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October 15, 1946

This document contains 9 p.
15 p. figs.

# CROSSROADS TECHNICAL INSTRUMENTATION REPORT: FASTAX PHOTOGRAPHY

By

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# CROSSROADS TECHNICAL INSTRUMENTATION REPORT

## TESTS A & B

15 October 1946

From: Los Alamos Field Group (013 H)

To: Technical Director, JTF 1

Project No.: IX - 1

Subject: Fastax Photography

Prepared by: Berlyn Brixner

Approved: M G Holloway

M. G. Holloway

## ABSTRACT

No photographic record of the nuclear explosion was obtained for test A because of the delay in starting the cameras.

A satisfactory photographic record of test B was obtained from cameras at the Enyu tower station. The space-time relations for the water jet and cloud formation were obtained from these films.





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# REPORT OF FASTAX PHOTOGRAPHY

## I. Introduction:

1.1 Test Able. The amount of energy released by the Atomic Bomb explosion was to be determined. The velocity of the shock wave provides a measure of this energy. A photographic record obtained from high speed motion picture cameras operating at 1000 frames per second or faster provides the necessary data.

1.2 Test Baker. The energy released during the explosion could not be determined by a shock wave velocity measurement because of the difficulty of under-water photography. A photographic record was to be obtained of the part of the explosion visible above the water surface.

## II. Instruments and Equipment:

2.1 A group of Fastax 16mm and 35mm cameras were installed in towers on Bikini and Enyu Islands. See Tables 1A and 1B with detailed specifications for each of the cameras used. Kodak Cine E 16mm cameras were also installed at the Enyu station to obtain a two hour record of the explosion and subsequent cloud. The possibility of a large error in dropping the bomb for Test Able led to the installation of a wide angle camera with moving film. This camera could record the explosion if it occured as much as 1-1/2 miles from the target center and had a time resolution better than 1/10 millisecond. A Mitchell 35mm camera was also installed in each of the towers.

Fastax and wide angle, continuous moving film cameras were also installed and operated in AAF photo planes by Army personnel.

Normal speed 16 and 35mm cameras were installed on board the AV-17 to obtain a pictorial record of both explosions.



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2.2 Power for all cameras and control equipment at the tower stations was obtained from storage batteries since gasoline powered generators were found to be unreliable. A relay rack at each station controlled the operation of the cameras. The camera control relays were closed by means of a circuit to a contact in the radio timing signal receiving box and were opened by switches which were actuated when the film receiving magazines were properly filled with exposed film. Camera operation was independent of the timing signal box after the initial contact was made except that recycling could be accomplished at any time prior to the starting of the first camera.

The cameras ran for various periods of time from 1.5 sec to fifty minutes depending on running speed and film capacity. Cameras were started at -5 sec, -2 sec, or -0.7 sec depending on the total running time.

III. <u>Results:</u>

3.1 <u>Test Able:</u>

All cameras operated properly but the timing signals were such as to start all the remotely controlled cameras about 15 seconds after the start of the nuclear explosion. The developed films from the high speed cameras showed no trace of an image since the exposure was set for the brilliant early stages. The Cine E film gave a satisfactory record for the period of 15 sec to 1-3/4 hours. The cameras on the AV-17 were manually started and gave a satisfactory pictorial record of the explosion. As far as known none of the high speed cameras operated by the AAF obtained a satisfactory record. No satisfactory record was obtained of the expansion of the ball of fire.

3.2 <u>Test Baker:</u>

All cameras at the Enyu station operated properly but none operated

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at the Bikini station. The [illegible] failure was not determined since it was found, [illegible], that the entire assembly of apparatus was still in readiness to function. The signal lines were actuated manually to operate the cameras. The timing boxes were also found to be in perfect operating condition, though test signals were not available for this test. If the recycle connection had been opened by local interference at the time the -2 minute signal was received it would have left the relay panel inoperative, and subsequent signals would not start the cameras.

The photographic record obtained was partially obscured by the normal cloud cover above 500 meters altitude. The irregular water jet and cloud fronts made accurate measurement difficult. In every case the maximum velocity was measured. The data is presented in the form of a nest of profiles. No correction was made for camera tilt or perspective since this was found to be less than 2%. All velocity plots were obtained from the slopes of the space time curves.

3.2.1 Water Jet:

The progress of the water jet for the first 1.6 seconds is clearly shown in Fig. 2. The jet assumes a cone shape in its later stages. The lateral expansion of the apex of this cone at the water level is relatively small. The vertical measurements were made near the vertical through the explosion center but in every case the highest point was selected. Measurements were also made at an angle of about 28 degrees from the vertical as there was an apparent particle motion in this direction. The very irregular contours lead to considerable uncertainty but a reasonably smooth curve is obtained. See Fig. 6. Later stages of the expansion of this water jet are obscured by the fog formed by the cloud chamber effect. A velocity curve, Fig. 7, [illegible] from the slope of the curves of Fig. 6. Direct measurements on the original film give a value of about 1900 meters/second velocity for the luminous front when it first appears above the water surface. The luminous front persisted for about 0.15 second. The jet is dome shaped up to about 1/2 second and gradually changes to what appears to be a flat ring shape in about 2 seconds.

3.2.2 Water Level Cloud:

A large circular cloud of mist or spray spreads out over the water surface from the explosion center. The cloud remains on the water surface for several minutes and then lifts to the prevailing cloud level, the bottom being at about 500 meters altitude. When the water jet spray falls back to the lagoon it undoubtedly carries along with it a large mass of air. This mass of air probably carries the finely divided water particles in a suspension and spreads over the water surface radially from the explosion center to form a circular cloud about four miles in diameter. As the cloud lifts it is seen that a heavy rain prevails under it and this persists for an hour or more as the cloud drifts to the north with the prevailing winds. Figure 3 shows successive profiles of this cloud formation. Plots of growth and velocity of growth are shown in Figures 8 and 9. The cause of the irregular velocities of the north-east cloud front is not apparent.

3.2.3 Cloud Chamber Effect:

About 0.75 second after the start of the explosion a ring shaped fog cloud is seen to develop around the water jet at an altitude of about 350 meters. This fog cloud continues to grow at a fairly constant velocity of about 330 meters per second (sound velocity in air) until it has formed a cloud of about four miles diameter in eleven seconds. During the initial stages this cloud is hemispherical in shape with its base about 200 meters above the lagoon surface. At 1.2 seconds fog

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starts to form simultaneously just above the water surface and just below the hemisphere base and this rapidly fills the space beneath the existing cloud and merges with it so as to be indistinguishable after 3 seconds. As the fog cloud grows radially it appears to lift from the water surface, probably by evaporation of the fog, to an altitude of about 400 meters. The maximum altitude for fog formation is not less than 800 meters but is difficult to ascertain because of the obscuring clouds. Profiles of this fog formation are shown in Figures 4 and 5.

## IV. Conclusions:

### 4.1 Test Able:

No information was obtained for determination of the rate of the expansion of the ball of fire.

### 4.2 Test Baker:

A good photographic record of the explosion was obtained from the Enyu Island station. The initial vertical velocity of the water jet is $1900 \pm 100$ m.p.s. The jet is luminous and resembles a shock wave front at first but later the luminous surface is very spotty as it darkens and resembles the burning of inflammable material. Perhaps the iron in the LSM 60 was the source of this flame. The jet becomes bulbous and appears to vent at its top center. This causes it to assume a cone-like appearance. Within 30 seconds the upper portion of this cone has expended to form a cloud 2000 meters in diameter and has reached a height of over 1400 meters. A portion of the water descends to form a surface cloud, 4 - 5 miles in diameter, which starts to rise in 3 - 4 minutes and gives rise to an intense rainstorm.

The shock wave in air gives rise to a cloud chamber fog. Measurement of the fog formation velocity gives values approximating air sound velocity



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at all points.

V. Recommendations for Future Tests:

It is clear that the tight schedule and consequent hasty preparations for Operation Crossroads led to many of the difficulties encountered. In a future test adequate notice should be given so that plans can be carefully executed. A specific time, not less than two weeks before the test, should be set after which no more changes in the installations would be made. Thereafter a series of tests should be started to determine reliability of operation of equipment and time should be allowed to make final adjustments of equipment. It would be desirable to have four camera stations spaced at about 90 degrees around the target so that a better check could be obtained between the various film records.

VI. Group Personnel:

The following people spent part or all of their time on the Fastax Photography Program.

| | | |
|---|---|---|
| Jack W. Aeby | Berlyn Brixner | J. Carlton Hoogterp |
| Albert A. Bartlett | Ralph L. Conrad | Willard Waite |
| | Felix E. Geiger | |

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## Table 1A    Test Able

| Location | Instrument | Code | Foc.L | Stop | Filter | Film | Speed | Shutter | Rel. exp. Daylight=1 | Image Scale | Results Starting | Results Film |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bikini | Aero Smear | B1 | 305mm | 32 | N D3 | PanX aero | 3m/sec | | 1/60000 | | 15 sec late | blank |
| " | 35mm Mitchell | B8 | 152 | 16 | ND1 | PanX | 100 | 1 5° | 1/130 | | " | " |
| " | " Fastax | B2 | 254 | 32 | ND3 | " | 1000 | -- | 1/40000 | | " | " |
| " | " " | B3 | 1 52 | 32 | ND2 | " | 1000 | -- | 1/4000 | | " | " |
| " | " " | B4 | 104 | 32 | ND1 | " | 1000 | -- | 1/400 | | " | " |
| " | 16mm " | B5 | 104 | 32 | ND2 | SuperX | 1000 | -- | 1/4000 | | " | " |
| " | " " | B6 | 50 | 16 | ND2 | " | 1000 | -- | 1/1000 | | " | " |
| " | " " | B7 | 35 | 22 | ND1 | " | 1000 | -- | 1/200 | | " | " |
| Enyu | Aero Smear | N1 | 305 | 22 | ND3 | PanX aero | 2m/sec | -- | 1/20000 | | " | " |
| " | 35mm Mitchell | N8 | 75 | 16 | ND1 | PanX | 100 | 15° | 1/130 | | " | " |
| " | " Faxtax | N2 | 104 | 32 | ND2 | " | 1000 | -- | 1/4000 | | " | " |
| " | " " | N3 | 152 | 32 | ND2 | " | 1000 | -- | 1/4000 | | " | " |
| " | " " | N4 | 254 | 22 | ND2 | " | 1000 | -- | 1/2000 | | " | " |
| " | 16mm " | N5 | 35 | 11 | ND2 | SuperX | 1000 | -- | 1/500 | | " | " |
| " | " " | N6 | 50 | 6.3 | ND2 | " | 1000 | -- | 1/160 | | " | " |
| " | " " | N7 | 104 | 22 | ND2 | " | 1000 | -- | 1/200 | | " | " |
| " | " Cine E | N9 | 152 | 4.5 | ND3-0 | IR PanK | 64 | 10° | 1/1000-1 | 1/6000 | " | O.K. |
| " | " " | N10 | 25 | 4.0 | 87A | " | 16 | 180° | 1 | 1/36000 | " | " |
| " | " " | N11 | 104 | 5.6 | " | " | 4 | 90° | 1 | 1/8800 | " | " |
| " | " " | N12 | 15 | 4.0 | " | " | 8 | 90° | 1 | 1/61000 | " | " |
| " | " " | N13 | 15 | 8.0 | " | " | 2 | 90° | 1 | " | " | " |
| " | " " | N14 | 15 | 11 | " | " | 2 | 90° | 1 | " | " | " |
| " | " " | N15 | 15 | 4.0 | " | " | 1 | 10° | 1 | " | " | " |
| " | " " | N16 | 15 | 4.0 | " | " | 1 | 10° | 1 | " | " | " |
| AV-17 | 35mm Mitchell | 17-1 | 231 | 5.6 | A | PanX | 24 | 45° | 1 | 1/13000 | O.K. | " |
| " | 16mm Cine Spc. | 17-3 | 104 | 4.5 | A | IR PanK | 32 | 180° | 1 | 1/35000 | " | " |

Table 1 B Test Baker

| Location | Instrument | Code | Foc.L | Stop | Filter | Film | Speed | Shutter | Rel. exp. Daylight=1 | Image Scale | Results Starting | Results Film |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bikini | 35mm Mitchell | B9 | 25mm | 4.0 | G | PanX | 100 | 45° | 1 | | Did not | N.G. |
| " | " Fastax | B2 | 381 | 32 | No | " | 1000 | — | 1/40 | | " " | " |
| " | " " | B3 | 50 | 11 | " | " | 200 | — | 1 | | " " | " |
| " | " " | B4 | 152 | 4.5 | " | " | 1000 | — | 1 | | " " | " |
| " | 16mm " | B5 | 104 | 22 | " | SuperX | 4000 | — | 1/80 | | " " | " |
| " | " " | B7 | 35 | 8 | " | " | 200 | — | 2 | | " " | " |
| " | " " | B8 | 254 | 4.5 | " | " | 1000 | — | 1 | | " " | " |
| " | 8mm " | B6 | 152 | 32 | " | " | 8000 | — | 1/330 | | " " | " |
| Enyu | 35mm Mitchell | N1 | 35mm | 4.0 | Aero 2 | PanX | 100 | 30° | 1 | 1/30000 | O.K. | O.K. |
| " | " Fastax | N2 | 104 | 11 | No | " | 200 | — | 1 | 1/8800 | " | " |
| " | " " | N3 | 152 | 4.5 | " | " | 1000 | — | 1 | 1/6000 | " | First part |
| " | " " | N4 | 381 | 5.6 | " | " | 1000 | — | 1 | 1/2400 | " | O.K. |
| " | 16mm " | N5 | 50 | 4.0 | " | SuperX | 1000 | — | 2 | 1/18000 | " | " |
| " | " " | N6 | 104 | 32 | " | " | 4000 | — | 1/160 | 1/8800 | " | " |
| " | " " | N7 | 254 | 26 | " | " | 4000 | — | 1/110 | 1/3600 | " | " |
| " | 8mm " | N8 | 152 | 45 | " | " | 8000 | — | 1/650 | 1/6000 | " | " |
| " | 16mm Cine E | N9 | 15 | 11 | 87A | Aero IR | 1 | 10° | 1 | 1/61000 | " | Poor |
| " | " " | N10 | 152 | 5.6 | " | " | 64 | 180° | 1 | 1/6000 | " | Photo |
| " | " " | N11 | 15 | 4 | " | " | 64 | 90° | 1 | 1/61000 | " | Quality |
| " | " " | N12 | 15 | 16 | " | " | 4 | 180° | 1 | 1/61000 | " | " |
| " | " " | N13 | 104 | 11 | " | " | 1 | 10° | 1 | 1/8800 | " | " |
| " | " " | N14 | 104 | 11 | " | " | 1 | 10° | 1 | 1/8800 | " | " |
| " | " " | N15 | 25 | 5.6 | " | " | 32 | 90° | 1 | 1/36000 | " | " |
| " | " " | N16 | 15 | 11 | " | " | 8 | 90° | 1 | 1/61000 | " | " |
| AV-17 | 35mm Mitchell | 17-1 | 104 | 8 | " | " | 24 | 60° | 1 | 1/22000 | " | O.K. |
| " | 16mm Cine Spc. | 17-6 | 104 | 11 | A | " | 32 | 180° | 1 | 1/22000 | " | " |

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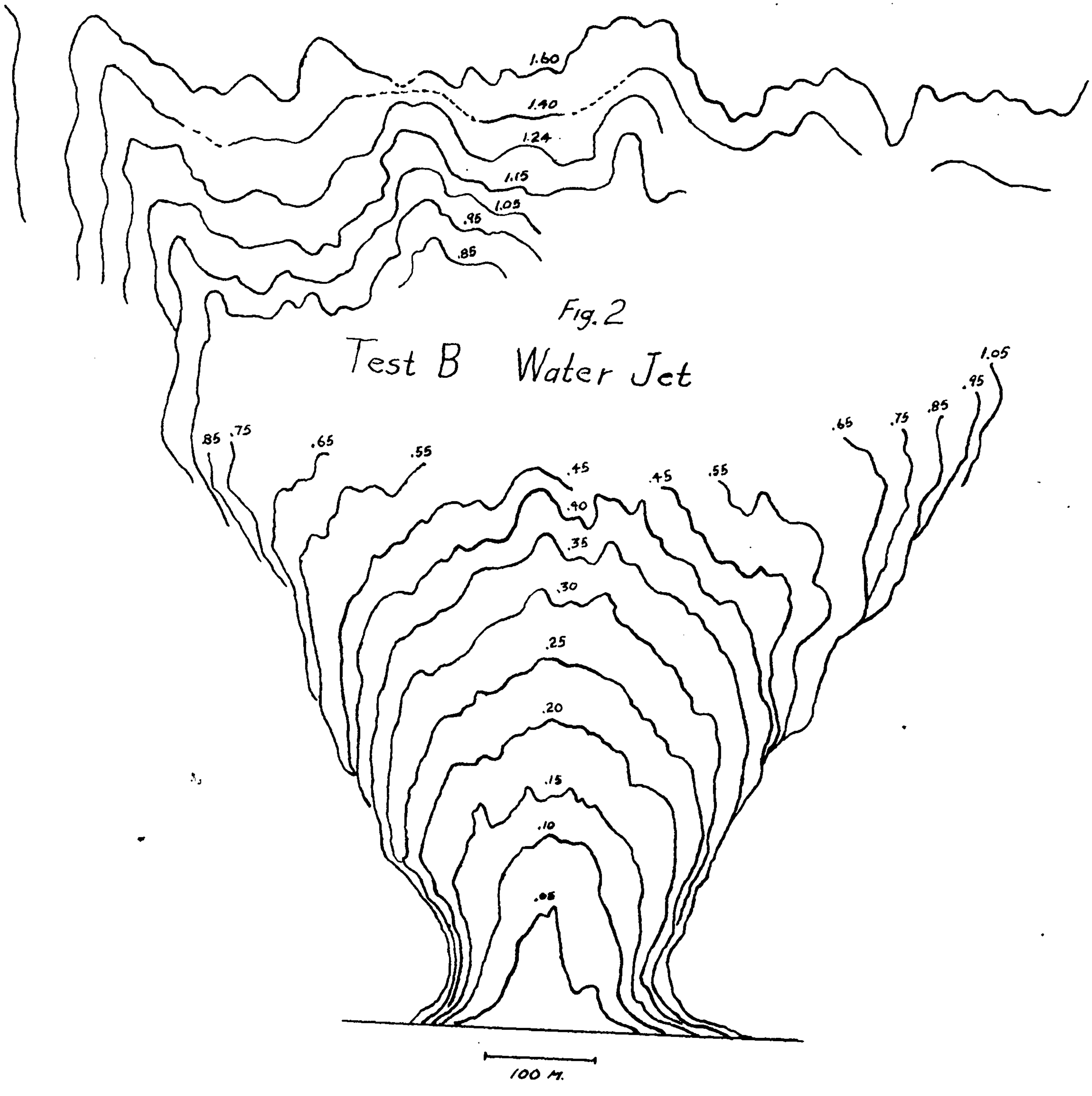


Fig. 2
Test B Water Jet


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Fig. 3

Test B Water Level Cloud

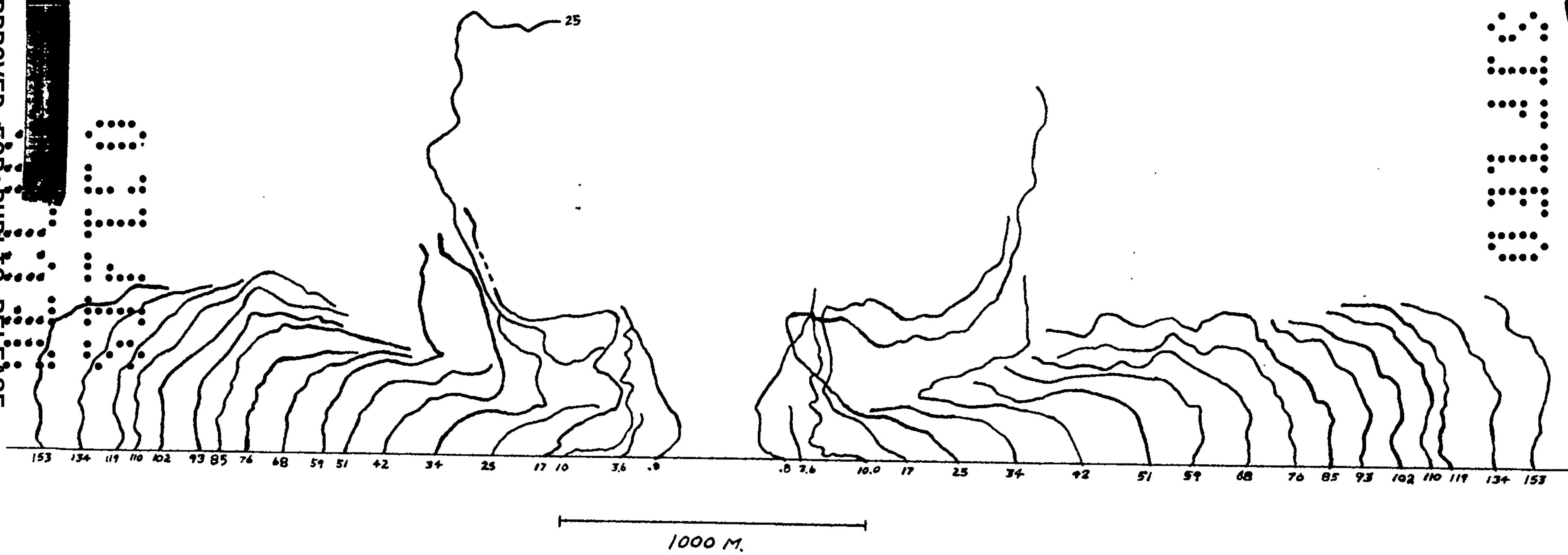

Fig. 4

Test B Cloud Chamber Effect

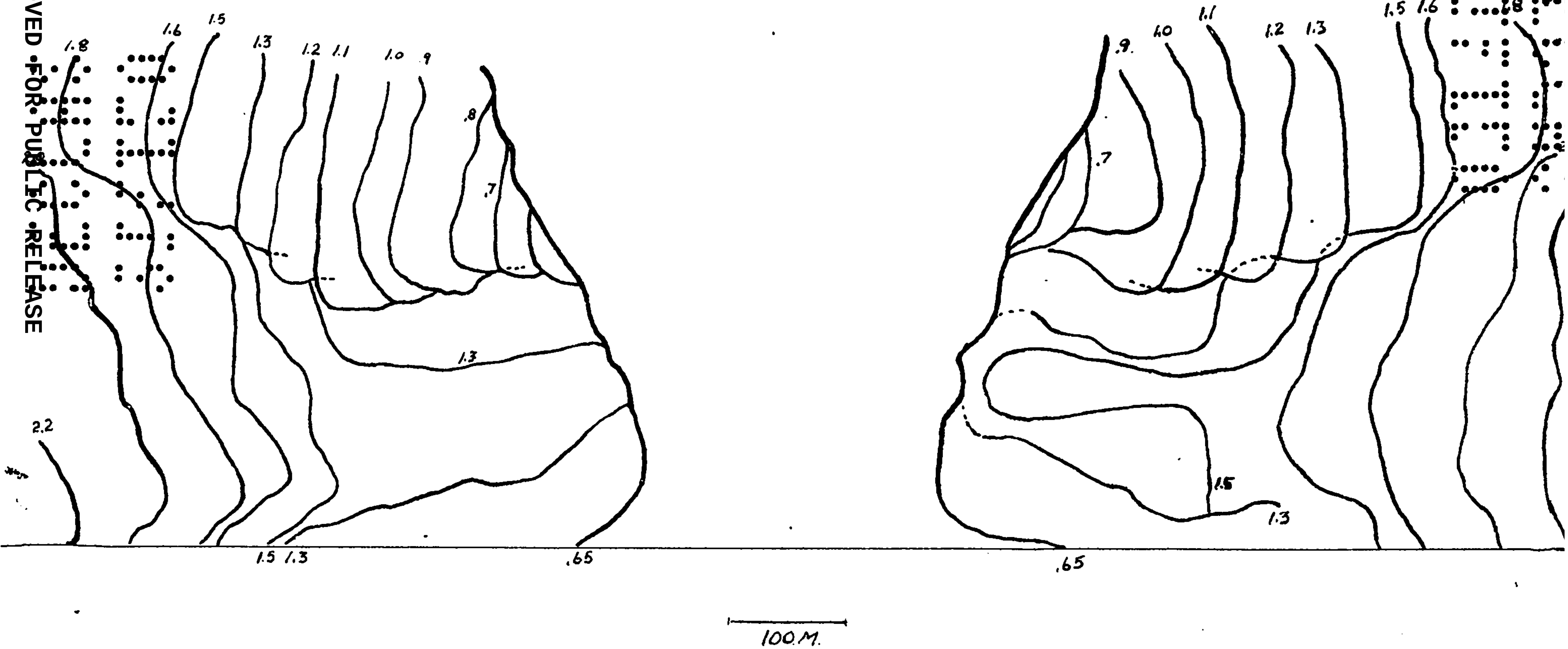


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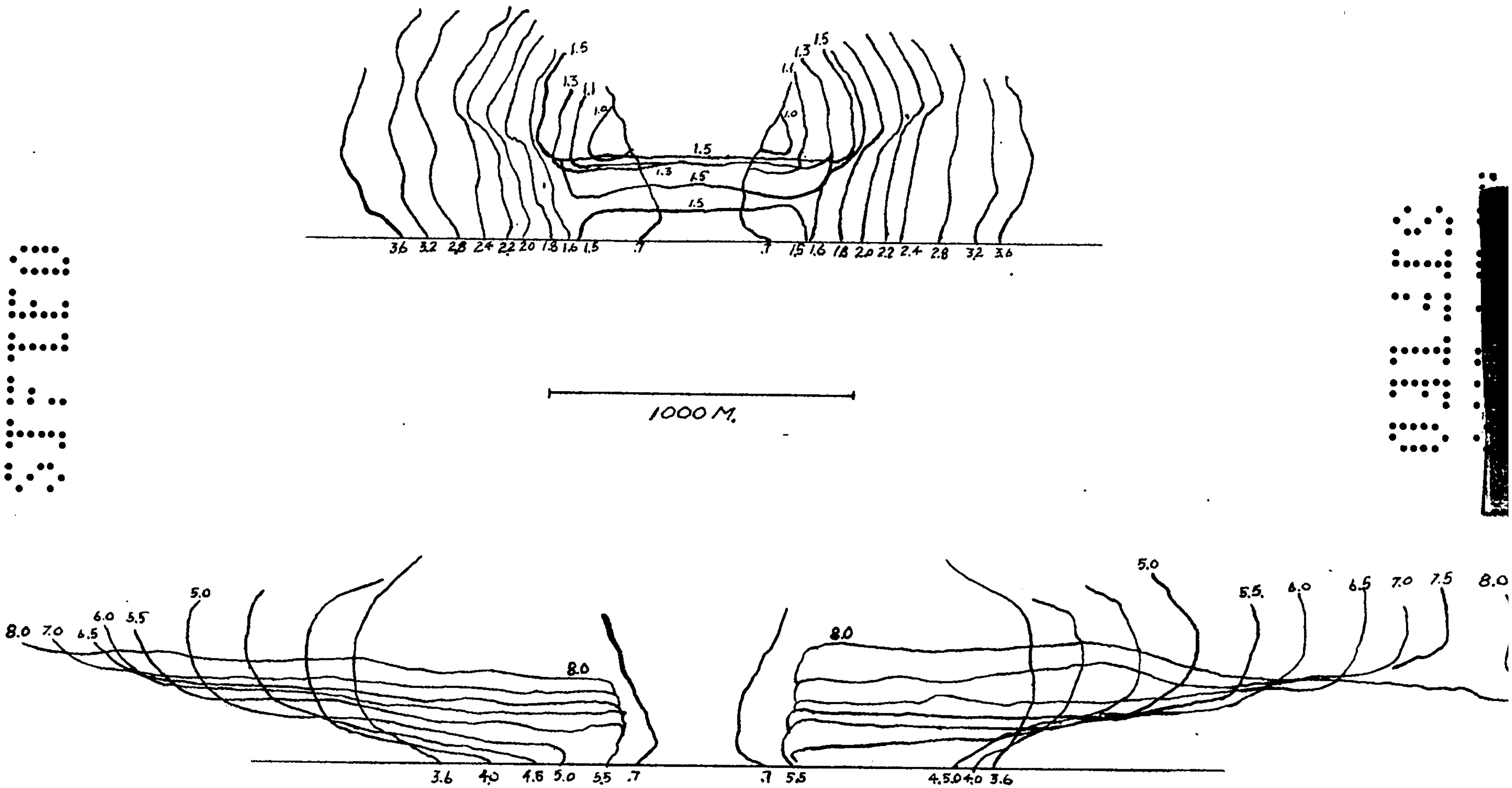
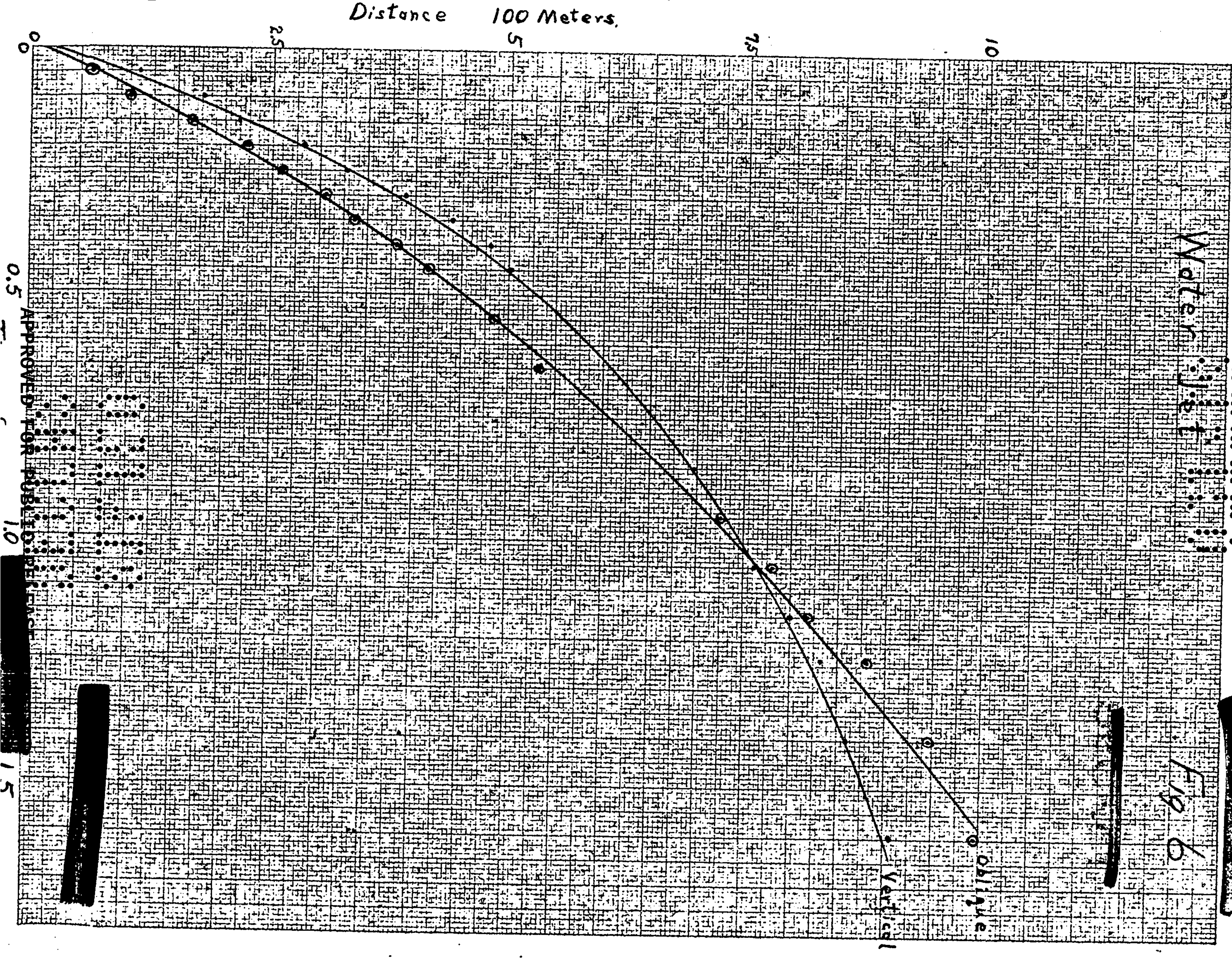
Fig. 5

Test B Cloud Chamber Effect



KEUFFEL & ESSER CO., N. Y., NO. 362-14
Millimeters, 5 mm. lines accented, cm. lines heavy.
MADE IN U. S. A.

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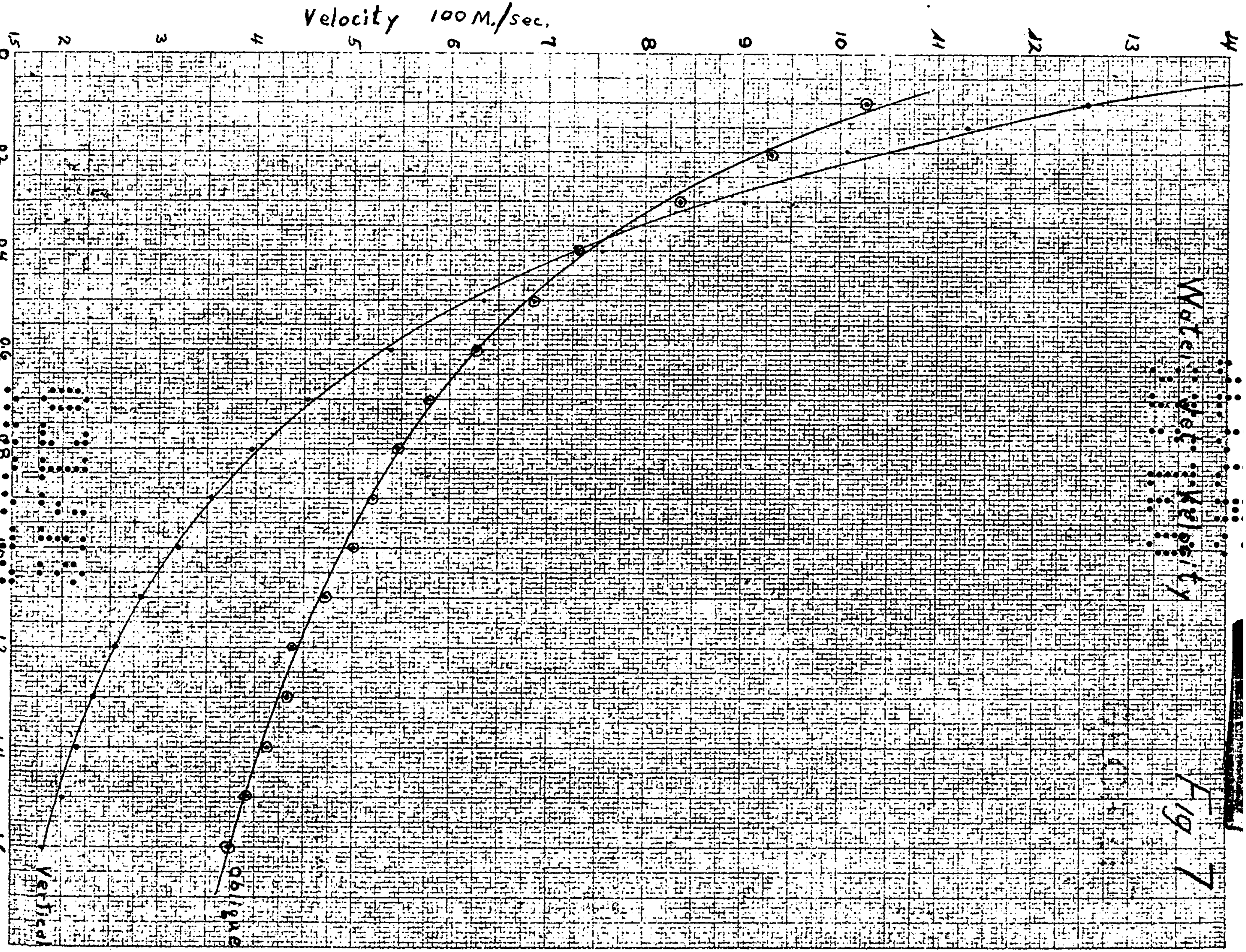

Velocity 100 M./sec.
2
3
4
5
6
7
8
9
10
11
12
13
14
Time sec.
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Vertical
Oblique
Water Velocity
Fig 7

KEUFFEL & ESSER CO., N. Y. NO. 359-14
Millimeters, 5 mm. lines accented, cm. lines heavy.
MADE IN U. S. A.

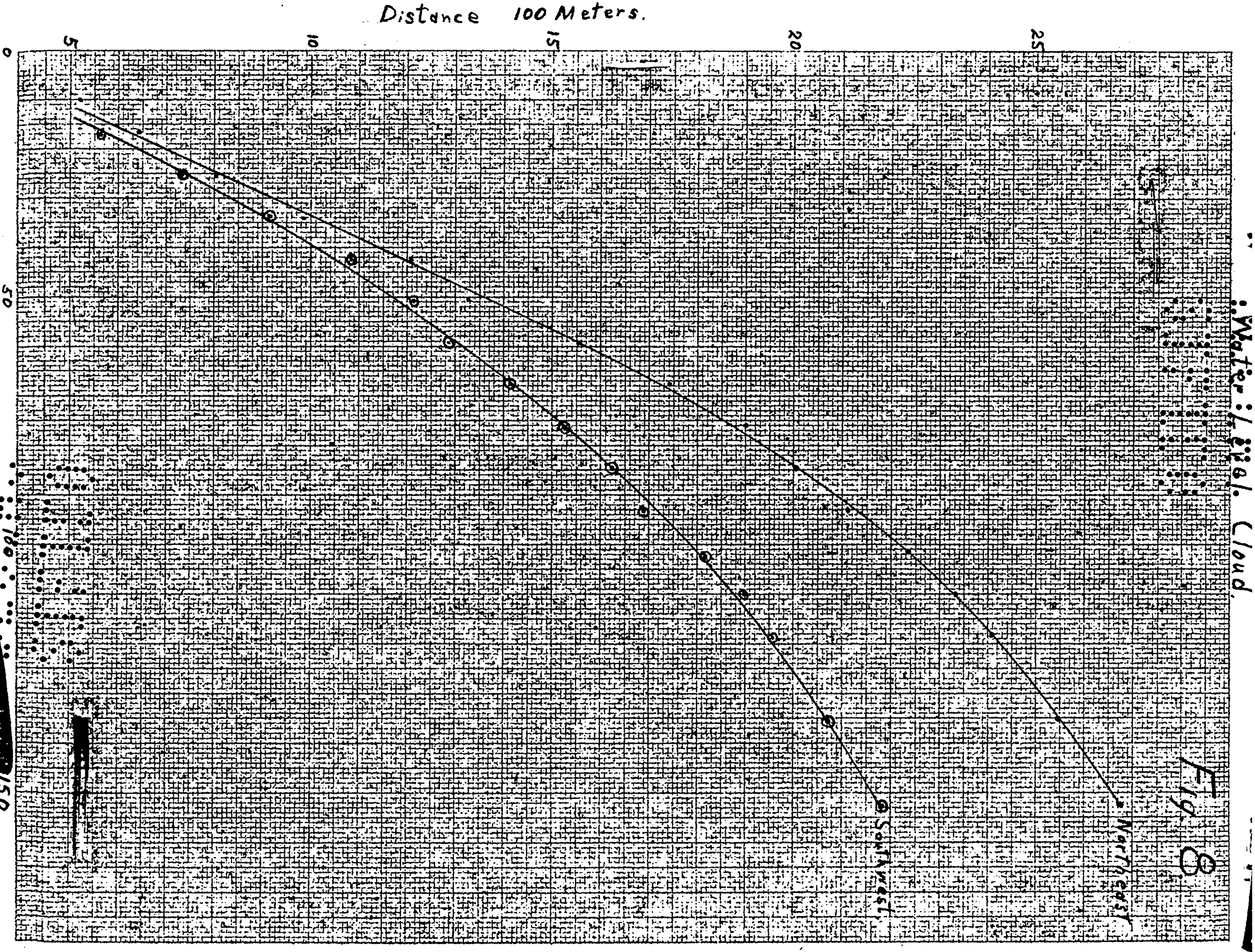
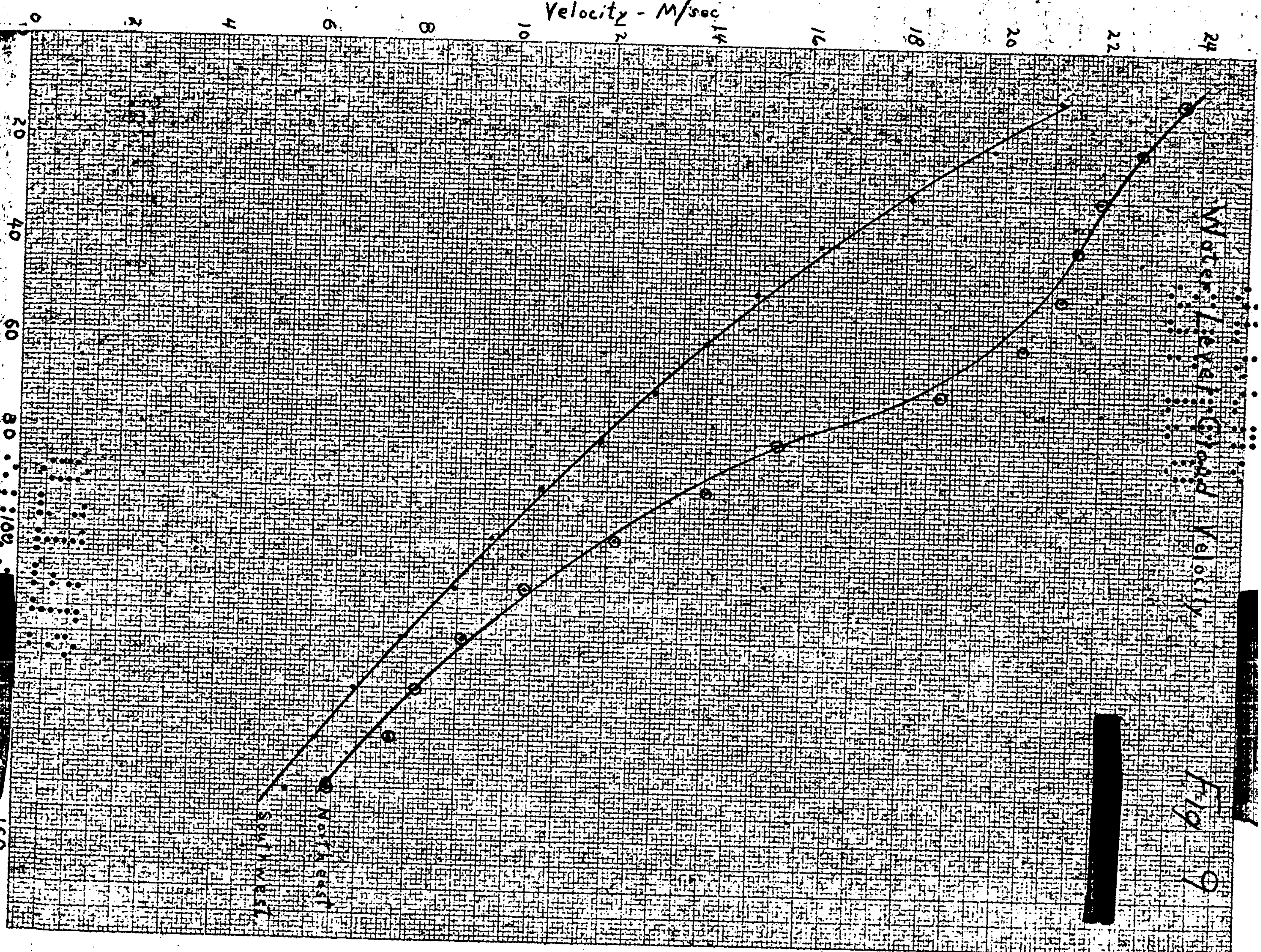



Fig. 8

KEUFFEL & ESSER CO., N. Y., NO. 359-14
Millimeters, 5 mm. lines accented, cm. lines heavy.
MADE IN U. S. A.

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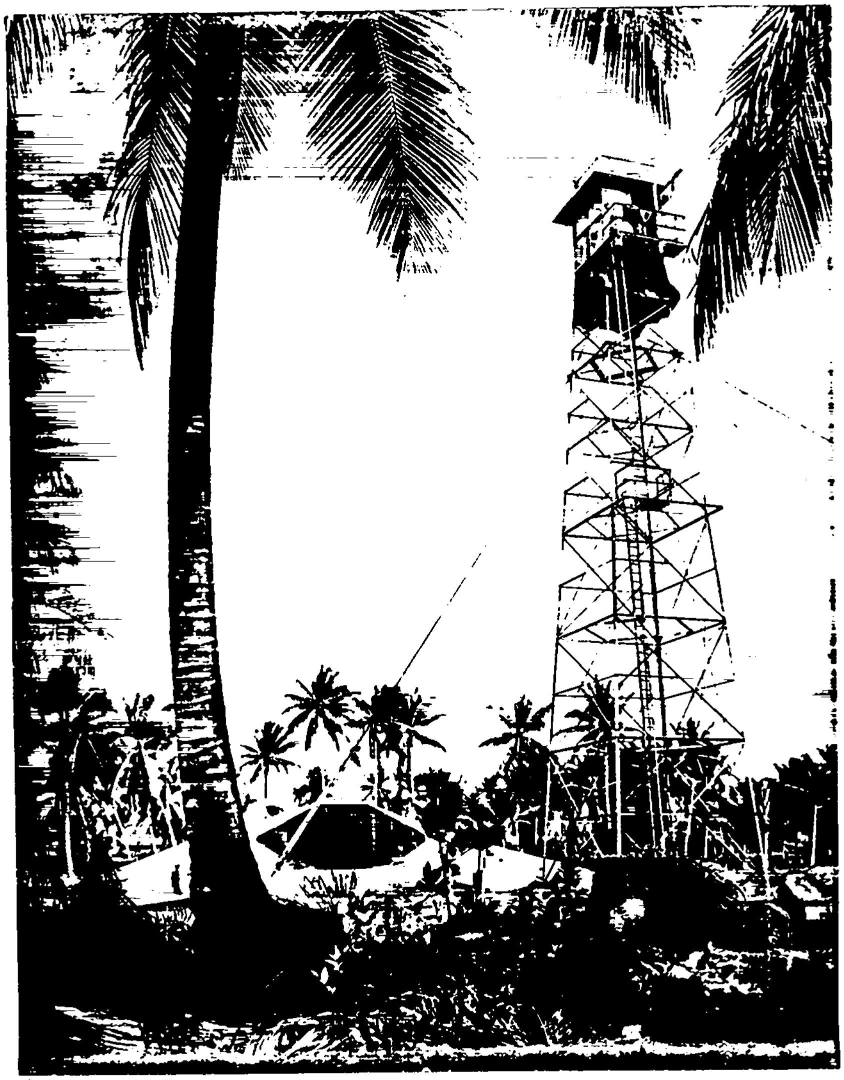

FIG. 10 -- General view of Fastax Photography tower and sand covered quonset storage room and work shop. The tarpaulin just below the tower cab protects storage batteries and chargers. The camera port is in the opposite side of cab.

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[redacted]

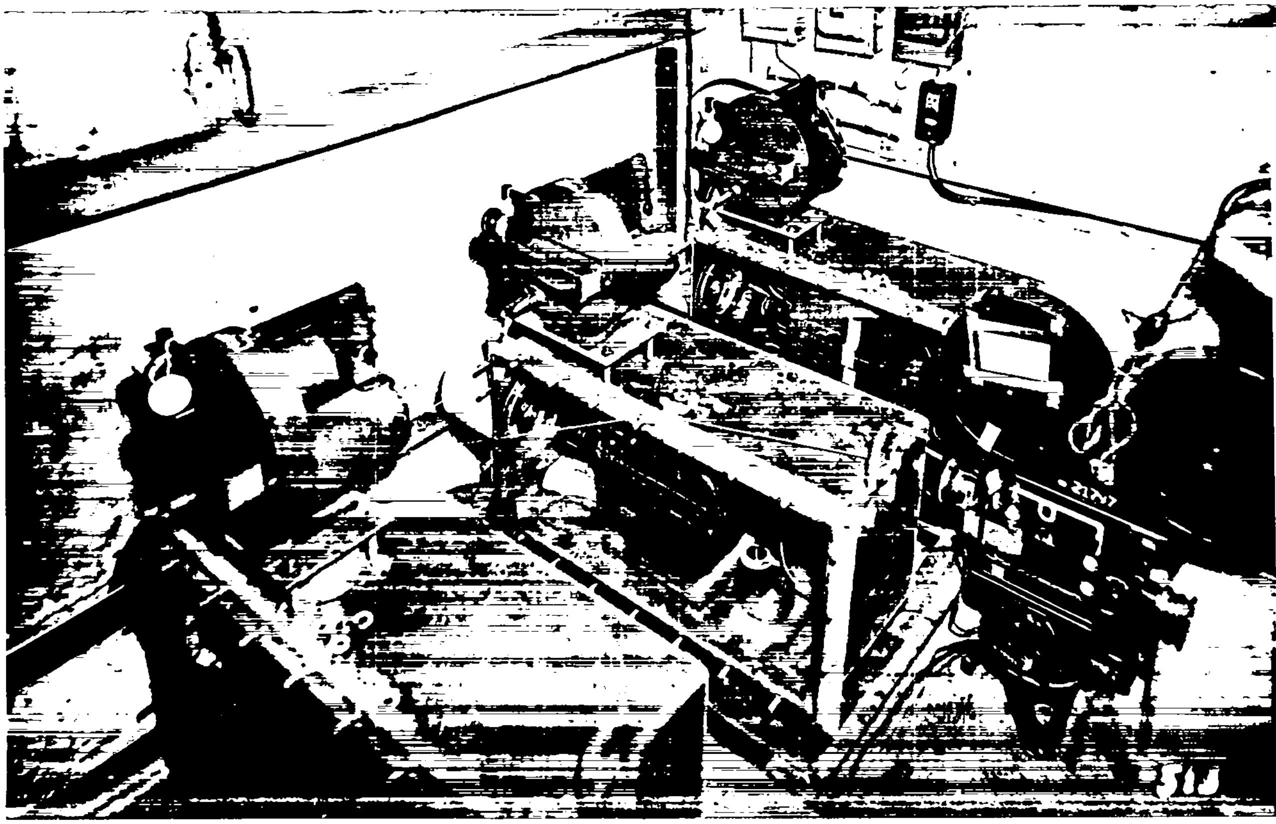

FIG. 11 -- Tower cab camera installation showing three armored camera boxes for 35mm Fastax and 16mm Fastax mounted on top of each. The Mitchell 100 f.p.s. camera is shown on the right. Cameras face the closed port of the cab.

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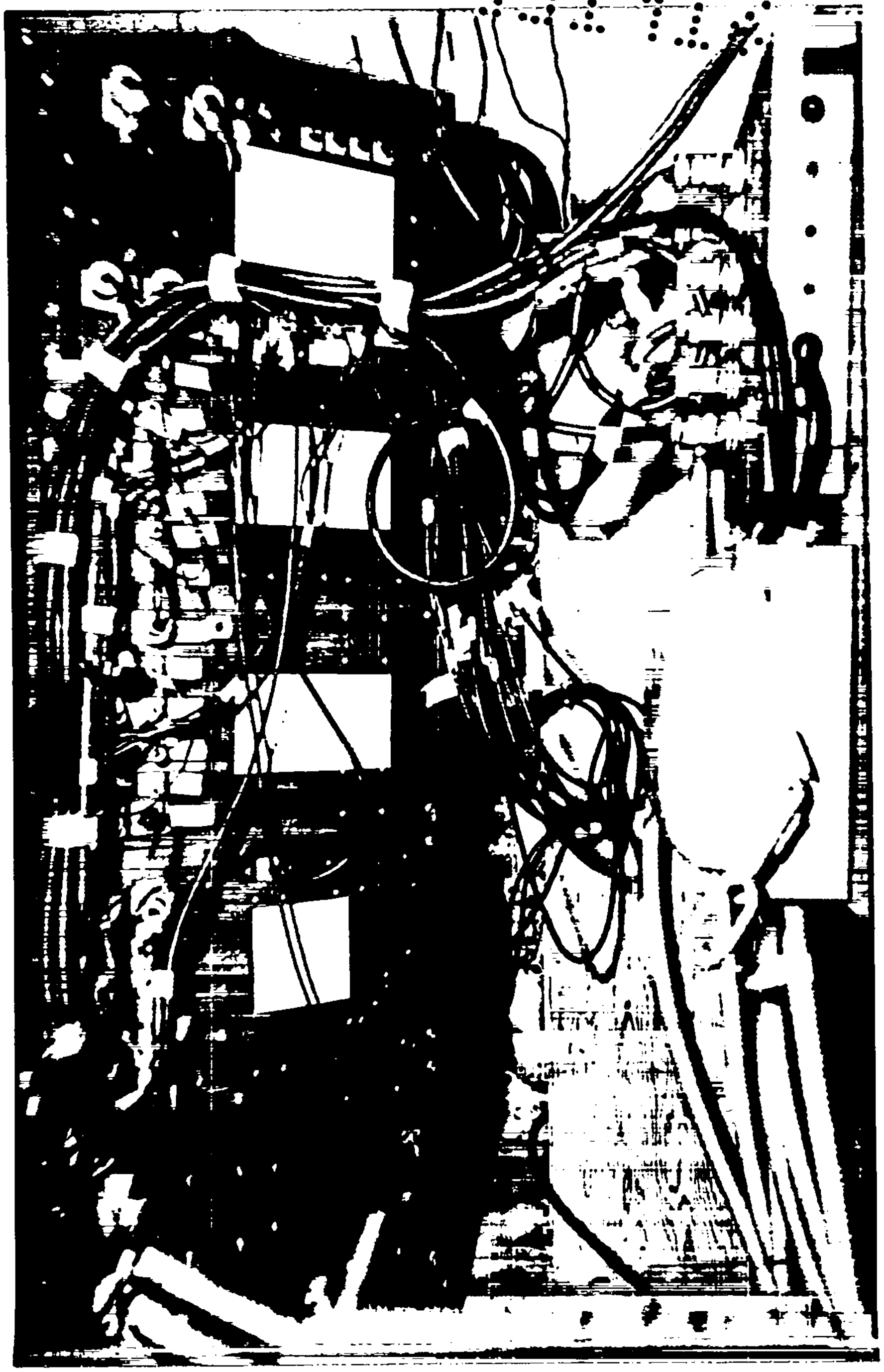

FIG. 12 -- Relay rack for control of all cameras is shown at left. Timing light pulse generators are in wood cabinet at right background. Master power control switch and distribution box are on right.

FIG. 13 -- Timing signal boxes are shown on shelf at upper right. Part of the camera installation is shown below.

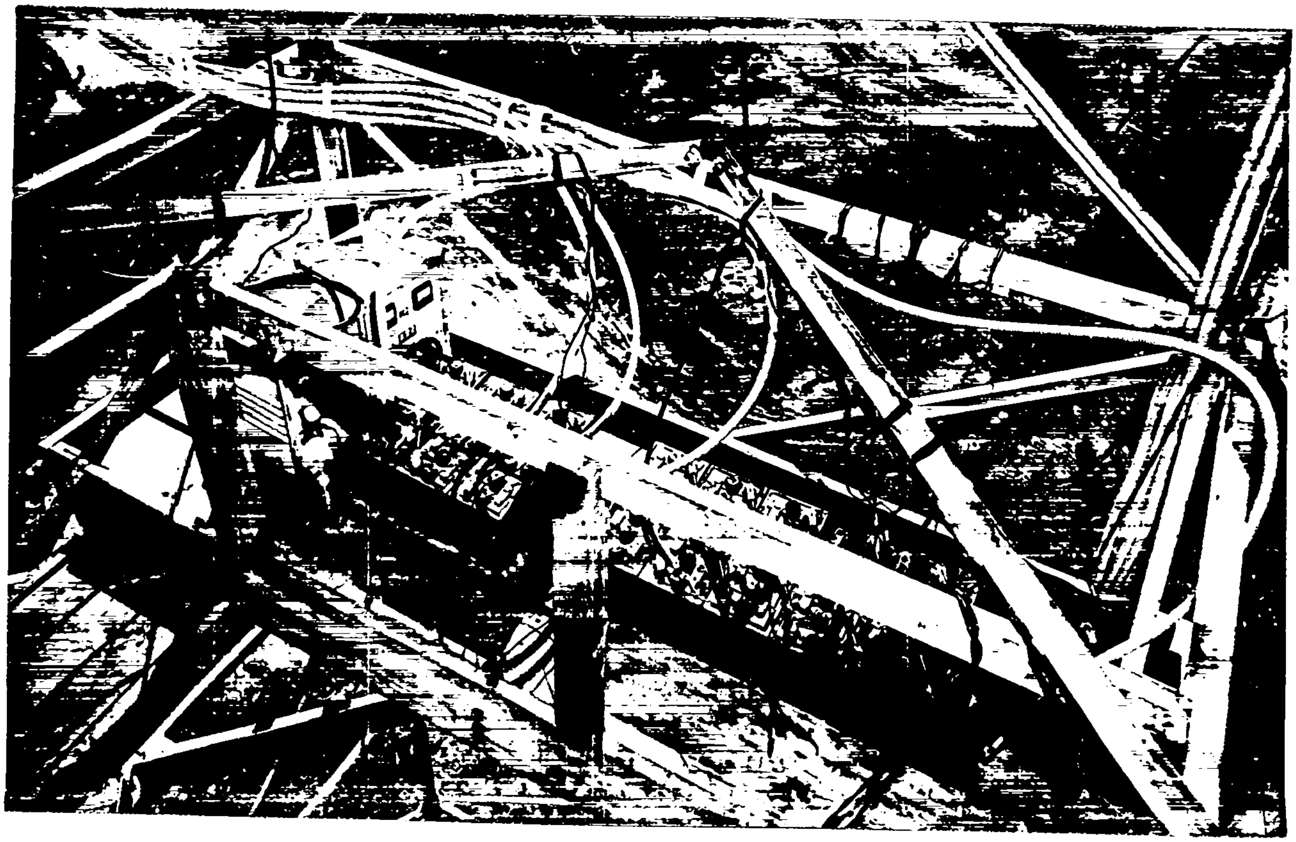

FIG. 14 -- Storage battery platform just below cab. Cables at upper left supply power to cab. Vertical cables at right supply higher voltage power from battery bank on ground.

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