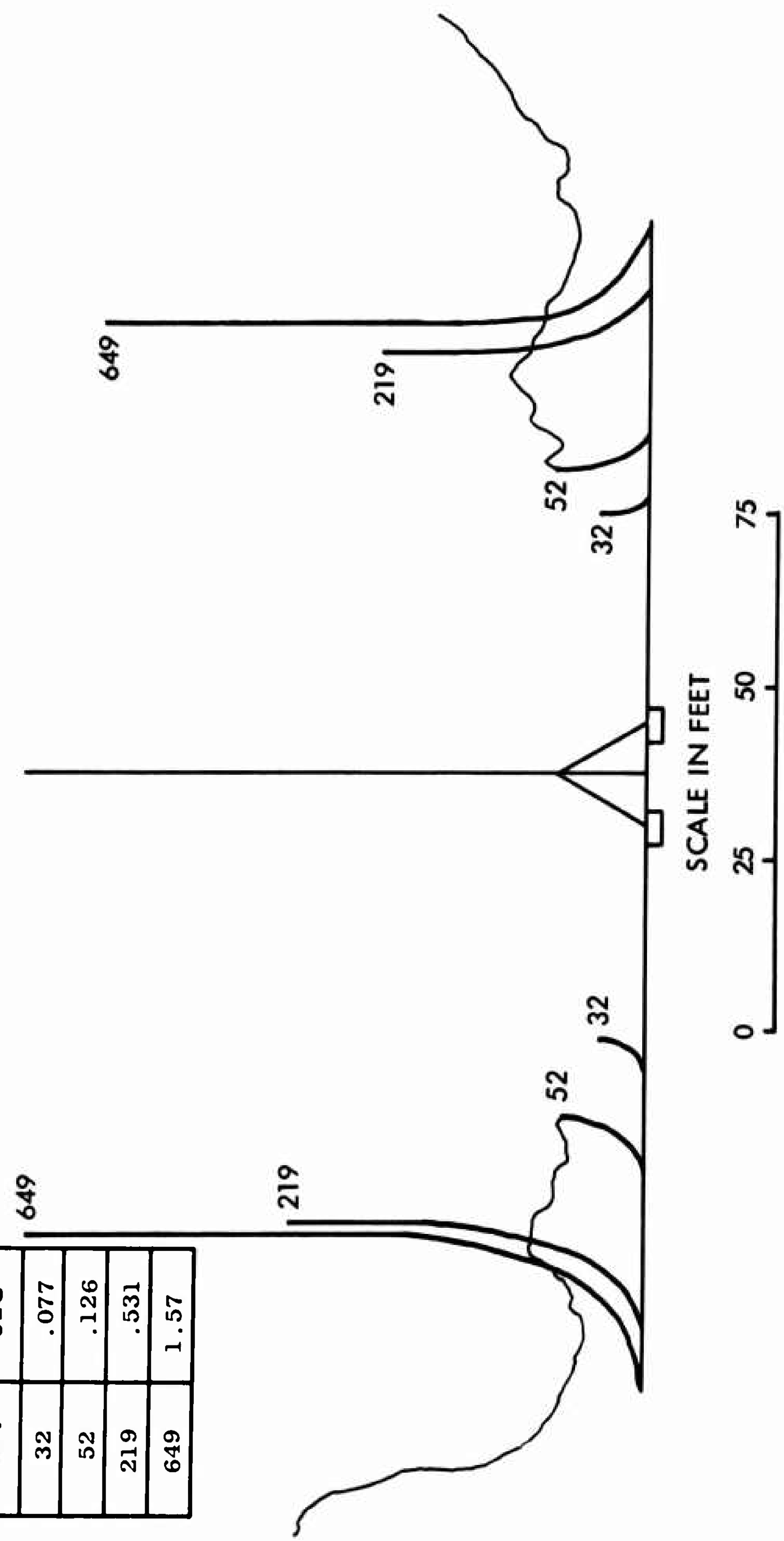


Fig. 16. Photo of Wave Generation, Shot 8 (10,200 ft Altitude, -51.5 ft, T_o + ~2.81 min)

Fig. 17. Photo of Wave Run-Up, Shot 8 (10,200 ft Altitude, -51.5 ft, $T_o + \sim 4.48$ min)

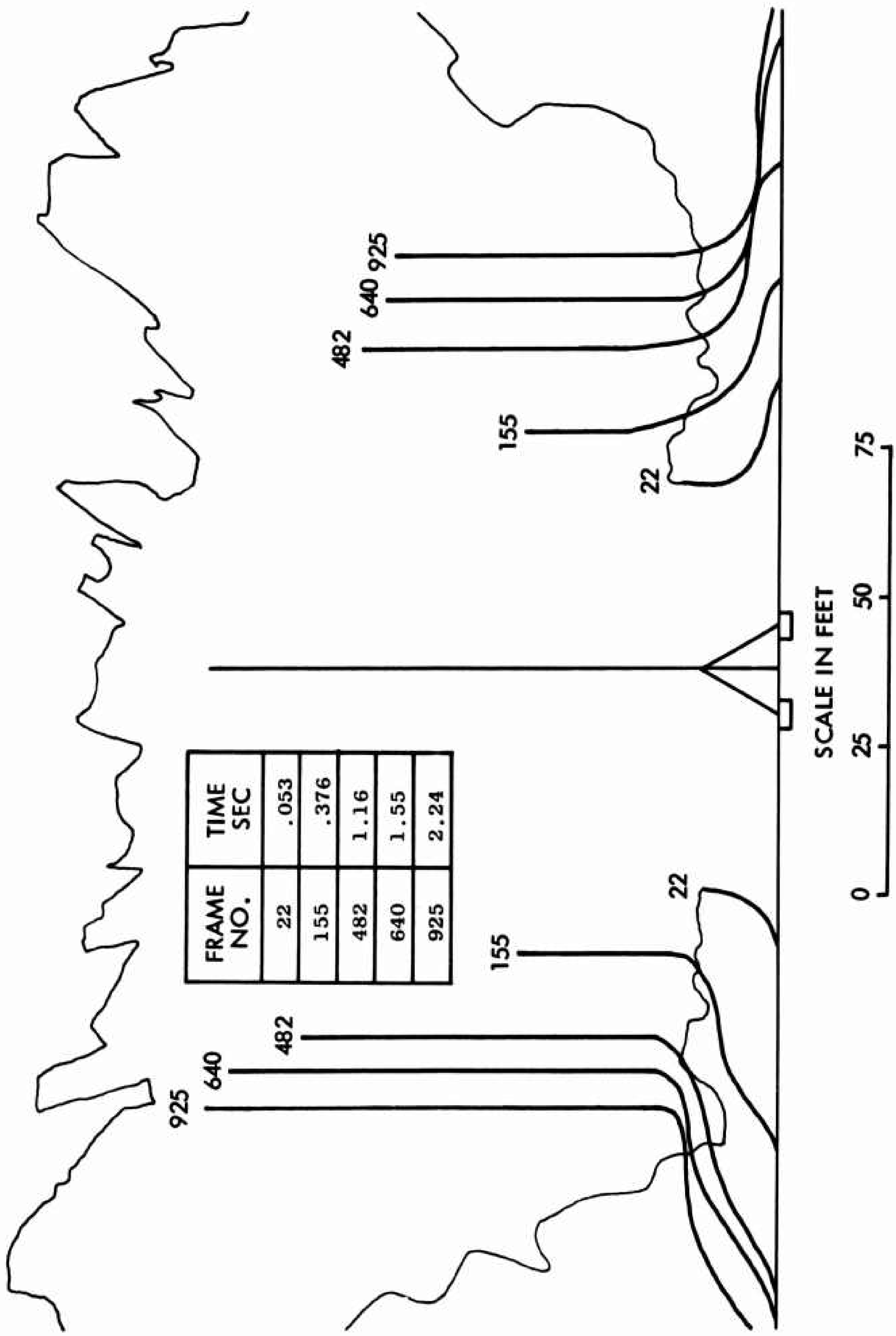
Appendix A

TRACINGS OF PLUME AND BASE SURGE



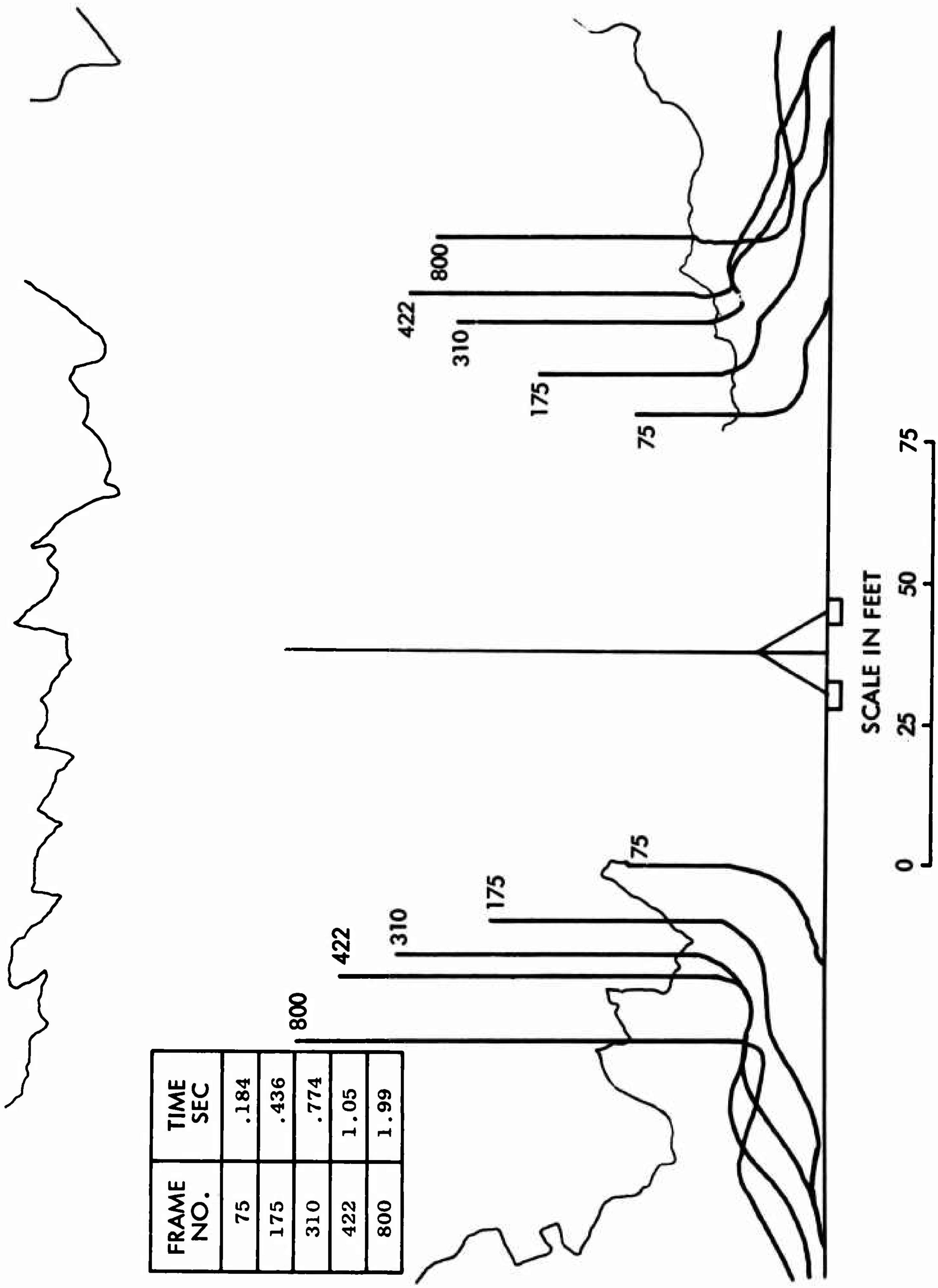
FRAME NO.	TIME SEC
32	.077
52	.126
219	.531
649	1.57

Shot 1, Fastax, Tower No. 1



FRAME NO.	TIME SEC
22	.053
155	.376
482	1.16
640	1.55
925	2.24

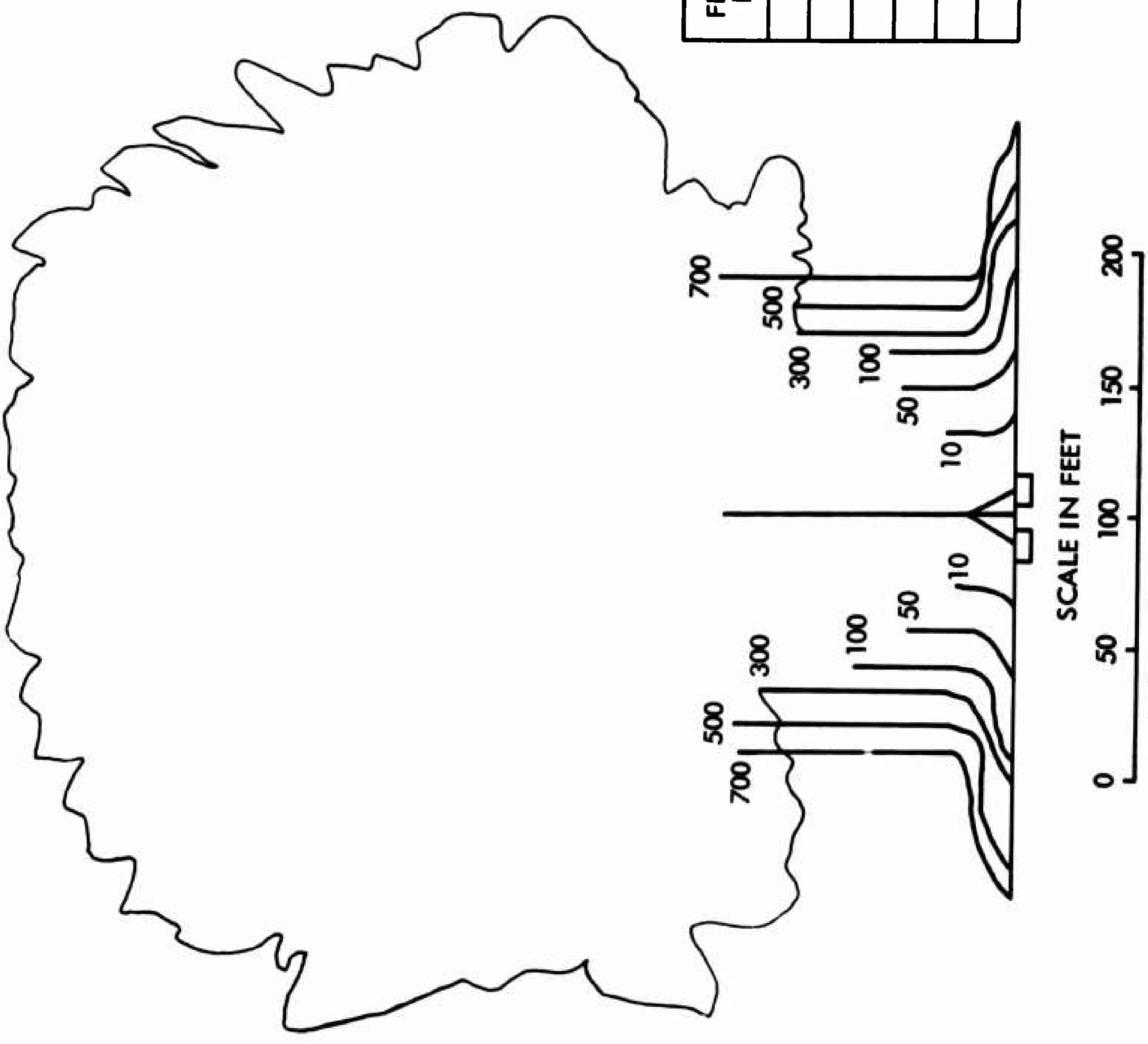
Shot 2, Fastax, Tower No. 1



FRAME NO.	TIME SEC
75	.184
175	.436
310	.774
422	1.05
800	1.99

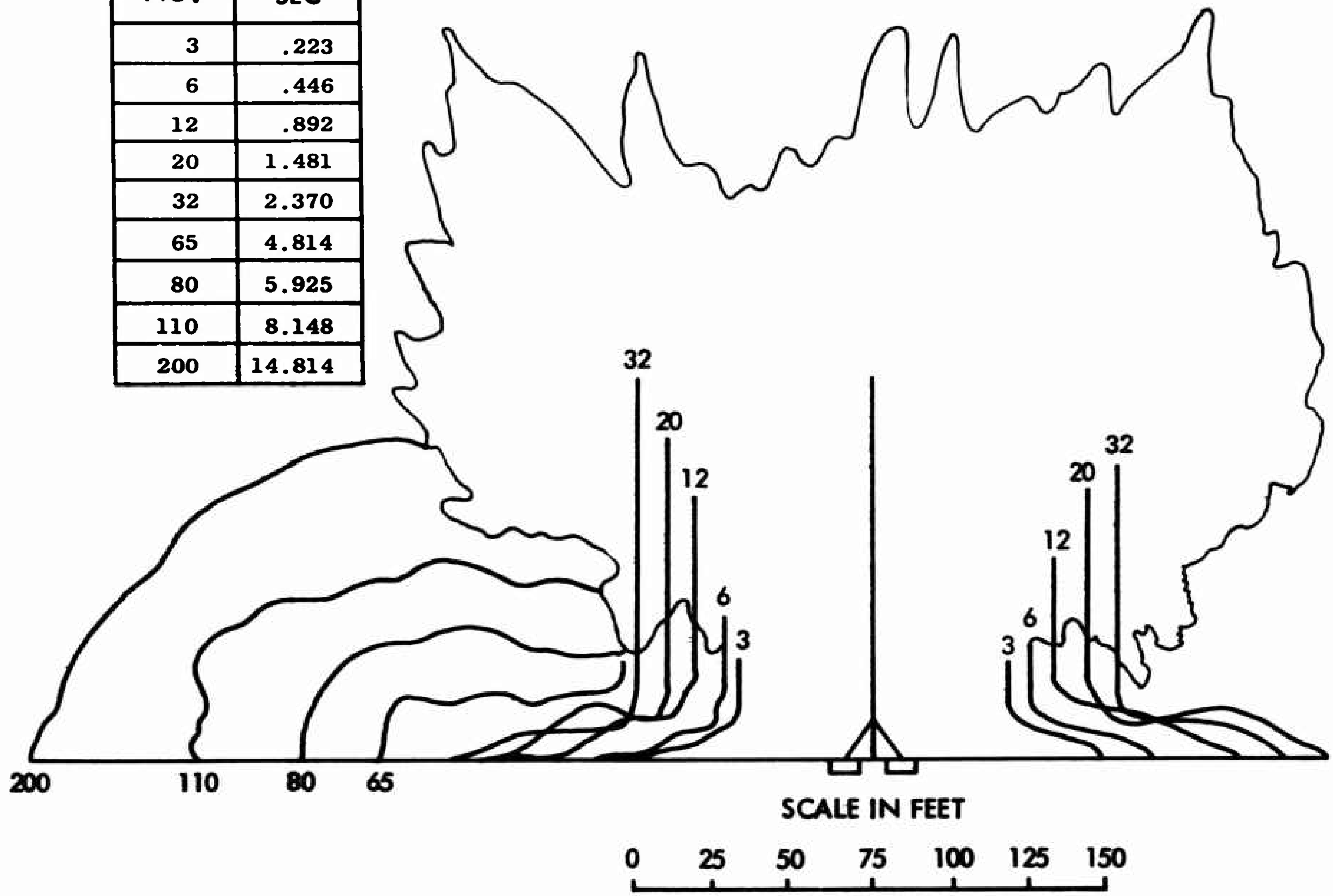
Shot 3, Fastax, Tower No. 1

FRAME NO.	TIME SEC
10	.032
50	.160
100	.320
300	.960
500	1.60
700	2.24

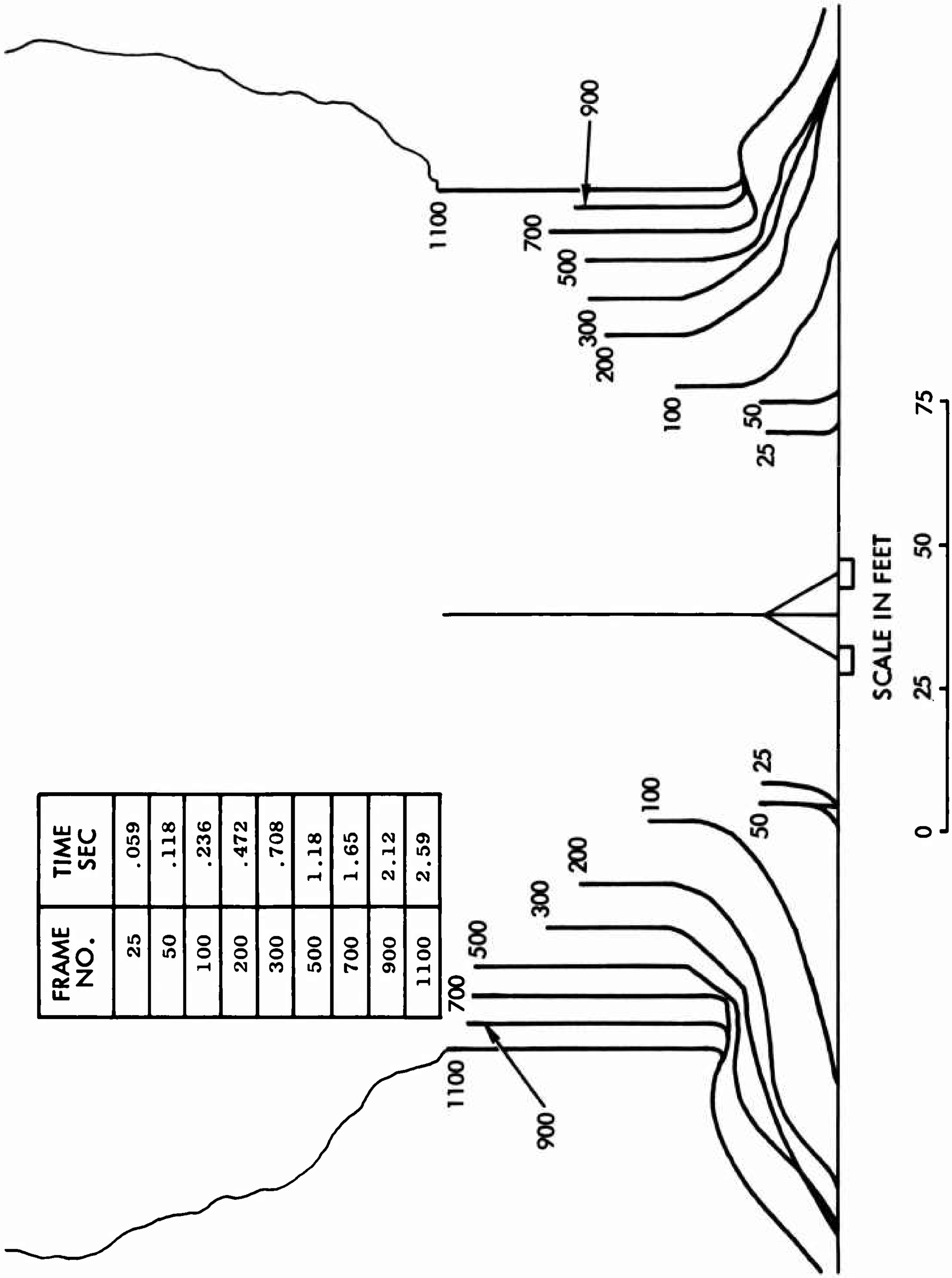


Shot 3, Hycam, Tower No. 3

FRAME NO.	TIME SEC
3	.223
6	.446
12	.892
20	1.481
32	2.370
65	4.814
80	5.925
110	8.148
200	14.814

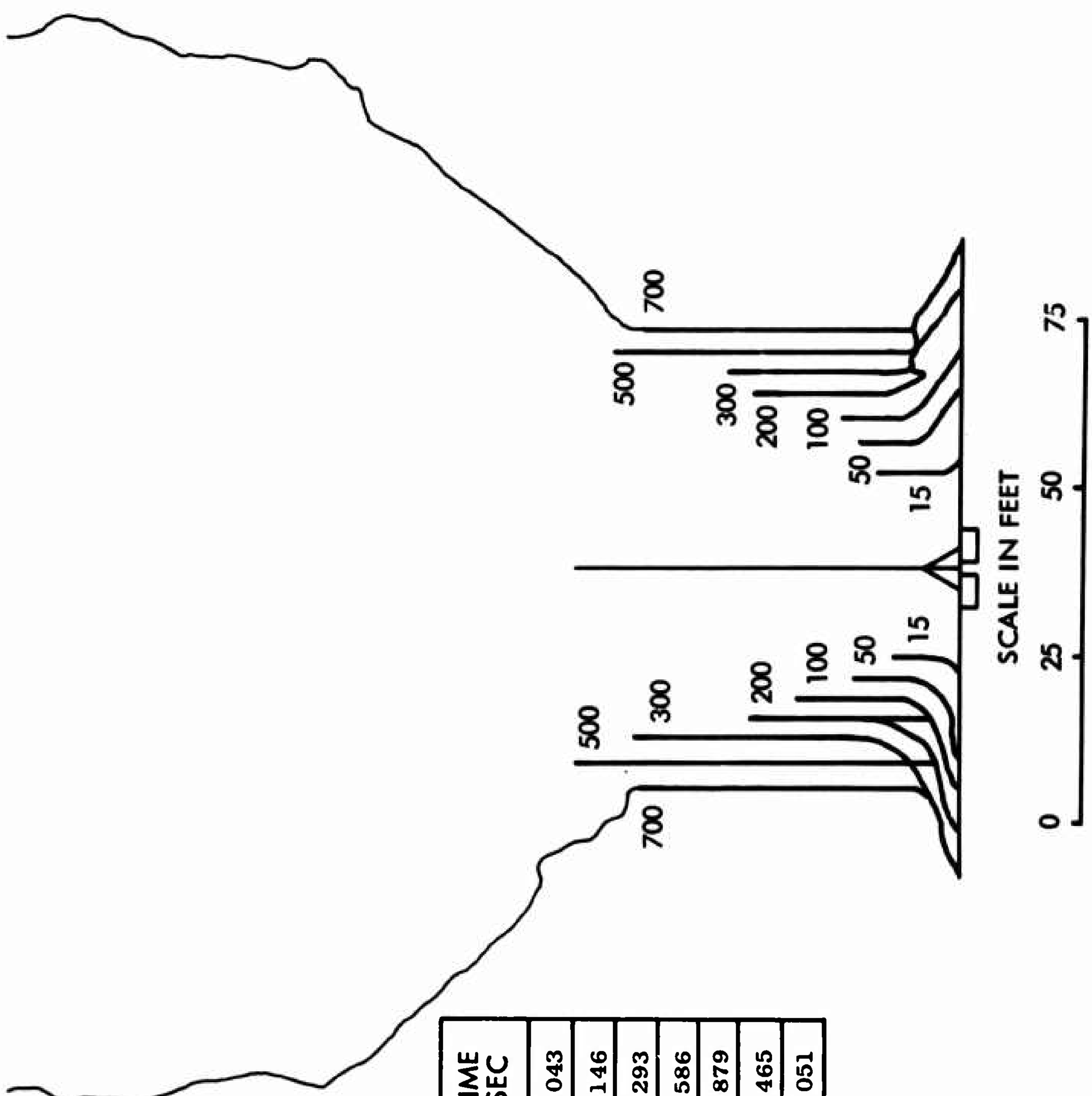


Shot 3, GSAP Camera, Tower No. 1



FRAME NO.	TIME SEC
25	.059
50	.118
100	.236
200	.472
300	.708
500	1.18
700	1.65
900	2.12
1100	2.59

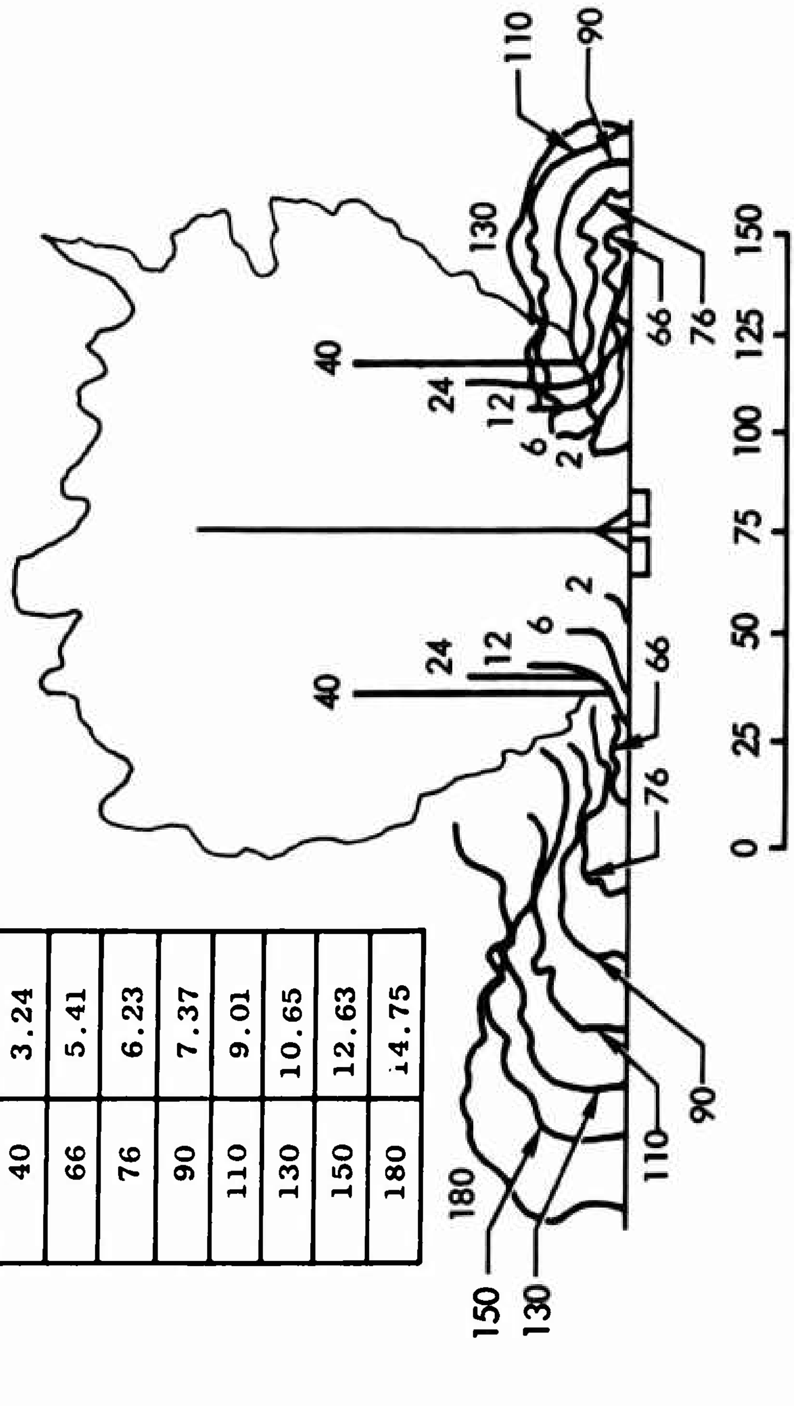
Shot 4, Fastax, Tower No. 1



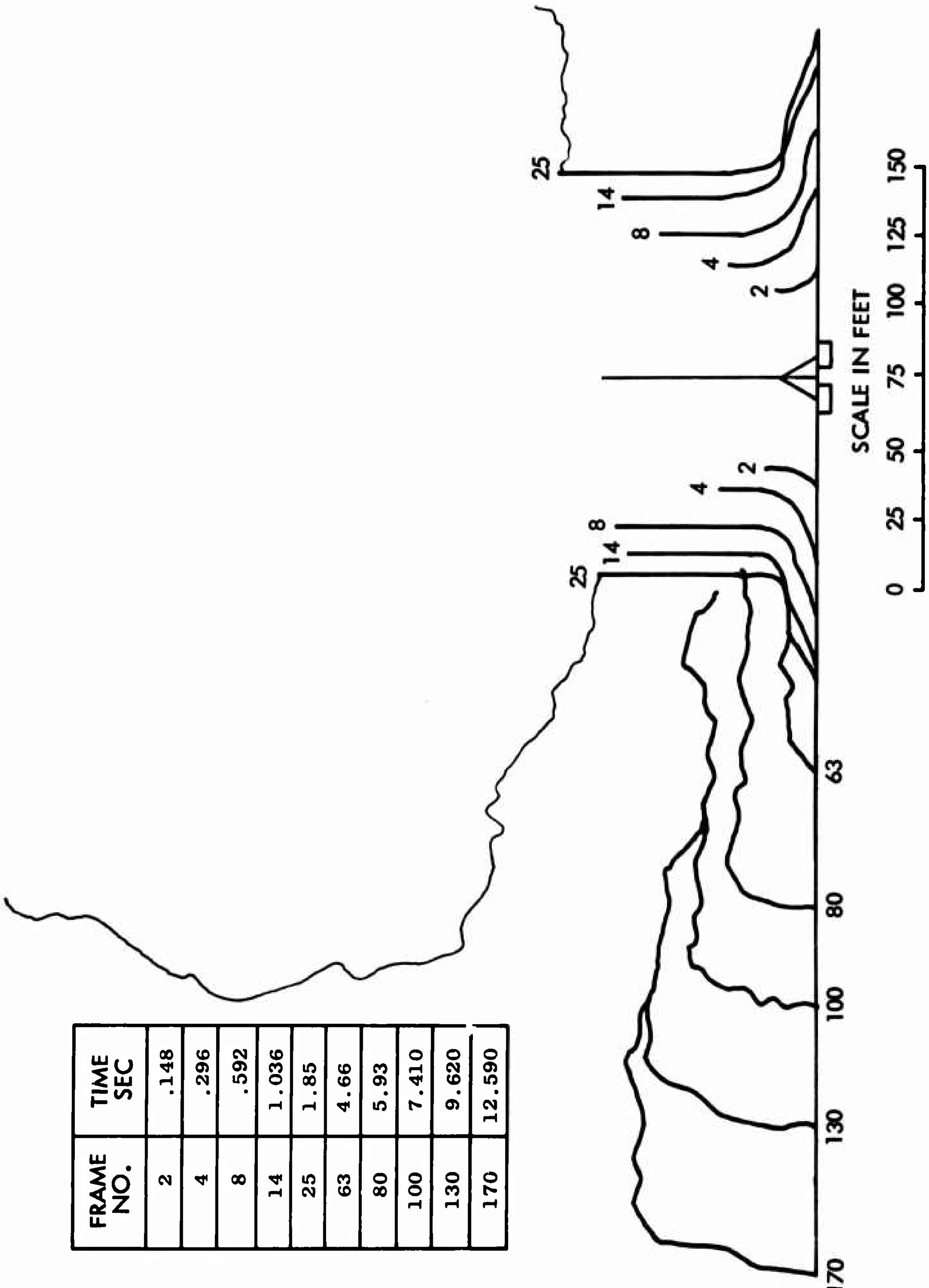
FRAME NO.	TIME SEC
15	.043
50	.146
100	.293
200	.586
300	.879
500	1.465
700	2.051

Shot 4, Hycam, Tower No. 3

FRAME NO.	TIME SEC
2	.163
6	.491
12	.983
24	1.96
40	3.24
66	5.41
76	6.23
90	7.37
110	9.01
130	10.65
150	12.63
180	14.75

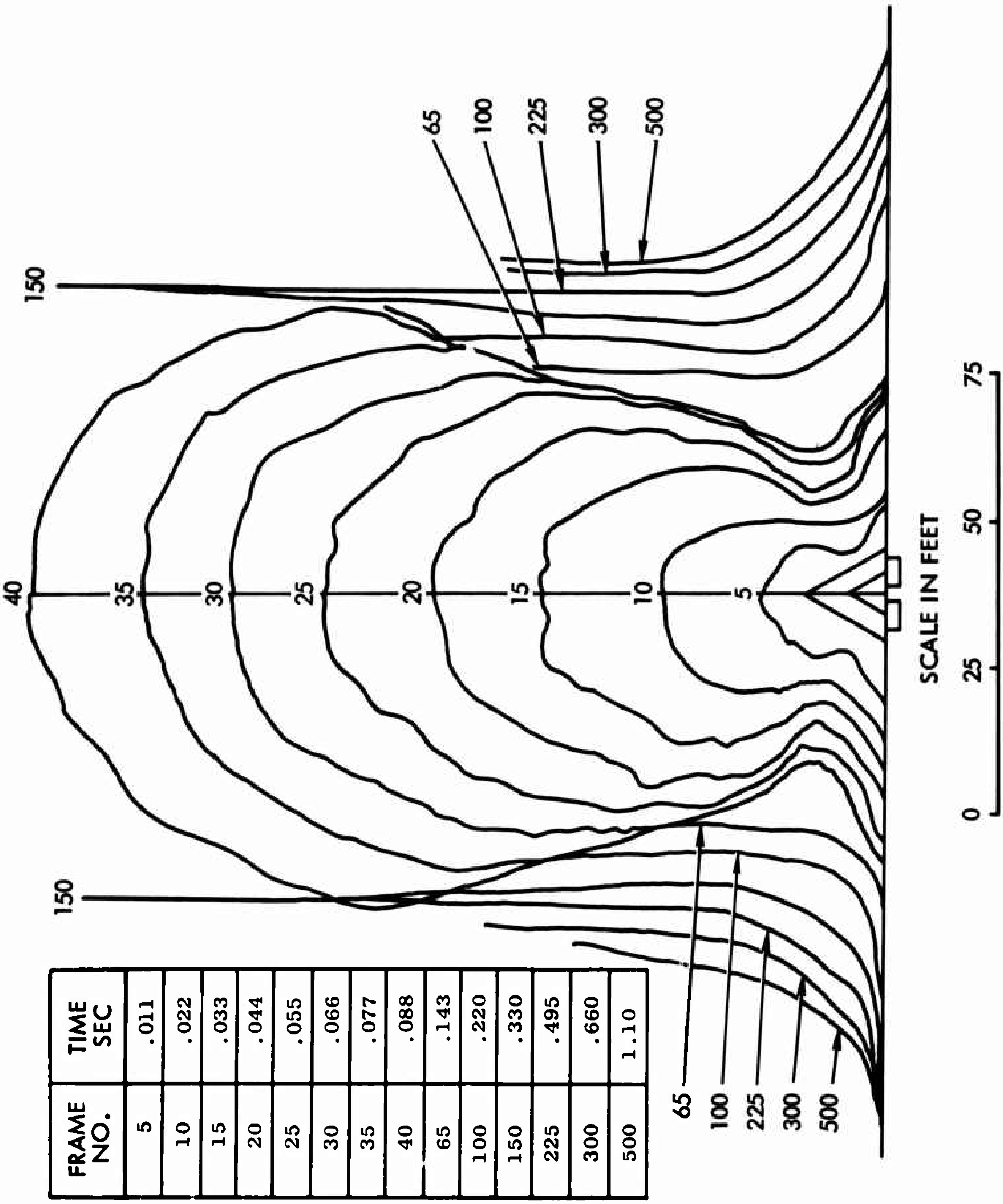


Shot 4, GSAP Camera, Tower No. 3



FRAME NO.	TIME SEC
2	.148
4	.296
8	.592
14	1.036
25	1.85
63	4.66
80	5.93
100	7.410
130	9.620
170	12.590

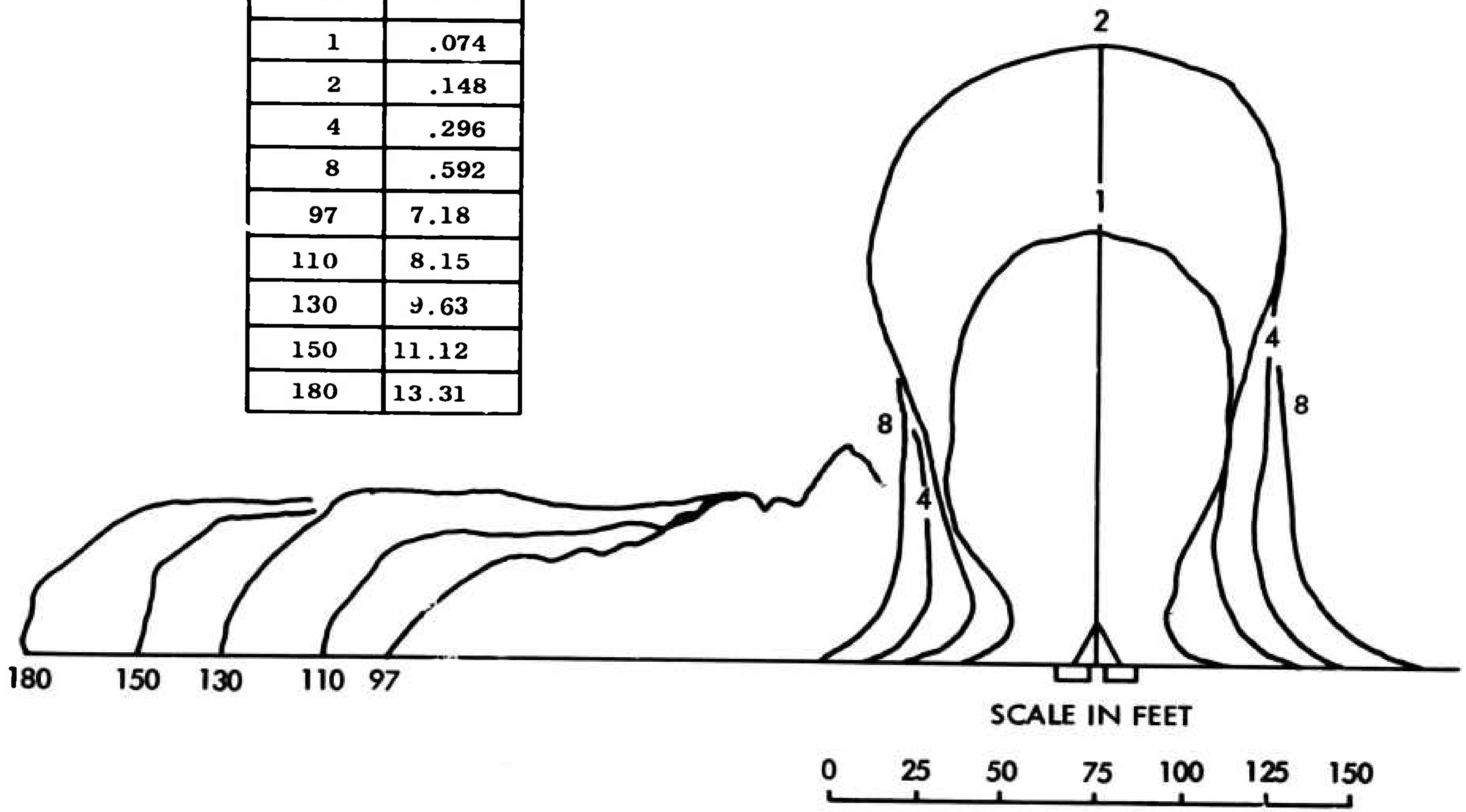
Shot 4, GSAP Camera, Tower No. 1



FRAME NO.	TIME SEC
5	.011
10	.022
15	.033
20	.044
25	.055
30	.066
35	.077
40	.088
65	.143
100	.220
150	.330
225	.495
300	.660
500	1.10

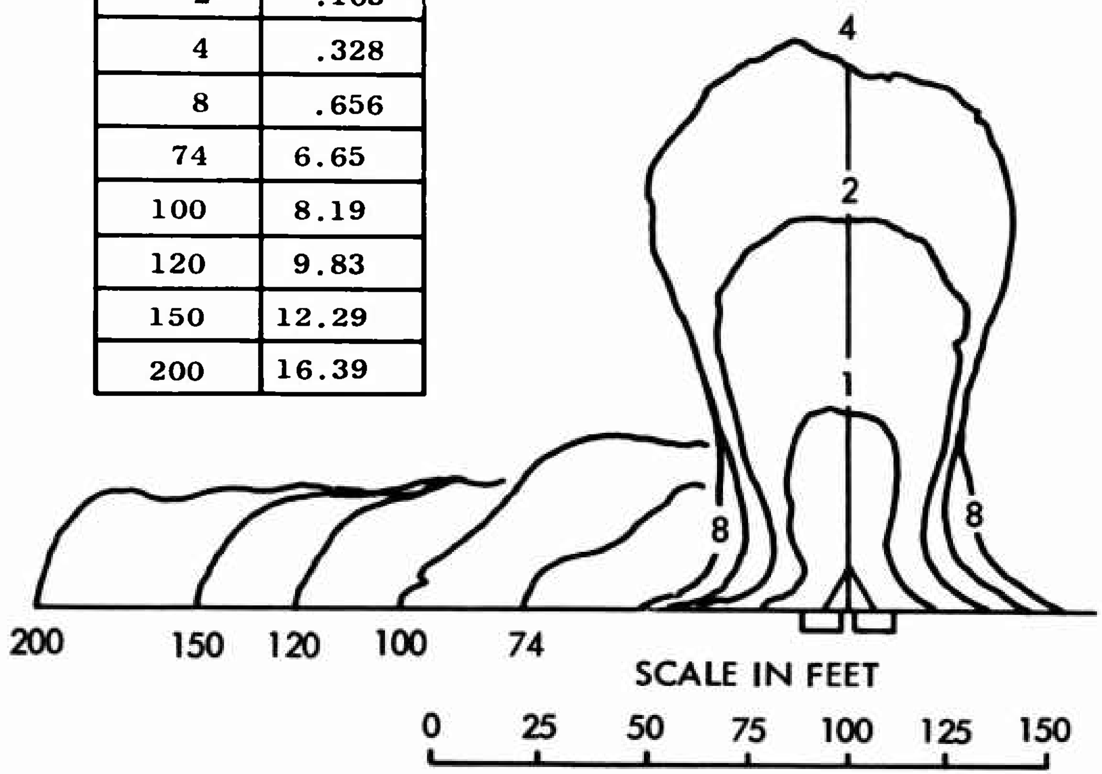
Shot 5, Fastax, Tower No. 1

FRAME NO.	TIME SEC
1	.074
2	.148
4	.296
8	.592
97	7.18
110	8.15
130	9.63
150	11.12
180	13.31



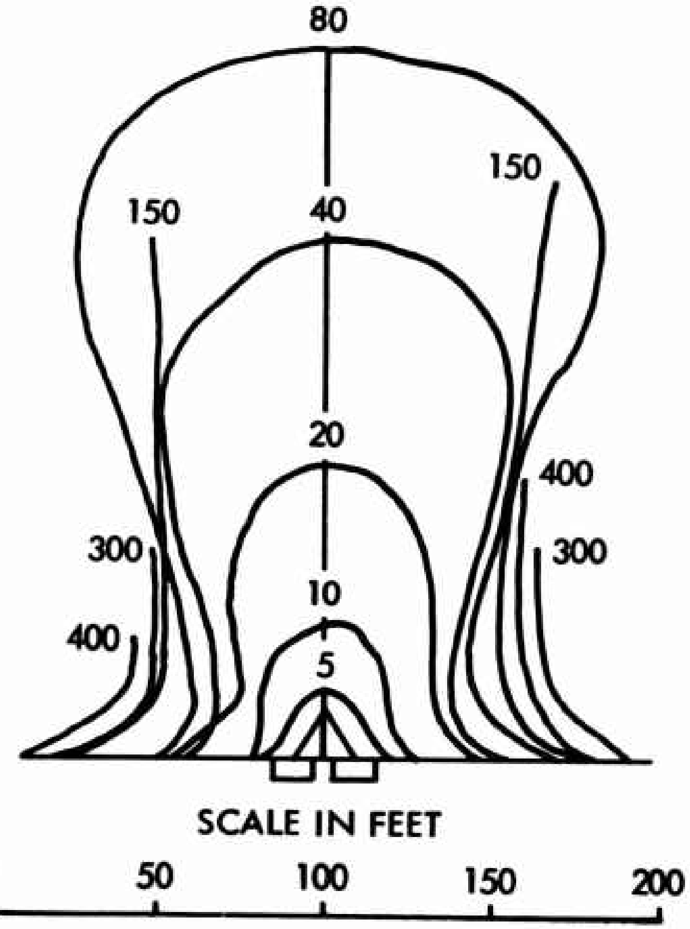
Shot 5, GSAP Camera, Tower No. 1

FRAME NO.	TIME SEC
1	.081
2	.163
4	.328
8	.656
74	6.65
100	8.19
120	9.83
150	12.29
200	16.39

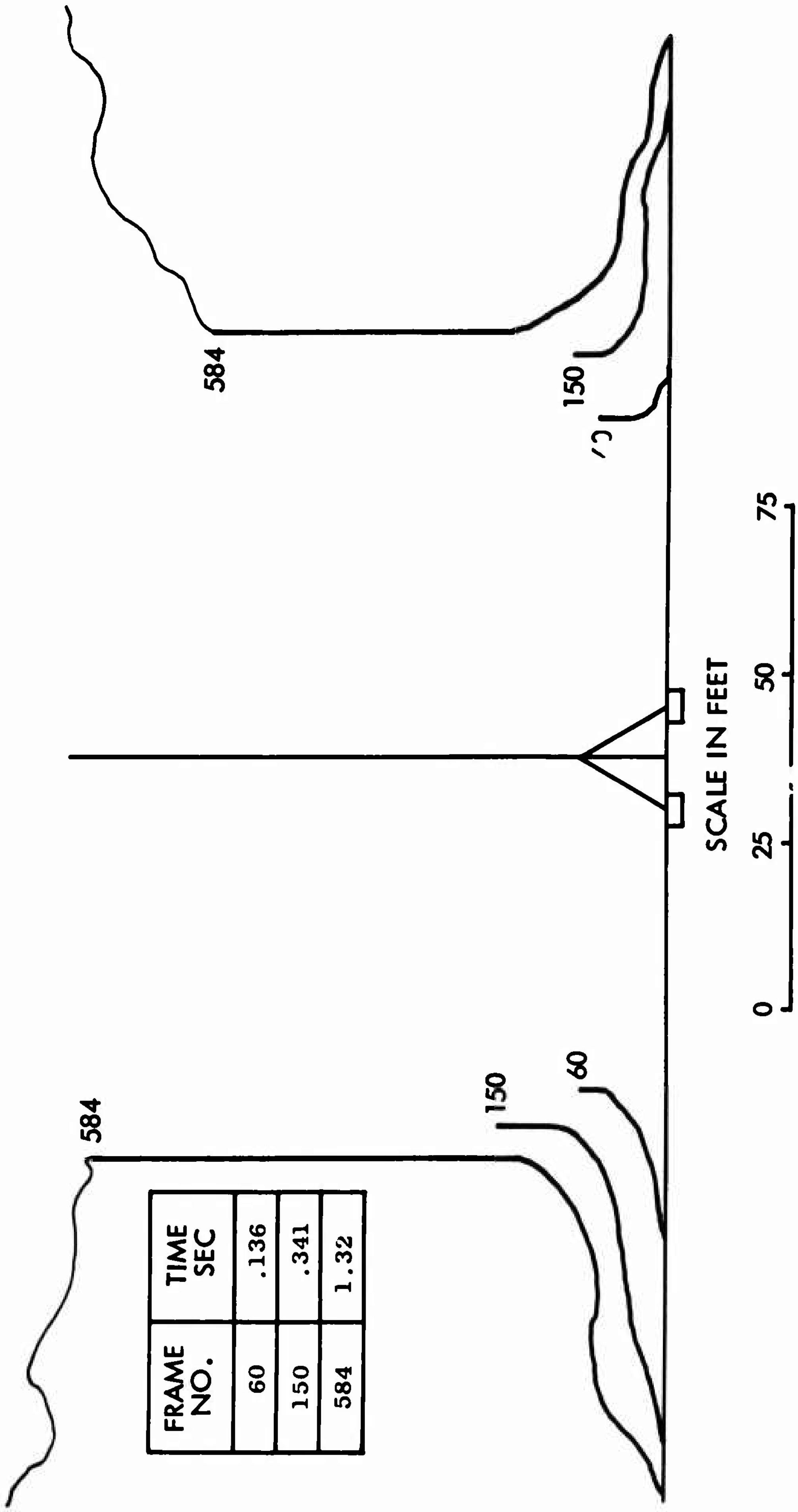


Shot 5, GSAP Camera, Tower No. 3

FRAME NO.	TIME SEC
5	.011
10	.023
20	.047
40	.095
80	.190
150	.357
300	.714
400	.952

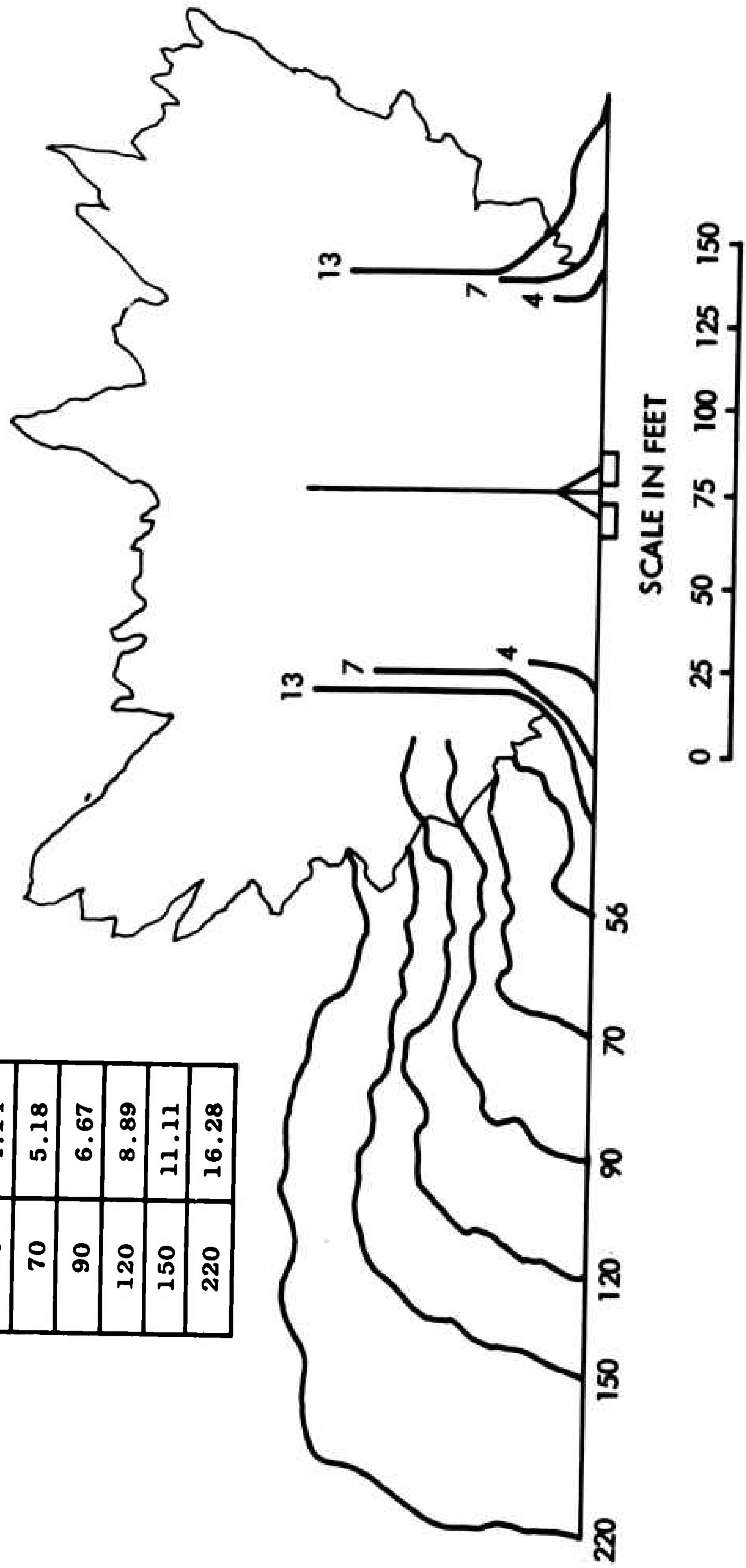


Shot 5, Hycam, Tower No. 3



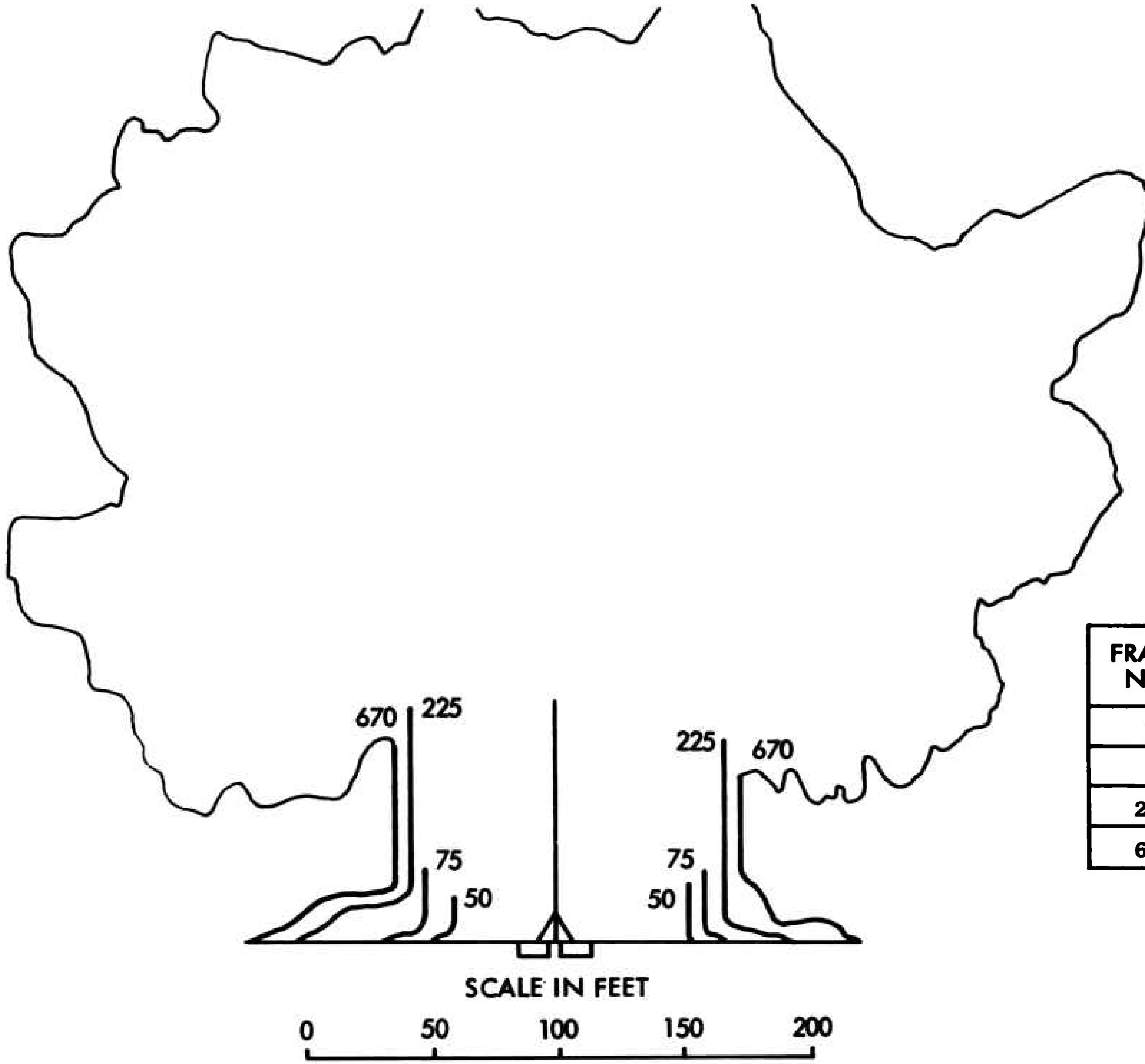
FRAME NO.	TIME SEC
60	.136
150	.341
584	1.32

Shot 6, Fastax, Tower No. 1



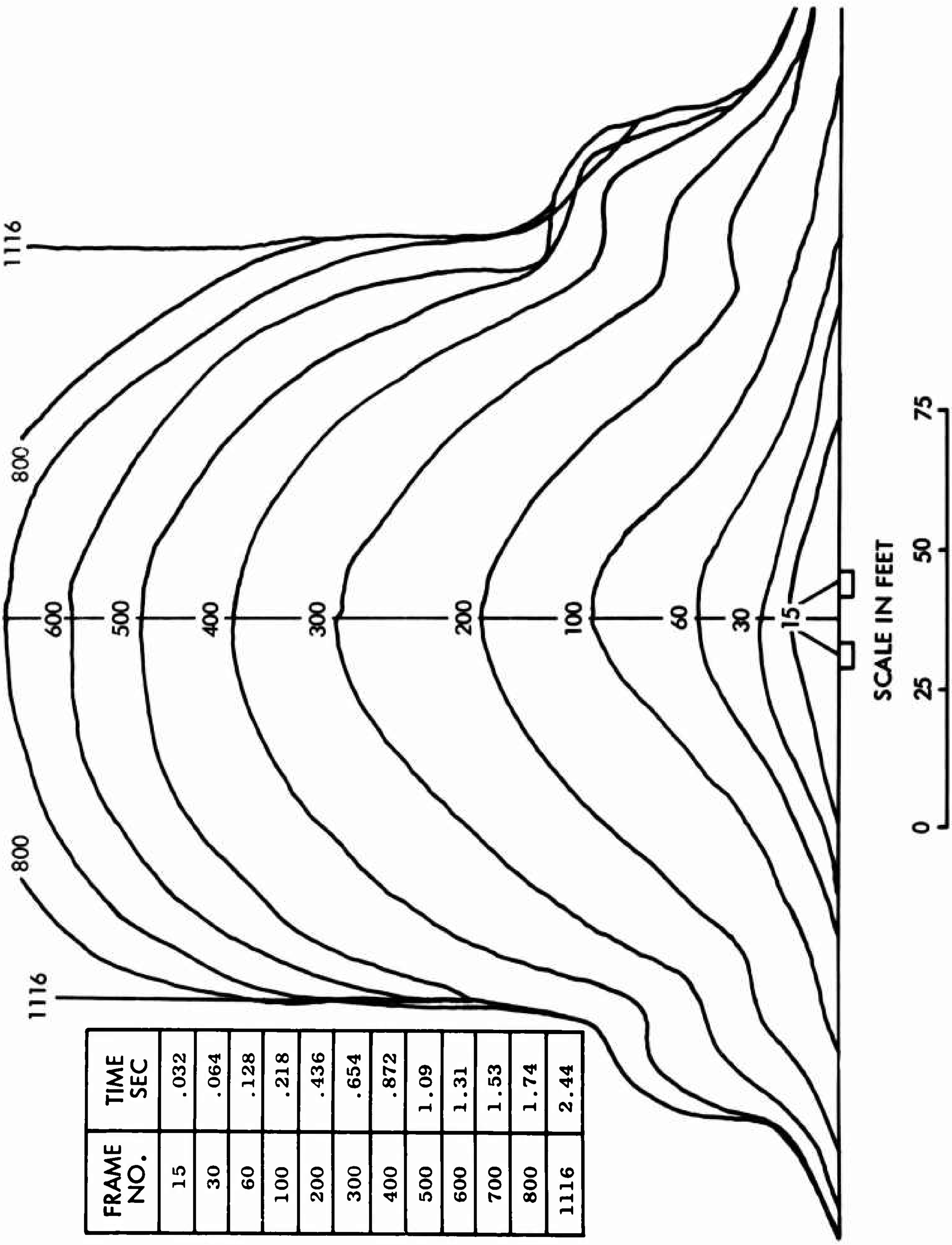
FRAME NO.	TIME SEC
4	.296
7	.528
13	.963
56	4.14
70	5.18
90	6.67
120	8.89
150	11.11
220	16.28

Shot 6, GSAP Camera, Tower No. 1



FRAME NO.	TIME SEC
50	.118
75	.177
225	.531
670	1.583

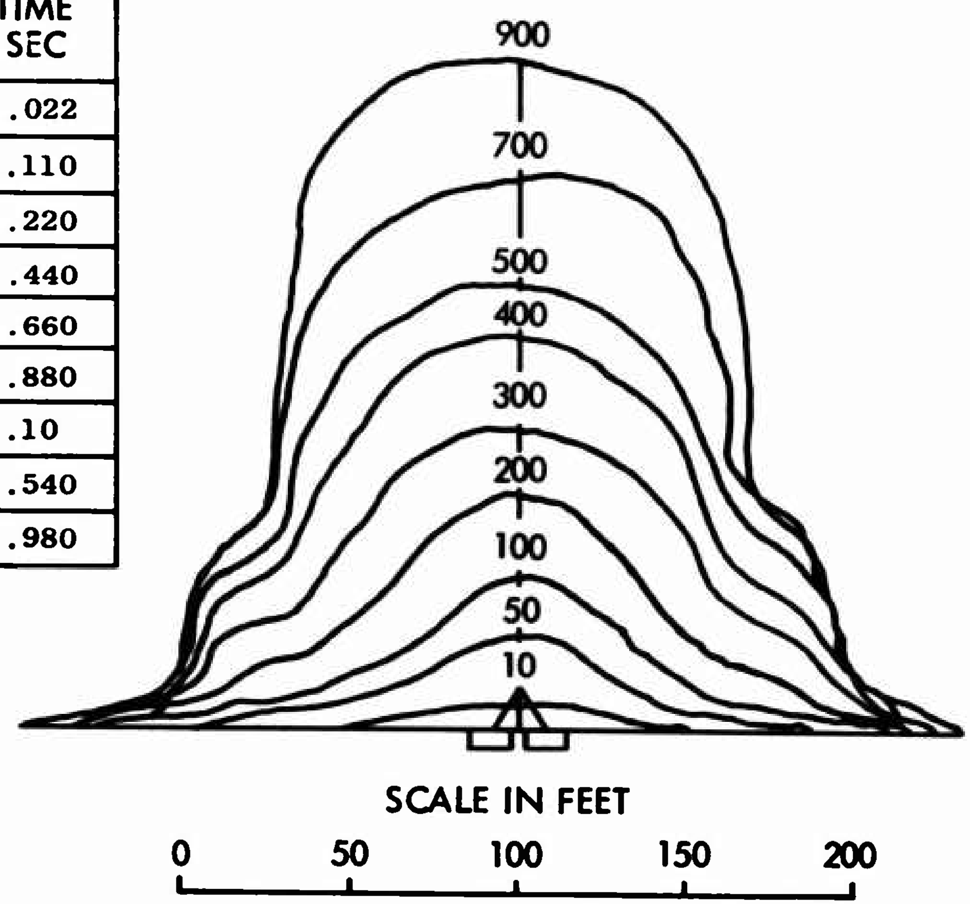
Shot 6, Hycam, Tower No. 3



FRAME NO.	TIME SEC
15	.032
30	.064
60	.128
100	.218
200	.436
300	.654
400	.872
500	1.09
600	1.31
700	1.53
800	1.74
1116	2.44

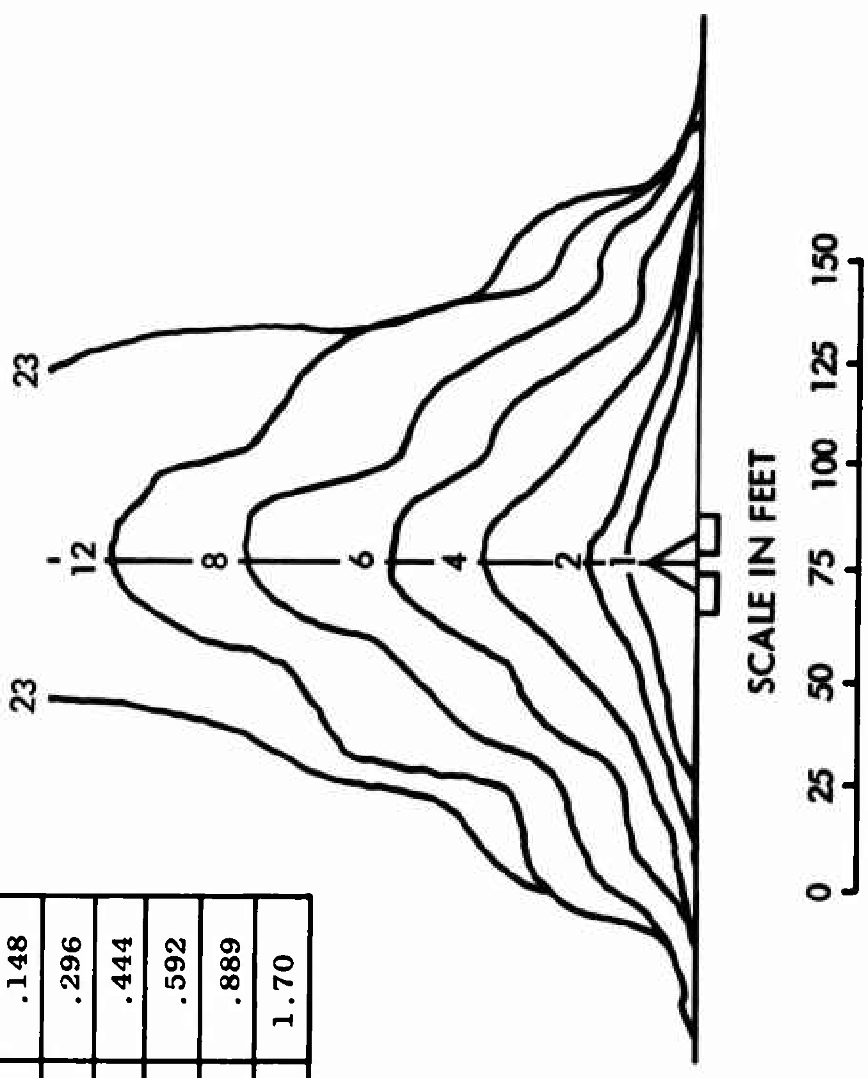
Shot 7, Fastax, Tower No. 1

FRAME NO.	TIME SEC
10	.022
50	.110
100	.220
200	.440
300	.660
400	.880
500	1.10
700	1.540
900	1.980



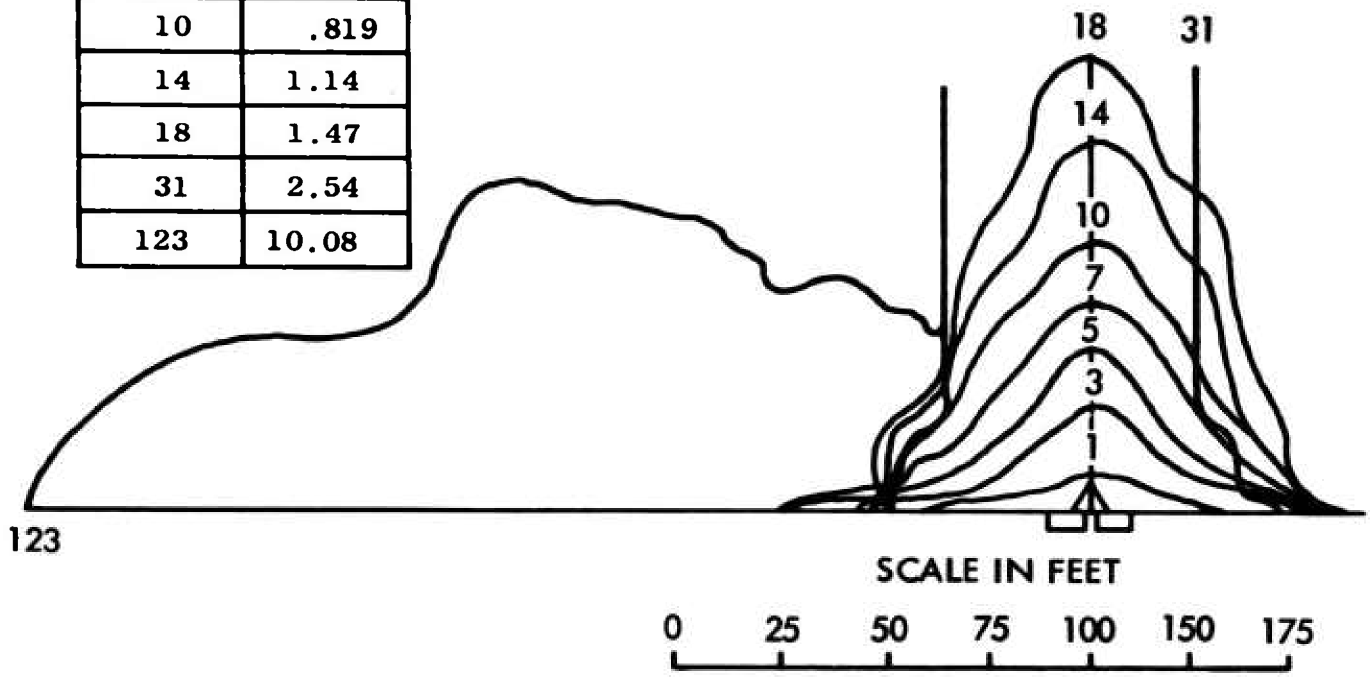
Shot 7, Hycam, Tower No. 3

FRAME NO.	TIME SEC
1	.074
2	.148
4	.296
6	.444
8	.592
12	.889
23	1.70

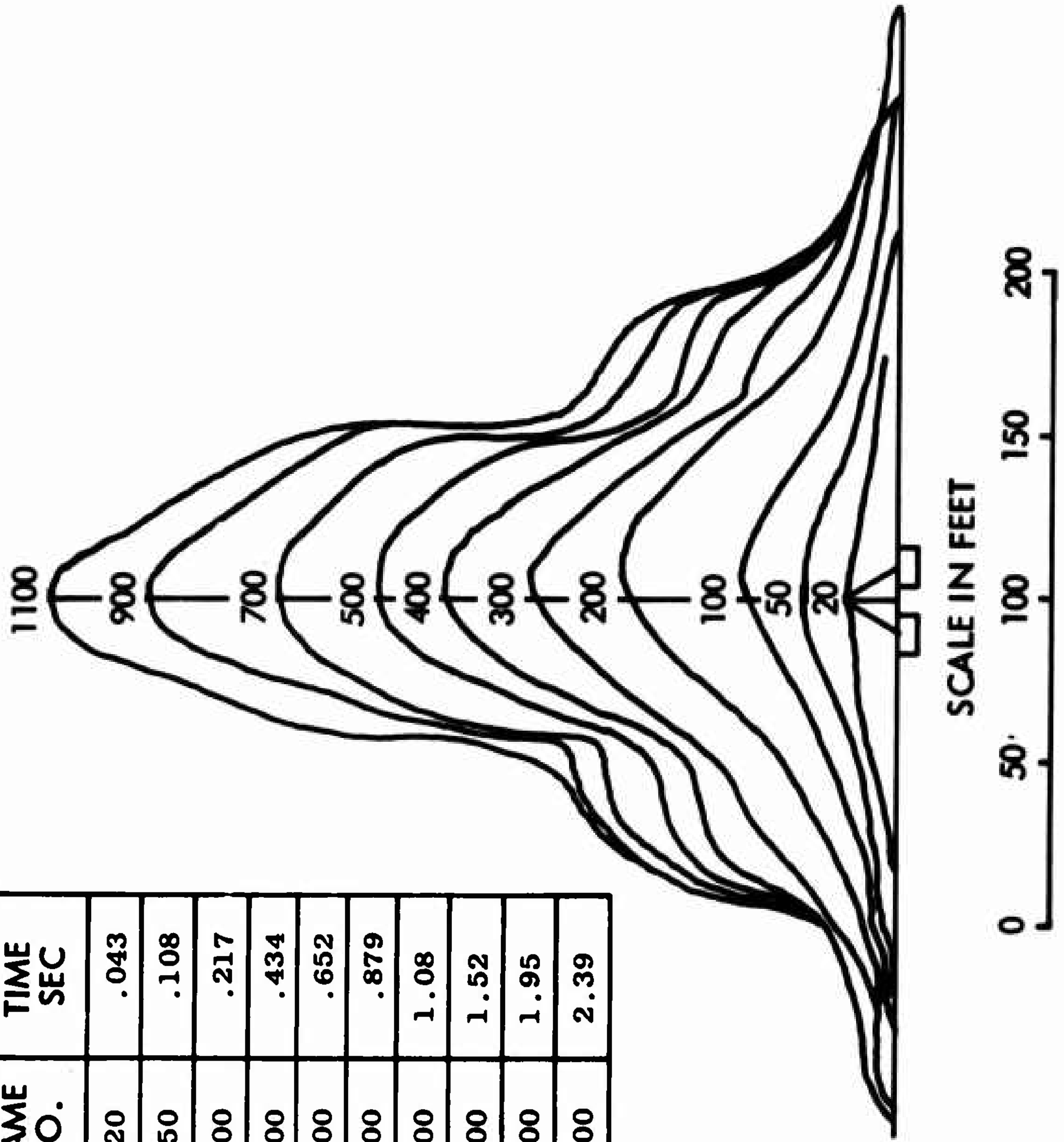


Shot 7, GSAP Camera, Tower No. 1

FRAME NO.	TIME SEC
1	.081
3	.245
5	.409
7	.573
10	.819
14	1.14
18	1.47
31	2.54
123	10.08



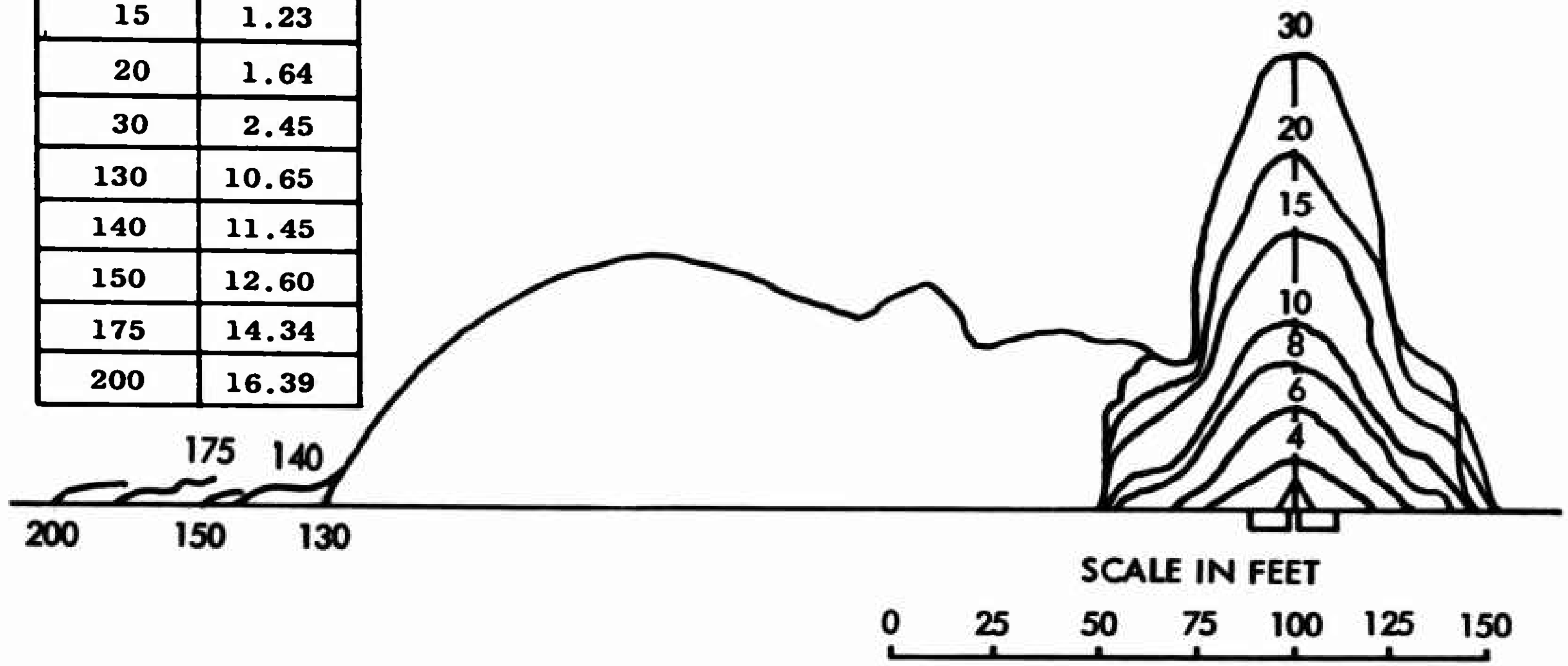
Shot 7, GSAP Camera, Tower No. 3



FRAME NO.	TIME SEC
20	.043
50	.108
100	.217
200	.434
300	.652
400	.879
500	1.08
700	1.52
900	1.95
1100	2.39

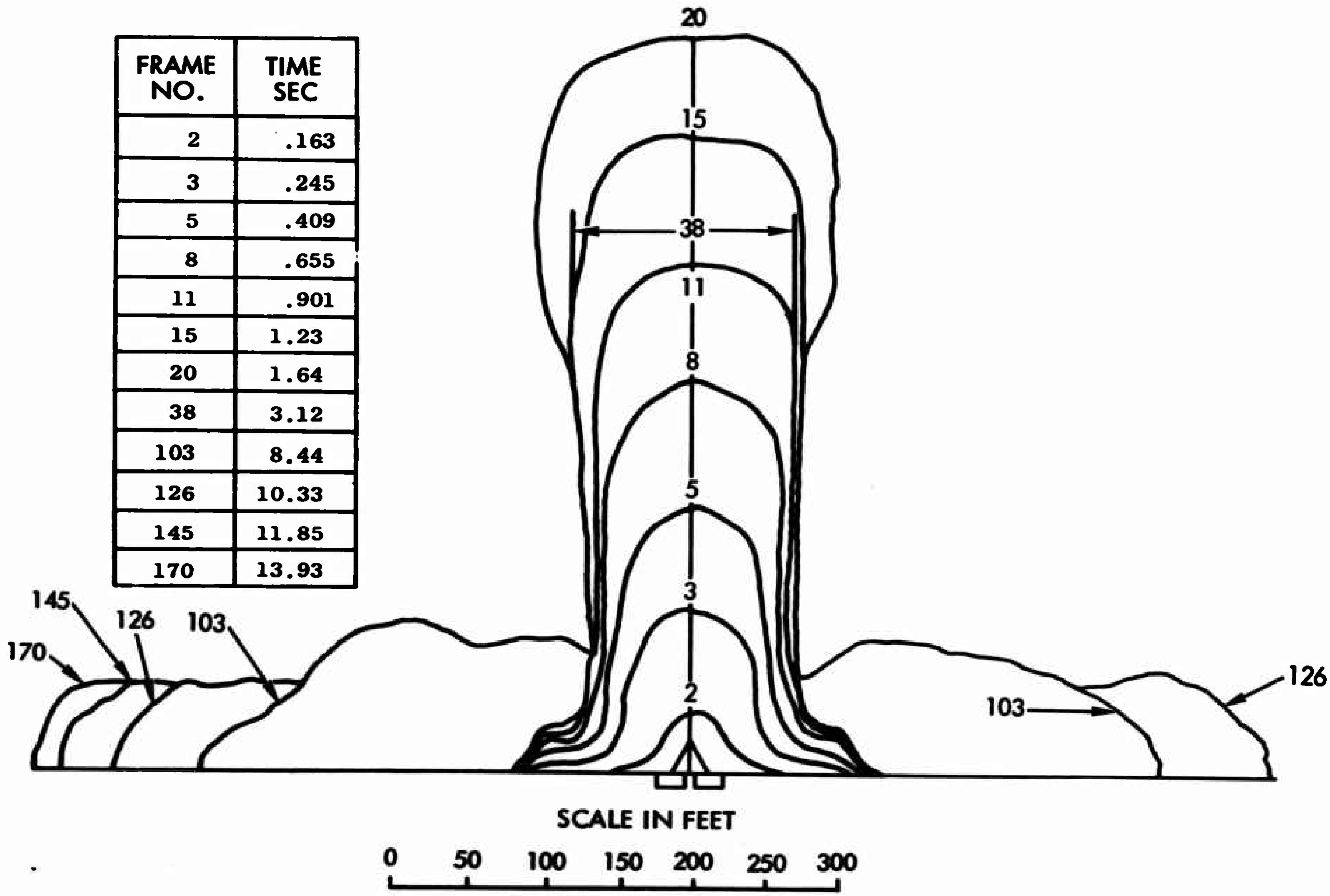
Shot 8, Hycam, Tower No. 3

FRAME NO.	TIME SEC
4	.326
6	.491
8	.655
10	.819
15	1.23
20	1.64
30	2.45
130	10.65
140	11.45
150	12.60
175	14.34
200	16.39

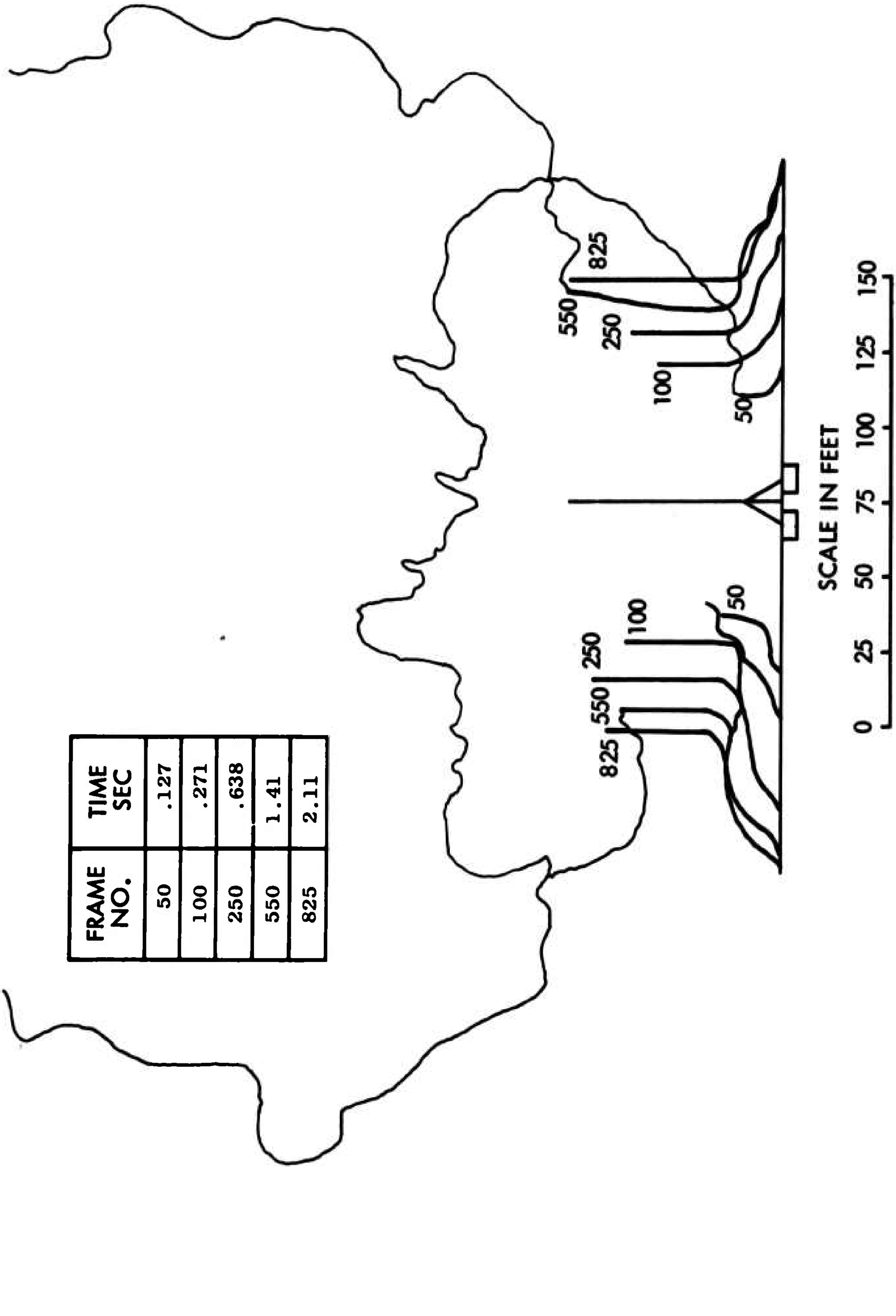


Shot 8, GSAP Camera, Tower No. 3

FRAME NO.	TIME SEC
2	.163
3	.245
5	.409
8	.655
11	.901
15	1.23
20	1.64
38	3.12
103	8.44
126	10.33
145	11.85
170	13.93

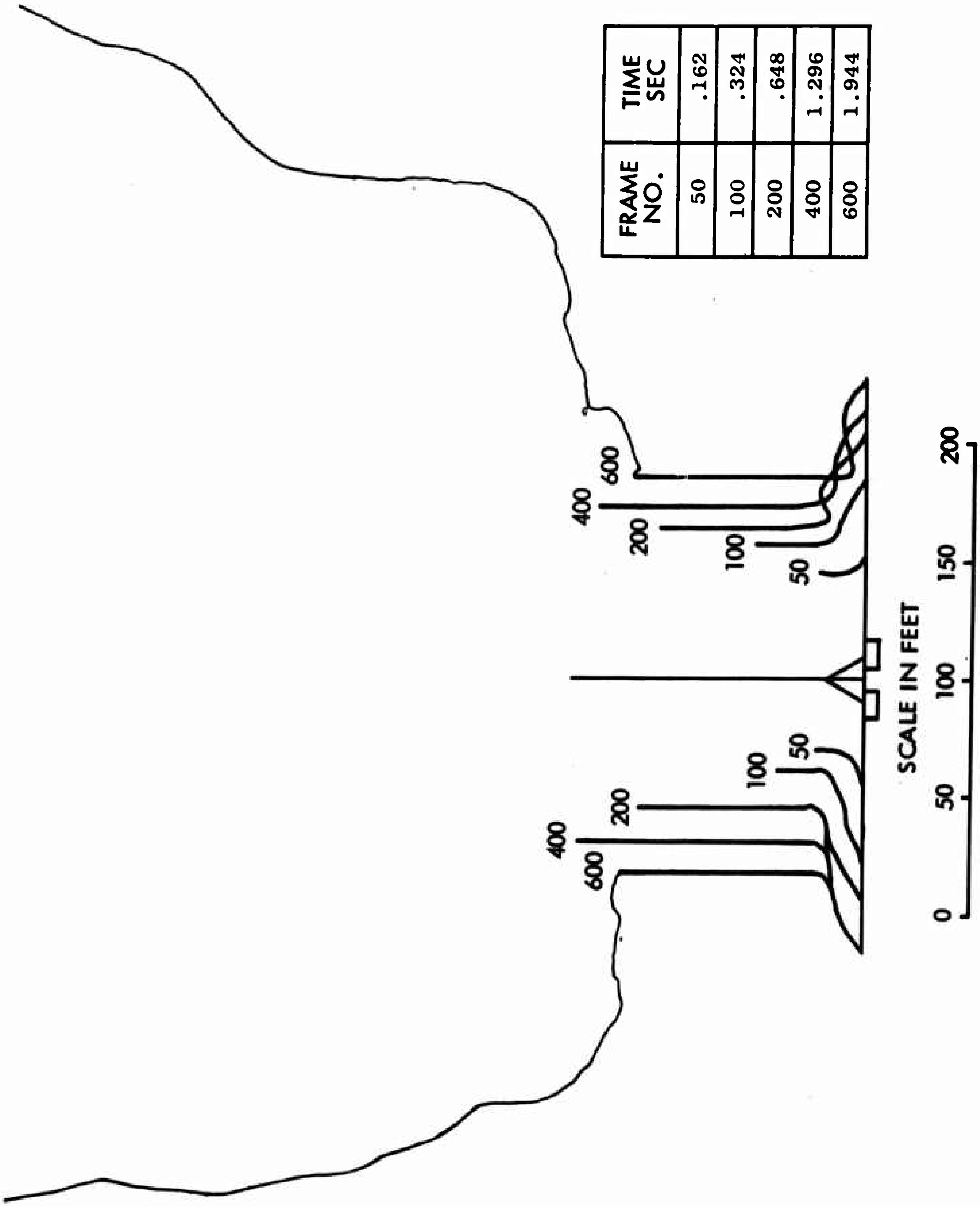


Shot 9, GSAP Camera, Tower No. 3



FRAME NO.	TIME SEC
50	.127
100	.271
250	.638
550	1.41
825	2.11

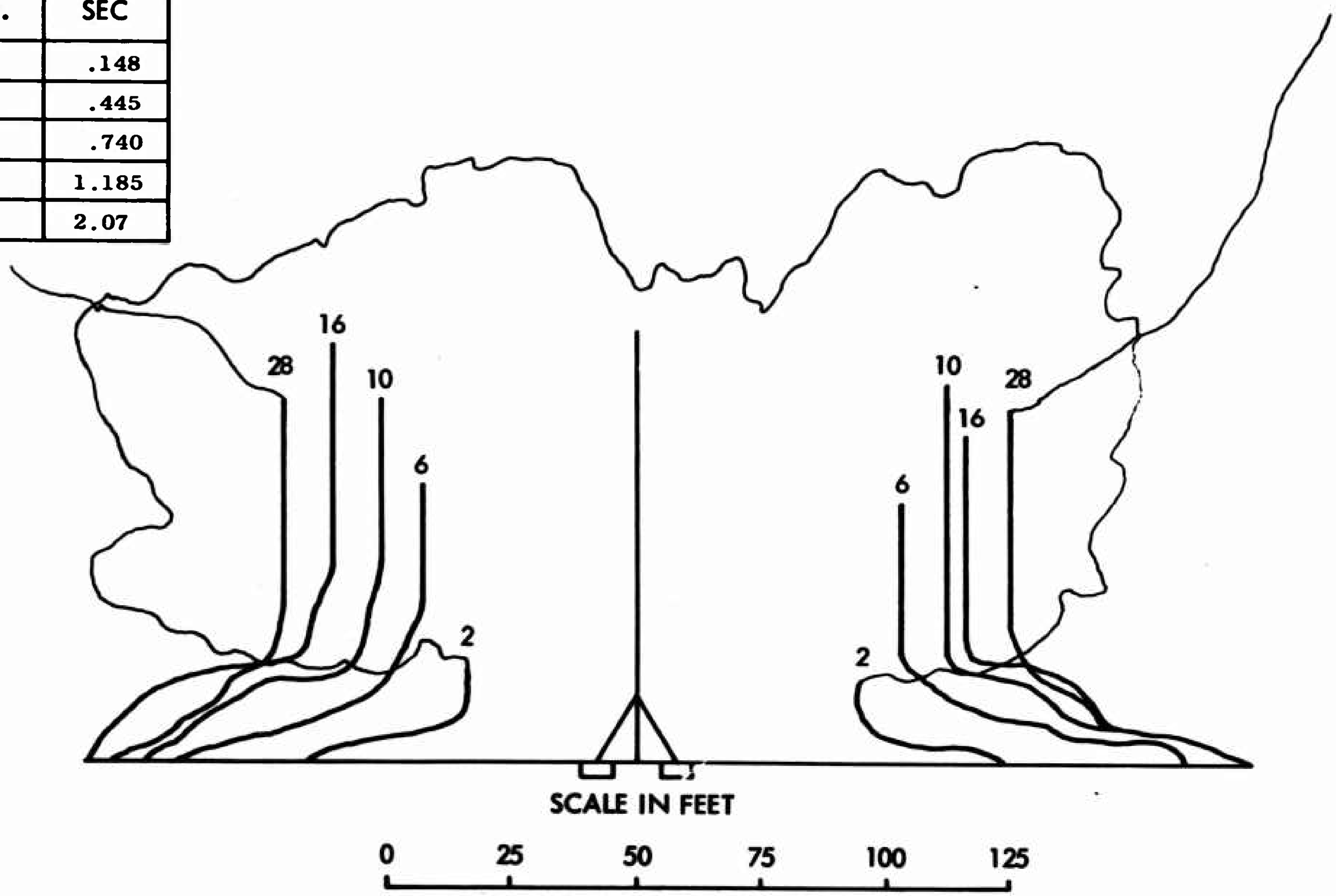
Shot 10, Fastax, Tower No. 1



FRAME NO.	TIME SEC
50	.162
100	.324
200	.648
400	1.296
600	1.944

Shot 10, Hycam, Tower No. 3

FRAME NO.	TIME SEC
2	.148
6	.445
10	.740
16	1.185
28	2.07



Shot 10, GSAP Camera, Tower No. 1

Appendix B

TABULAR PRESENTATION OF WAVE RUN-UP

SHOT NO. 3 CHARGE POSITION: -1.4 ft

DATE: 082365 CAMERA: GSAP, TOWER NO. 1, RUN-UP RAMP NO. 1

WAVE NO.	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	1	0	0
2	13.3	7.5	3	5
3	24.9	15	5	7
4	26.8	8	4	4
5	28.9	8	2	40
6	36.1	13	4	7
7	38.5	10	3	40
8	46.3	12	4	6
9	48.6	12	3	38
10	56	12.5	4	5
11	58	12	2	37
12	65.5	12	3	4
13	67.3	12	2	36
14	74.3	12	2	4
15	75.8	11	2	34

* Throughout Appendix B, zero time is the time of initial water surge at beach.

SHOT NO. 4

DATE: 082465

CHARGE POSITION -1.04 ft

CAMERA: GSAP, TOWER NO. 2,
RUN-UP RAMP NO. 2

WAVE NO.	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	2	0	0
2	12.2	16	3	50
3	24.4	20	6	10
4	26.1	10	3	50
5	36.2	17	5	10
6	40.1	9.5	3	45
7	46.5	15	5	10
8	50.8	11	2	42
9	56.7	15	4	10
10	61	13	2	40
11				
12				
13				
14				
15				

SHOT NO. 5 CHARGE POSITION -8.2 ft

DATE: 082665 CAMERA: GSAP, TOWER NO. 1, RUN-UP RAMP NO. 1

WAVE NO.	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	2.5	0	0
2	8.5	12	3	55
3	25.9	13	4	8
4	27.4	12	2	50
5	36.8	12	3	9
6	39	11	2	45
7	46.9	10	3	9
8	48.5	11	2	44
9	56.7	10	2	10
10	58.5	10	2	40
11	65.4	12	2	10
12	67.1	10	2	37
13	74.3	10	2	10
14	75.9	7.5	2	36
15	82.9	12	2	11

SHOT NO. 5 CHARGE POSITION -8.2 ft

DATE: 082665 CAMERA: GSAP, TOWER NO. 2, RUN-UP RAMP NO. 2

WAVE NO.	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	7	0	-
2	14.1	20	5	10
3	16.4	10	3	65
4	26.4	20	4	10
5	28.2	8	3	60
6	37.8	15	3	9
[illegible]	39.7	12	2	58
8	48.6	15	3	10
9	50.5	17	2	55
10	59.3	15	3	10
11	61.2	13	2	49
12				
13				
14				
15				

SHOT NO. 6 CHARGE POSITION 0 ft

DATE: 082665 CAMERA: GSAP, TOWER NO. 2, RUN-UP RAMP NO. 2

WAVE NO.	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	5	0	0
2	8.8	8	3	5
3	10.4	8	3	6
4	20.3	16	4	50
5	22.7	16	3	10
6	30.7	10	4	50
7	32.4	12	3	10
8	40	20	4	48
9	41.8	15	3	10
10	49.5	14	3	45
11				
12				
13				
14				
15				

SHOT NO. 7 CHARGE POSITION -41 ft

DATE: 082765 CAMERA: GSAP TOWER NO. 1

RUN-UP RAMP NO. 1

WAVE NO.	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	2	0	0
2	7	14	5	5
3	8.3	8	3	60
4	19.8	11	4	5
5	21.3	10	3	57
6	31.2	11	4	5
7	42.7	11	3	50
8	52.1	11	3	5
9	53.5	9	2	40
10	61.2	10	3	7.5
11	63.4	8	2	37
12	70.3	11	3	9
13	71.3	7.5	2	36
14	79.6	10	3	9
15	81.0	7.5	2	35

SHOT NO. 8 CHARGE POSITION -51.5 ft

DATE: 083065 CAMERA: GSAP TOWER NO. 1
RUN-UP RAMP NO. 1

WAVE NO.	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	3	0	0
2	17.9	11	4	5
3	19.9	5	2	52
4	29.4	16	4	7
5	31.1	5	3	47
6	38.8	12	4	7
7	41.1	7	3	45
8	49.2	11	4	8
9	51.4	6	3	40
10	58.2	11	3	8
11	59.7	6	2	35
12	67.3	11	2	10
13	69.5	5	2	33
14	75.6	12	2	10
15	78.3	4.5	2	30

SHOT NO. 8 CHARGE POSITION -51.5 ft

DATE: 083065 CAMERA: GSAP TOWER NO 2

RUN-UP RAMP NO 2

WAVE NO	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	2	0	0
2	13.3	12	5	60
3	25.8	16	5	55
4	37.4	20	5	50
5	48.2	23	5	10
6	49.8	20	4	45
7	57.8	21	5	10
8	59.9	12	4	45
9	68.4	15	5	10
10				
11				
12				
13				
14				
15				

SHOT NO. 9 CHARGE POSITION -21 ft

DATE: 090765 CAMERA: GSAP TOWER NO. 1
RUN-UP RAMP NO. 1

WAVE NO.	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	2	0	0
2	11.5	10	8	5
3	13	5	6	10
4	14.5	5	3	50
5	24.3	13	6	5
6	25.7	6	4	10
7	27.8	5	3	45
8	35.6	11	4	4
9	36.3	7.5	3	47
10	45.9	10	4	5
11	47.2	7.5	4	45
12	55.4	9.5	4	4
13	56.8	6.5	3	43
14	64.7	10	3	4
15	66.1	7	2	40

SHOT NO. 10 CHARGE POSITION -1.04 ft

DATE: 090865 CAMERA: GSAP TOWER NO. 2
RUN-UP RAMP NO. 2

WAVE NO	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	6	0	0
2	12	15	3	5
3	13.3	20	3	55
4	22.1	15	3	5
5	23.6	22	3	45
6	30.9	17	3	5
7	32.4	22	3	42
8	38.0	15	3	5
9	39.4	22	2	37
10	46.0	15	3	5
11	47.3	20	2	35
12	53.9	15	3	5
13	55.1	15	2	35
14	61.2	15	2	35
15	69.4	15	2	35

SHOT NO. 10

DATE: 090865

CHARGE POSITION -1.04 ft

CAMERA: GSAP TOWER NO 1, RUN-UP RAMP NO. 1

WAVE NO	TIME (sec)	RUN-UP DISTANCE (ft)	EST. WAVE HEIGHT (in.)	EST. DISTANCE BETWEEN WAVES (ft)
1	* 0	10	0	0
2	10.4	13.5	3	5
3	11.4	14	3	45
4	19.1	15	3	5
5	20.2	14	2	37
6	26.5	19	3	5
7	27.7	19	2	35
8	33.9	20	3	5
9	35.2	19	2	35
10	40.7	10	3	4
11	42.3	18	2	35
12	47.3	10	3	4
13	48.4	19	2	35
14	55.1	11	3	4
15	56.5	20	2	35

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3. REPORT TITLE

Explosion-Generated Wave Tests - Mono Lake, California
Ground and Aerial Photography

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report

5. AUTHOR(S) (Last name, first name, initial)

Walter, D.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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13. ABSTRACT

In the summer of 1965, a series of ten spherical cast TNT charges, each weighing approximately 10,000 lb were exploded at Mono Lake, California. As part of that program, URS Corporation conducted a project to acquire ground-based, high- and normal-speed, motion picture photography of base surge, plume, and wave run-up characteristics on all shots, and another to acquire aerial photography of wave refraction on two shots.

The high-speed and normal-speed motion pictures show excellent detail of base surge and plume. Run-up information is good; on many films waves within waves can be seen near the shore. The aerial photography obtained is good, and wave generation, refraction, and run-up can readily be seen.

DD FORM 1 JAN 64 1473

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Wave Run-up						
Wave Generation by Explosions						
Surface Effects						
Wave Refraction						

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AD627354

URS CORPORATION

February 14, 1966

ERRATA

Attention is called to the following corrections in URS report 654-2, Explosion-Generated Wave Tests, Mono Lake, California, Ground and Aerial Photography, January 1966.

Page A-9: This distance scale in this illustration is incorrect. The scale should be the same as all other illustrations relating to Hycam Tower No. 3

Pages A-10, 14, 22, 24: The distance scales in these illustrations should read 0, 50, 100, 150, 200, 250, 300.

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