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SURF TESTS OF A 1/7.5 SCALE MODEL OF THE LACV-30.(U)
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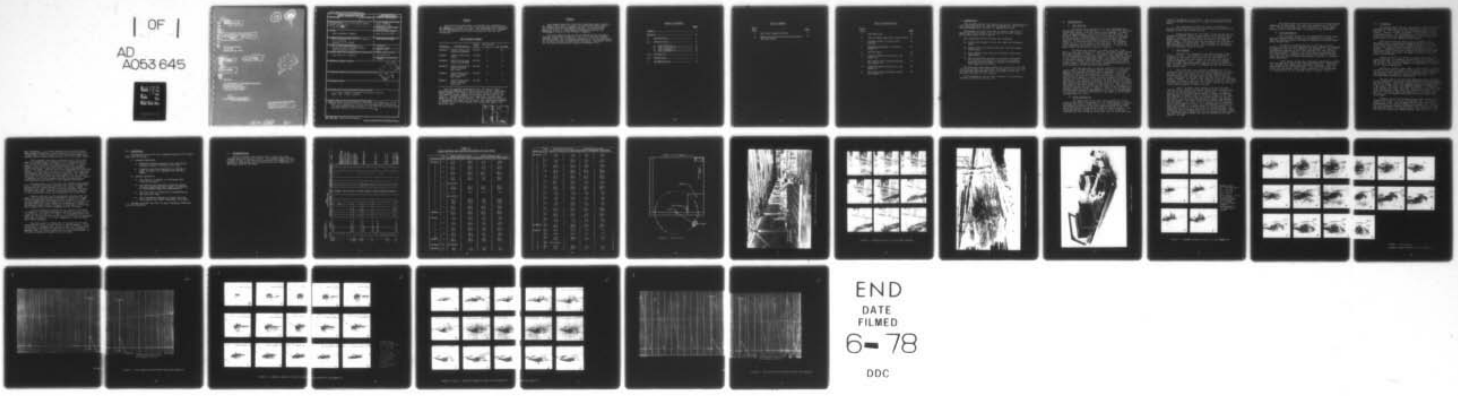

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(15) Contract No. DAAK[redacted]02-74-C-[redacted]0317

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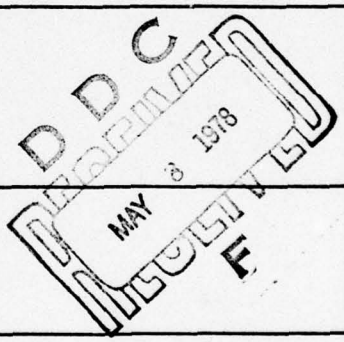

17. DISTRIBUTION STATEMENT (*of the abstract entered in Block 20, if different from Report*)

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20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

Surf tests were performed to determine the capability of the LACV-30 to perform in 6 and 8 foot plunging surf conditions. The test program demonstrated that the LACV-30 model performed satisfactorily in all conditions tested.

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SUMMARY

Surf tests were performed to determine the capability of the LACV-30 to perform in 6 and 8 foot plunging surf conditions. The testing period was one week. The table below is a summary of the configuration and tests performed for the two surf conditions.

TEST PROGRAM SUMMARY

Condition	Configuration	Weight lbs.	Surf Height ft.	No. of Runs
Landward	Vehicle with surf fence and MILVANs	115,000	6	11
Seaward	Vehicle with surf fence	84,375	6	5
Landward	Vehicle with surf fence and MILVANs	115,000	8	9
Landward	Vehicle with surf fence, MILVANs and crane	115,000	8	7
Seaward	Vehicle with surf fence, MILVANs and crane	115,000	8	5
Seaward	Vehicle with surf fence, MILVANs and crane	84,375	8	1

The test program demonstrated that the LACV-30 model performed satisfactorily in all conditions tested. When operating landward, the vehicle speed should equal or exceed the surf speed to reduce impact of the waves on the stern of the vehicle. Seaward operations will experience frequent wave impact on the bow of the vehicle. The surf fence is effective in minimizing the wash over the deck. Best performance appears to result for surf entry speeds just below hump speed, 20.5 miles per hour.

PREFACE

This report describes surf tests performed under Contract No. DAAK 02-75-C-0149, a program to deliver two Pilot Model Air Cushion Vehicles designated LACV-30. The contracting agency is the U. S. Army Mobility Equipment Research and Development Center in Fort Belvoir, Virginia.

The work reported herein was performed by Bell Aerospace Company, a Division of Textron, Inc., P. O. Box One, Buffalo, New York 14240. The testing was performed at the ACV Laboratory at the Bell facility in Wheatfield, New York. The report covers the one week testing period ending 26 September 1975.

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I. INTRODUCTION

This report presents the results of the surf testing of the 1/7.5 scale model of the LACV-30 configuration. These tests were performed under Contract No. DAAK02-75-C-0149.

The purpose of these tests was to obtain a qualitative prediction of the behavior of the LACV-30 in surf, using a 1/7.5 scale model of the vehicle.

The conditions tested included the following:

a) Scaled surf heights of six and eight foot plunging surf.

b) Vehicle with and without payload, with and without swing crane.

c) Both seaward (into surf) and landward (with surf) approaches.

d) Wave sensors were placed in the water tank ahead of the beach installation to provide continuous monitory of wave height to produce the resulting surf height at the beach.

The principal data taken during the tests are in the form of motion pictures and videotape recordings of each test run. This coverage was provided by the Government and is not included as a part of this report.

Brief discussions of the craft behavior in negotiating surf are included in Section III.

II. INVESTIGATION

1. Test Facility

The tests were conducted in the Bell Aerospace ACV Laboratory located in Wheatfield, N. Y. The water tank facility is 100 feet square, with two sides forming beaches. A water depth of approximately three and one-half feet was used. To generate surf, a hydraulically driven wave maker is installed in the northwest corner parallel to the west end of the tank such that waves could be generated toward the east beach, figure 1. A beach extension was installed in the northeast corner with a 1 in 10 slope in the surf area. The beach is now a permanent installation in the facility. A view of the beach under construction is shown in figure 2.

The model was attached to a boom, 37.5 feet long, which in turn was attached to a pole on the beach, midway across the tank as shown in figure 1. All power lines required for lift and propulsion motors were attached to the boom and relayed to the center pole through slip rings. The model was attached to the boom through a universal joint which enables the model to be free in pitch, roll and heave, but restricted in yaw to a small angle. During initial tests, excessive freedom in the joint permitted relatively large yaw motion.

Surf was generated to provide either 6 or 8 foot (full scale) peak to trough plunging surf at the beach, as measured against a calibrated pole just before breaking. A selected sequence of pictures are presented in figure 3 to show the progression of wave and a resulting surf height of 8 feet. In each of the pictures is visible a black and white grid which enables the test operator to measure the deep water wave height and adjust it as required to produce a 8 foot surf at the beach. Wave sensors were placed ahead of the grid to provide continuous monitoring of the wave height at this location. The effect of the grid can best be seen in figure 4 which is an enlargement of sequence number 57 shown in figure 3. Here it can be seen that the deep water height is approximately 14 inches, corresponding to 8.75 feet, when the surf height at the beach is 12.8 inches, corresponding to 8 feet.

2. Model Description

The model used in the surf test program is a 1/7.5 scale of the LACV-30 configuration. The model shown in figure 5, includes surf fence, swing crane, inlet air management system and MILVAN containers on the deck representative of the full scale LACV-30 at a design gross weight of 115,000 pounds. The hovering condition shown is for a 2% aft center of gravity location and lift fan speed of 945 RPM, both of which were held

constant throughout the surf test. The aft c.g. position was obtained through the placement of weight fore and aft on the model.

The configuration shown in figure 5 includes the modified stern seal arrangement which reduces the cushion flow leakage at the stern of the vehicle.

Propulsion power for the model is provided by two 7.5 horsepower electric motors mounted ahead of the modeled power module. Thrust is obtained using two six inch diameter four bladed model propellers mounted at the rear of the modeled power module. The thrust has been calibrated as a function of prpeller RPM and forward speed, and is capable of exceeding that available on the LACV-30. Lift fan power is provided by two 1.4 horsepower electric motors.

3. Test Program

The surf test program for the LACV-30 model is presented in Table I. The number of each run was prominently displayed on the model (see figure 6 from run number 22). A total of 38 runs were made during the one week test period ending 26 September 1975. Twelve of the runs were repeats, made to enable the photographer supplied by the government to take selected color movies. Two passes through the surf were made for all runs.

The first five test runs were landward with a configuration which included surf fence and MILVANs but no crane. The full scale gross weight was the design maximum value of 115,000 pounds, lift fan speed was 945 rpm, surf height was 6 feet and propeller RPM was varied between runs to provide a range of speeds. Run number 1 was repeated to provide increased coverage. Excessive model yaw was noticed during the early runs. The universal boom attachment to the model as well as the boom itself were corrected to reduce the yaw.

Runs 6 through 9 were seaward tests with MILVANs removed, at the minimum achievable model weight corresponding to a full scale gross weight of 84,375 pounds. In order to achieve the 84,375 pounds gross weight, a bungee arrangement was employed to support some of the model weight on the boom. This was due to the fact that the minimum weight for the 2% aft center of gravity was substantially higher, approximately 105,000 pounds. Run number 6 was re-run because the vehicle was initially out of trim. Runs 10 through 16 were landward with a surf height of 8 feet. The configuration included surf fence and MILVANs for a gross weight of 115,000 pounds. The next series of tests in 8 foot surf were performed with a configuration which included surf fence, crane and MILVANs. Runs 17 through 21 were landward and runs 22 through 24 were seaward. The full scale gross weight was 115,000 pounds and lift fan speed of 945 RPM.

The final series of tests were to be for the light-weight condition, 84,375 pounds full scale and seaward into an 8 foot surf. On the first pass, the boom fractured at a point approximately 20 feet from the model. Testing was thus concluded.

4. Data Acquisition

Data recorded during the test program was vehicle speed and wave height midway between the wavemaker and the beach. Data was recorded using a Minneapolis Honeywell Visicorder which gives instant data.

The basic data gathering was in the form of motion pictures to show the craft behavior and water impact in attempting to negotiate the surf both landward and seaward. The speeds for entering and leaving the surf were recorded for each test run and are presented in Table II in model speed and corresponding full scale speed. Sequence camera shots were taken for a few test runs by a Bell Aerospace photographer and will be discussed where applicable.

A wave height sensor was continually monitored to assure that the specified wave height was being generated. Samples of the recorded wave heights are presented in figures 7 and 9 for runs number 22 and 24 respectively. The scale factor used is 8 feet of wave height (full scale) equivalent to 6 inches peak to trough height on the tracings shown in figures 7 and 9.

III. DISCUSSION

The primary data from the test program consists of motion pictures and videotape recordings obtained directly by the government. The coverage is not presented as part of this report. However, a brief discussion of each series of runs is presented here. The discussion of the tests will be made using full scale craft characteristics for such items as gross weight, lift fan speed and surf height.

The first series of tests, runs 1 through 5, were performed with a configuration representing a full loaded LACV-30 proceeding from ship to shore through a 6 foot surf. In all five tests the model negotiated the surf with no problem. It appeared that the most satisfactory method when going from ship to shore was to match the speed of the craft with water speed and reduce the impact of surf hitting the stern of the vehicle.

During the first test series, a large number of color reruns were made to determine the best angle of coverage. It was decided that the most important view landward was to show the action of the surf with respect to impingement of water on the aft deck and propeller.

During the initial three runs, a large amount of yaw was noticed as the vehicle swung into the waves. Investigation of the boom and model resulted in the strengthening of the boom and changing the connection between model and boom. This condition was corrected in later tests.

The next series of tests were seaward and were performed at the lightweight condition of 84,375 pounds without MILLER and swing crane. This series involved surf entry speeds ranging from 14 to 34 mph, with surf departure speeds averaging about 9 mph slower than entry, (but widely variable). In general, entry speeds above hump (20.5 mph) resulted in heavy wave impact with considerable spray, while the lower entry speeds tend to cause the vehicle to spend excessive time in the surf zone. The best test performance was achieved at entry speeds just below hump.

However, two factors should be noted when evaluating the seaward test results. First, considerable run to run variability was noted. This probably results from surf phase differences as the vehicle crosses the breaker line. Second, the test procedure involves setting a fixed thrust level and starting the model at a fixed distance from the beach. Thus, the tests at lower entry speeds are at lower thrust levels,

and conversely. It is quite possible that a thrust level high enough to maintain a speed through a surf of say 10 to 15 mph combined with initial entry at about that speed may provide better seaward behavior than any of the cases tested.

The remaining tests were performed in an 8 foot surf. Runs 10 through 16 were landward for a configuration with surf fence and MILVANs at a design gross weight of 115,000 pounds. Runs 10 and 11 were demonstration runs to insure proper monitoring of deep water wave height and plunging surf at the beach. Runs 12 and 13 were performed at very slow speeds. In both tests, the surf wave, caught up to the stern and impinged upon the aft deck and propeller. The remaining three runs were performed at higher speeds and the vehicle traversed the surf nicely with no impact on the stern. Again, it appears that vehicle speeds matching or exceeding surf speed produces good behavior in the landward direction.

The next series of tests were both landward and seaward with a configuration which included surf fence, MILVANs and swing crane at a gross weight of 115,000 pounds. Again matching craft speed with surf speed was desirable for ship to shore traverses. Seaward runs produced heavier impacts on the bow and surf fence than experienced in 6 foot surf.

Figure 6 presents selected sequence pictures from run number 22, showing the model entering the surf at 24.8 mph, riding through and leaving the surf at a speed of 7.3 mph. The photographs show the impact of the waves on the bow. The recorded deep water wave heights are presented in figure 7. The maximum height, peak to trough, is equivalent to 8.8 feet which results in an 8 foot plunging surf at the beach.

Selected sequence pictures of run number 24 are shown in figure 8. The speed entering the surf is 16.6 mph and the speed leaving the surf is 7.7 mph. The photographs show the impact of the bow and wave to be not as severe as the high speed run shown in figure 6. The craft appeared to ride the deep water waves smoothly.

The last series of tests were to be made for the same configuration but at a gross weight of 84,375 pounds. On the first pass, it appeared that the lower part of the boom made contact with the water and resulted in the boom breaking. It appeared that the vehicle speed was too slow and resulted in the model struggling through the 8 foot surf.

IV. CONCLUSIONS

Conclusions of the surf test program using the 1/7.5 scale model are as follows:

A. Landward Operations

a. Landward operation appears to be very satisfactory in both 6 foot and 8 foot surf.

b. Propeller and stern immersion is avoided if speed is equal to or greater than the wave speed.

B. Seaward Operations

a. The vehicle is capable of traversing both 6 and 8 foot surf.

b. The head-on wave encounter situation tested involves substantial wave impact, accompanied by considerable spray and deceleration.

c. The surf fence is effective in minimizing the wash over the deck.

d. Best performance appears to result for surf entry speeds just below hump speed (20.5 mph).

Because the model was fixed in yaw, broaching tendencies were not evaluated.

V. RECOMMENDATIONS

Verify the model test results with a full scale test program using the LACV-30 vehicle. The program should include a range of surf entry speeds both landward and seaward for the purpose of determining vehicle behavior and its comparison to the films taken of the model.

*Designation corresponds to identification numbers attached to model cabin for each run

TABLE I

SURF TEST PROGRAM SCHEDULE

Condition	Run* No.	Configuration Description	Gross Wt-Lb. Model	Gross Wt-Lb. Full Scale	Lift Fan Speed-RPM Model	Lift Fan Speed-RPM Full Scale	Prop Speed RPM	Surf Height-Ft. Model	Surf Height-Ft. Full Scale	Camera Coverage Videotape	Camera Coverage Color	Camera Coverage Boom	Comments
Landward (Ship to Shore)	1	Vehicle with surf fence and MILVANS	272.2	114835.0	2614	945	6000	0.80	6	x		x	
	2						7000			x		x	
	3						8000			x		x	
	4						9000			x		x	
	3				2614		8000				x	x	Repeat of Run No. 3
	3→				2630		8000				x	x	Additional color coverage yaw appeared large going into surf
	1→						6000				x	x	Repeat of Run No. 1
	1→						6000			x	x	x	Stern shot - attempt to correct yaw
	1→						6000			x		x	Boom strengthed, yaw corrected - stern shot
	1→						7000				x	x	Repeat of Run No. 2
Landward	5	Vehicle with surf fence and MILVANS	272.2	114835.0	2630		8000			x		x	Repeat of Run No. 3
Seaward (Shore to Ship)	6	Vehicle with surf fence	200.00	84375.0	2630		5000				x	x	Low speed -Vehicle appeared out of trim
	6						5000				x	x	Repeat of Run No. 6 - Vehicle trimmed.
	7						6000			x		x	
	8						7000			x		x	
Seaward	9	Vehicle with surf fence	200.0	84375.0	2630		8000	0.80	6	x		x	
Landward	10	Vehicle with surf fence and MILVANS	272.2	114835.0	2630		5000	<1.07	< 8	x		x	Demonstration run - surf not quite high enough.
	11						7000			x		x	
	12						5000	1.07	8	x		x	
	13						6000			x		x	
	14						7000			x		x	
	15						8000			x		x	
Landward	16	Vehicle with surf fence and MILVANS	272.2	114835.0	2630	945	9000	1.07	8	x		x	
	13→						6000				x	x	Repeat of Run No. 13
	15→						8000				x	x	Repeat of Run No. 15
	17	Vehicle with surf fence, MILVANS and crane					5000			x		x	
	18						6000			x		x	
	19						7000			x		x	
	20						8000			x		x	
	21						9000			x		x	
	18→						6000				x		Repeat of Run No. 18
Landward	20→						8000				x		Repeat of Run No. 20
Seaward	22						7000			x		x	
	23						6000			x		x	
	24						5000			x		x	
	24→						5000				x		Repeat of Run No. 24
	23→		272.2	114835.0			6000				x		Repeat of Run No. 23
Seaward	25	Vehicle with surf fence, MILVANS and crane	200.0	84375.0	2630	945	5000	1.07	8	x		x	Vehicle negotiated surf then boom collapsed, ending testing.

TABLE II

SPEEDS ENTERING AND LEAVING SURF-MODEL AND FULL SCALE

Condition	Run No.	Speed Entering Surf		Speed Leaving Surf	
		Model-Ft/Sec	Full Scale-MPH	Model Ft/Sec	Full Scale-MPH
Landward	1	8.3	15.5	5.1	9.5
		11.3	21.1	9.0	16.8
	2	10.4	19.4	9.2	17.2
		11.6	21.7	9.4	17.6
	3	13.1	24.5	11.1	20.7
		13.4	25.0	12.0	22.4
	4	11.4	21.3	9.8	18.3
		12.3	23.0	9.7	18.1
	3	No Record			
	3	13.0	24.3	10.7	20.0
		12.85	24.0	10.2	19.0
	1	7.1	13.3	4.7	8.8
	1	No Record			
	1	10.7	20.0	7.1	13.3
		9.3	17.4	6.3	11.8
		9.3	17.4	7.9	14.8
	1	13.7	25.6	10.3	19.2
		13.6	25.4	10.4	19.4
Landward	5	16.5	30.8	13.6	25.4
		14.3	26.7	12.2	22.8
Seaward	6	8.4	15.7	4.0	7.5
		7.6	14.2	2.6	4.9
	6	8.6	16.1	4.3	8.0
		9.8	18.3	7.0	13.1
	7	11.1	20.7	8.3	15.5
		11.6	21.7	6.8	12.7
	8	8.3	15.5	4.7	8.8
		15.3	28.6	8.6	16.1
Seaward	9	11.7	21.8	6.8	12.7
		18.0	33.6	5.4	10.1
Landward	10	No Record			
Landward	11	3.6	6.7	2.3	4.3
		3.4	6.3	2.4	4.5

Condition	Run No.	Speed Entering Surf		Speed Leaving Surf	
		Model-Ft/Sec	Full Scale-MPH	Model Ft/Sec	Full Scale-MPH
Landward	12	2.7	5.0	1.4	2.6
		2.7	5.0	0.4	0.7
	13	5.6	10.5	3.4	6.3
		7.6	14.2	6.4	12.0
	14	11.8	22.0	6.8	12.7
		11.4	21.3	5.3	9.9
	15	11.8	22.0	12.4	23.2
		12.3	23.0	9.3	17.4
	16	16.3	30.4	13.3	24.8
		15.4	28.8	12.6	23.5
	13	6.9	12.9	4.1	7.7
		8.4	15.7	6.4	12.0
	15	14.1	26.3	10.6	19.8
		13.5	25.2	12.7	23.7
	17	2.9	5.4	1.3	2.4
		1.8	3.4	0.5	0.9
	18	5.9	11.0	5.1	9.5
		3.4	6.3	4.7	8.8
	19	7.8	14.6	3.9	7.3
		7.3	13.6	4.1	7.7
	20	11.0	20.5	12.1	22.6
		11.4	21.3	10.6	19.8
	21	12.7	23.7	9.8	18.3
		13.6	25.4	11.6	21.7
	18	2.3	4.3	1.5	2.8
		2.1	3.9	2.6	4.9
Landward	20	9.9	18.5	9.2	17.2
		12.1	22.6	11.1	20.7
Seaward	22	13.3	24.8	3.9	7.3
	23	10.3	19.2	3.9	7.3
	24	8.9	16.6	4.1	7.7
		10.0	18.7	3.9	7.3
	24	No Record			
	23	10.2	19.0	4.1	7.7
		11.4	21.3	5.3	9.9

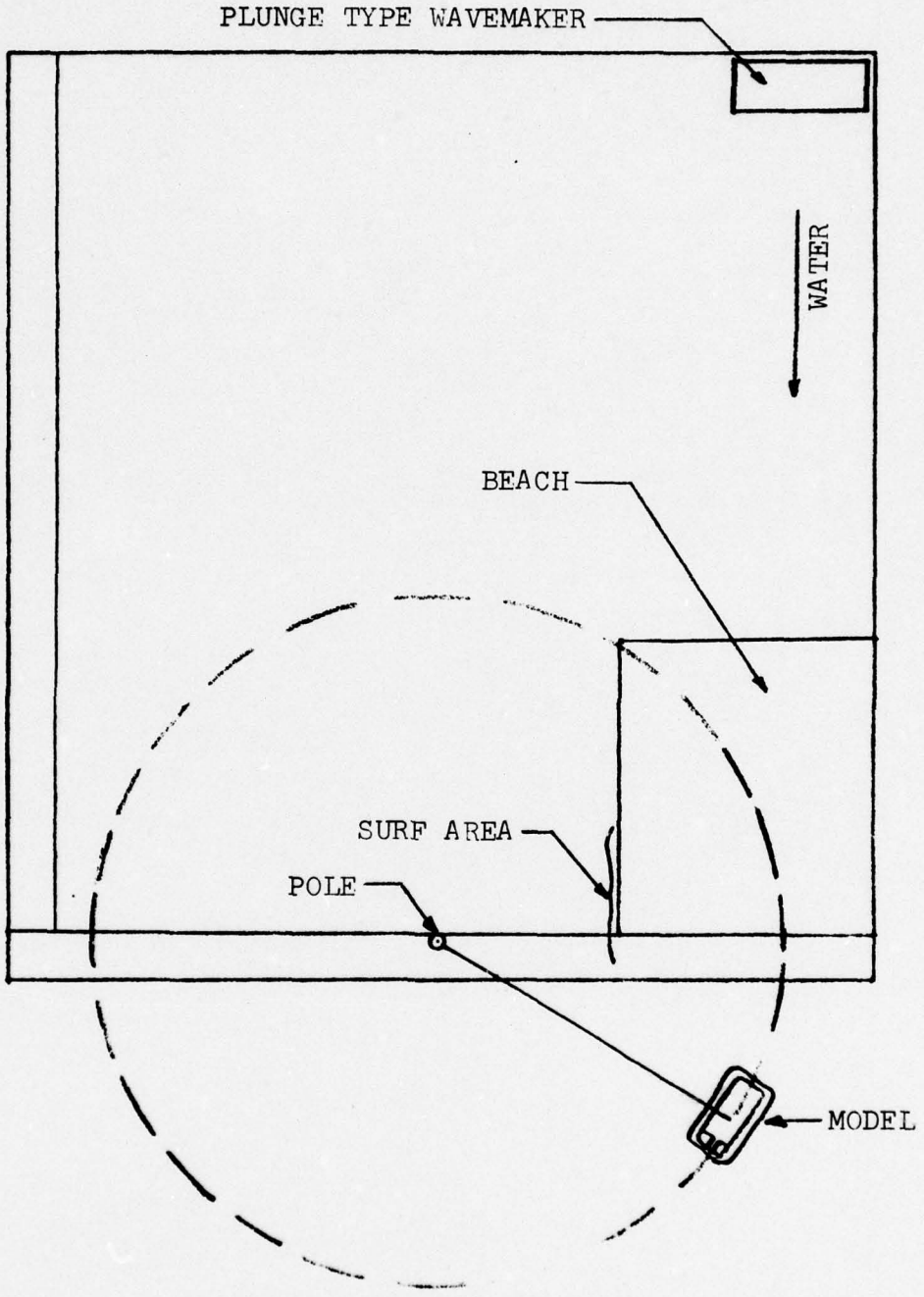


FIGURE 1. SURF FACILITY

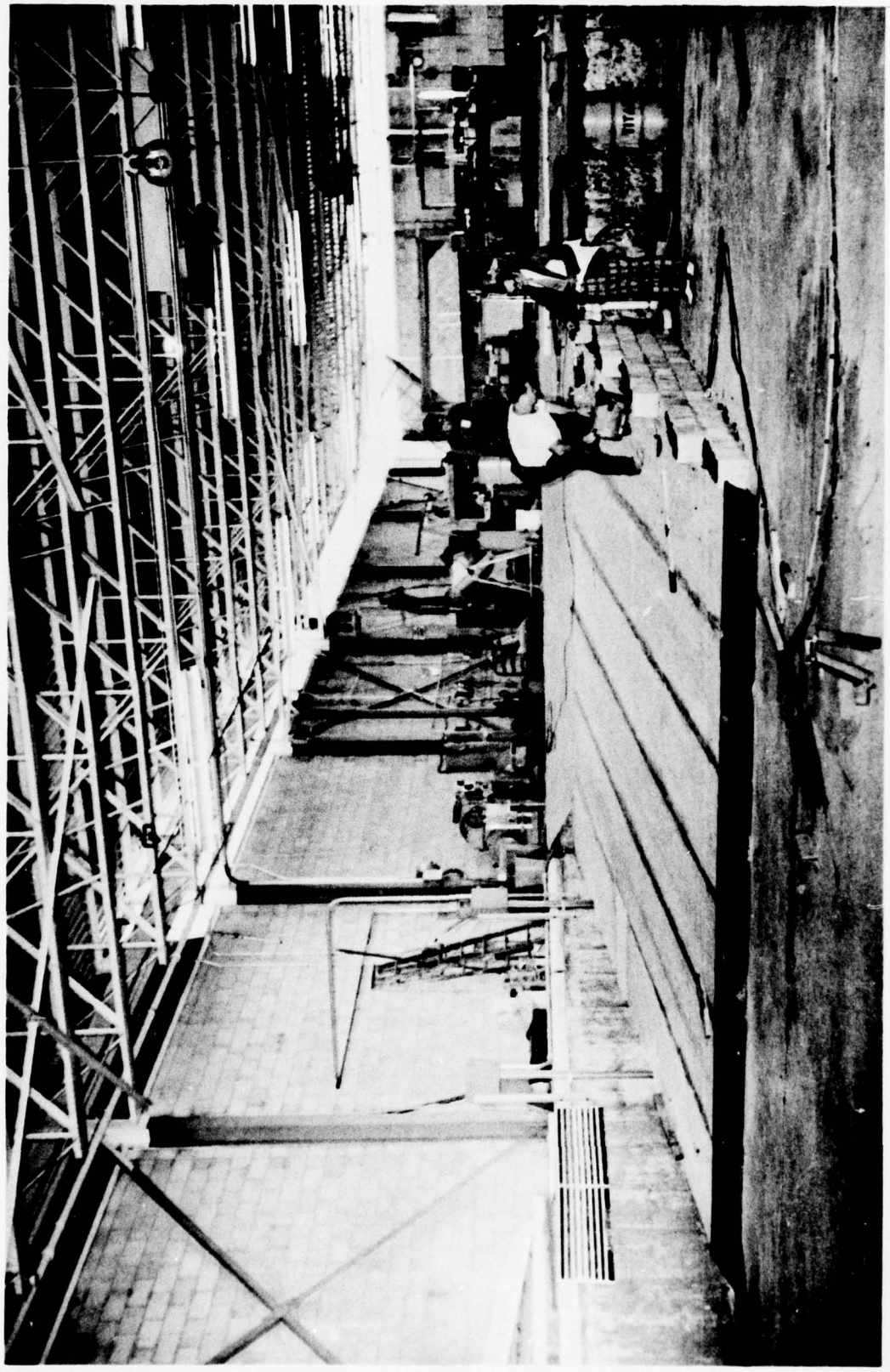


FIGURE 2. VIEW OF BEACH RAMP UNDER CONSTRUCTION

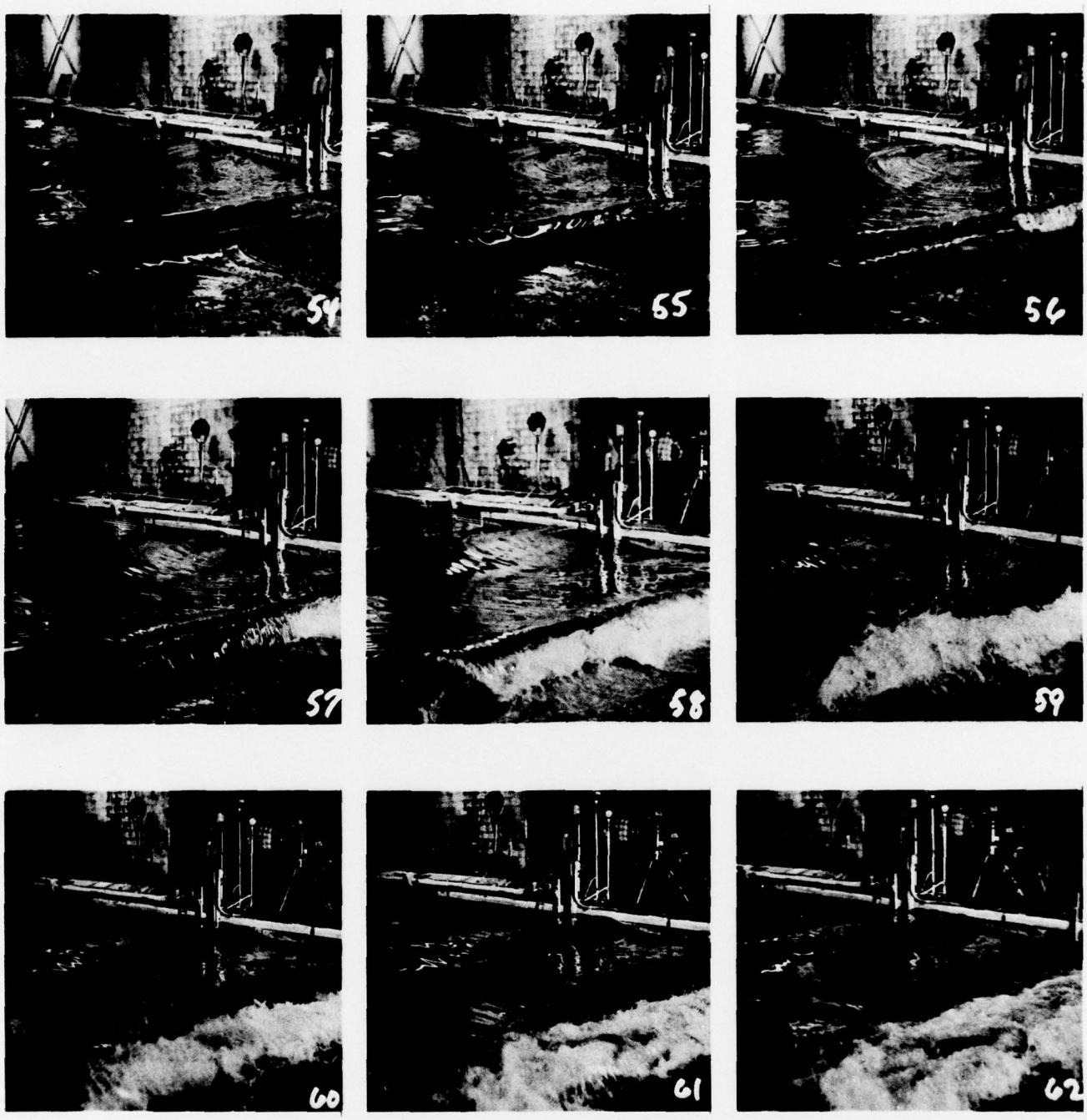


FIGURE 3. SEQUENCE SHOTS OF 8 FOOT SURF BUILDUP

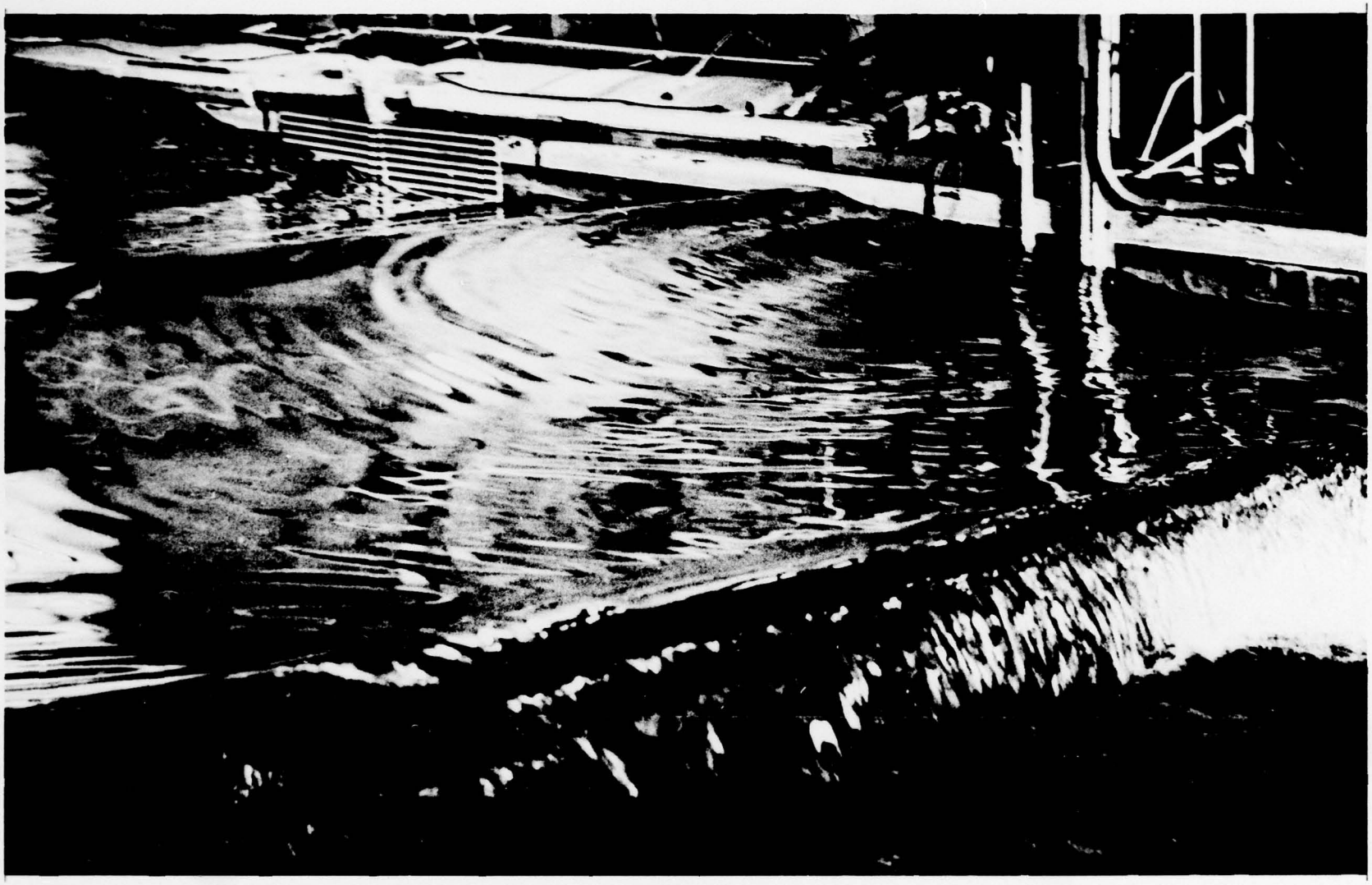


FIGURE 4. ENLARGED PHOTOGRAPH OF SEQUENCE NUMBER 57

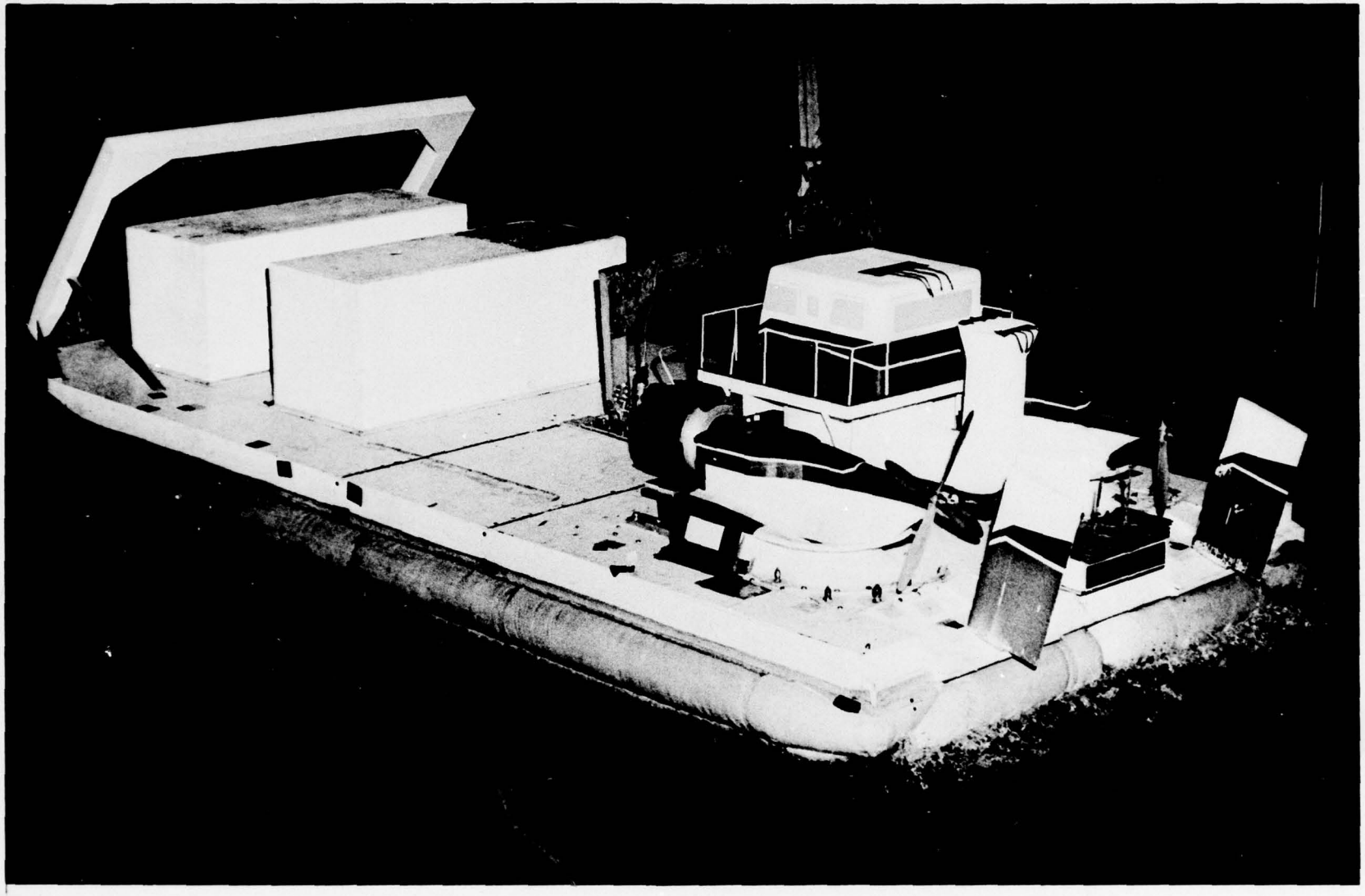
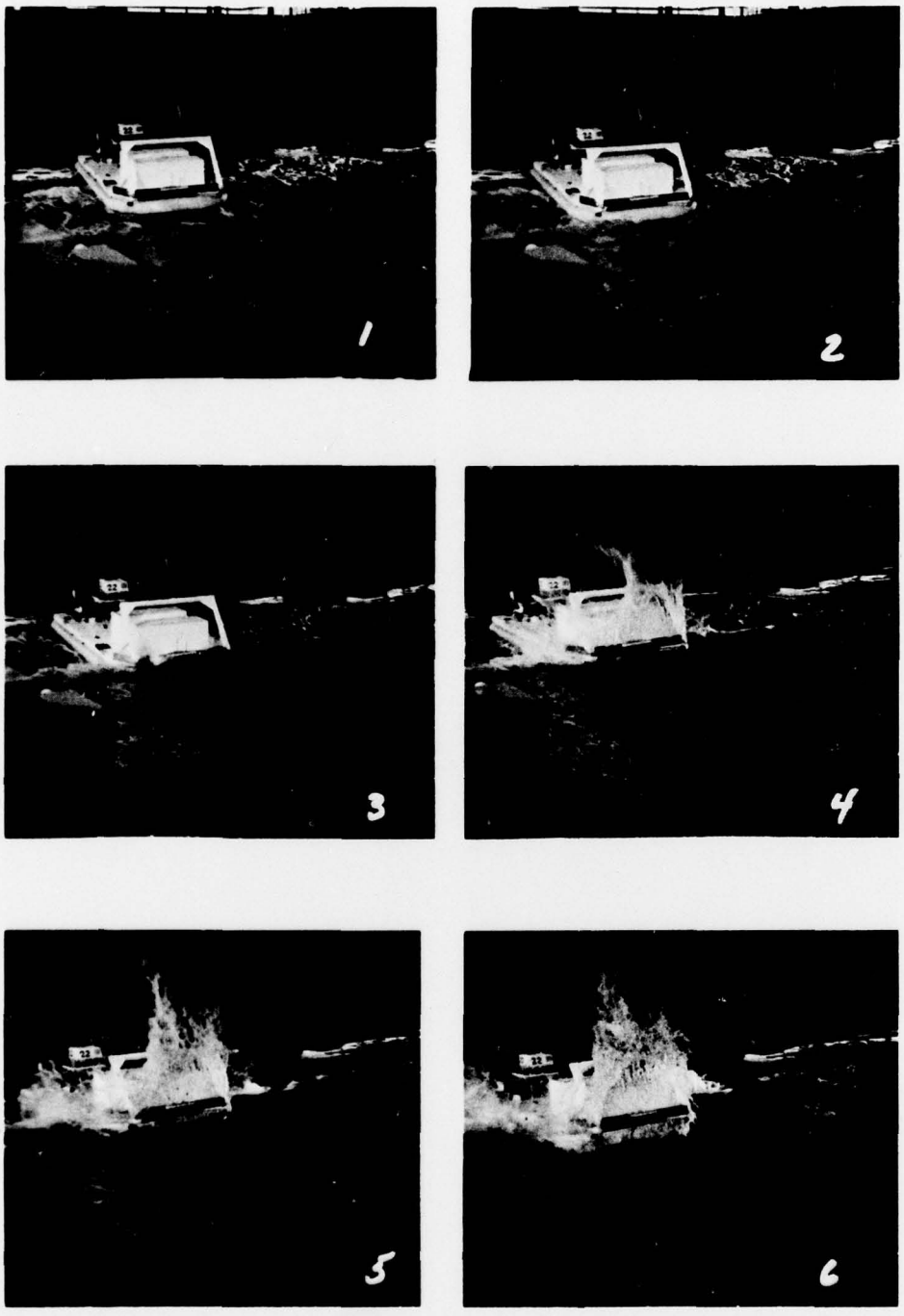


FIGURE 5. LACV-30 MODEL



Seaward Test
W_G = 114,835 lbs.
N_F = 945 RPM
L_{CG} = 2% aft
Surf Height - 8 ft.
V = 24.8 MPH
(entering surf)
V = 7.3 MPH
(entering deep
water)
Camera Speed is
10 frames per
second

FIGURE 6. SEQUENCE CAMERA PICTURES FOR RUN NUMBER 22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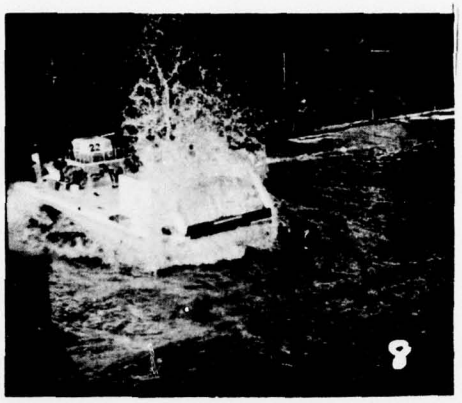
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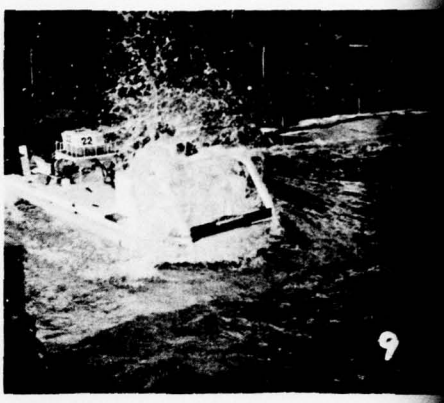
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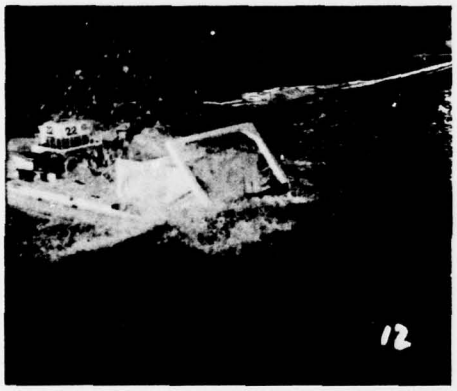
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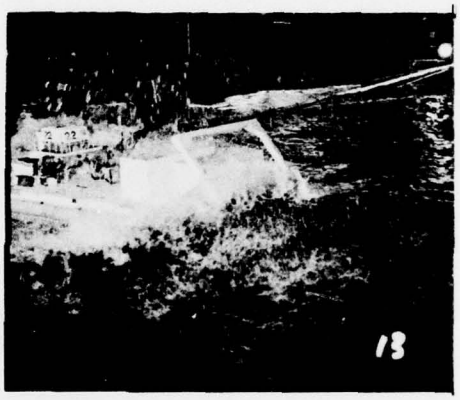
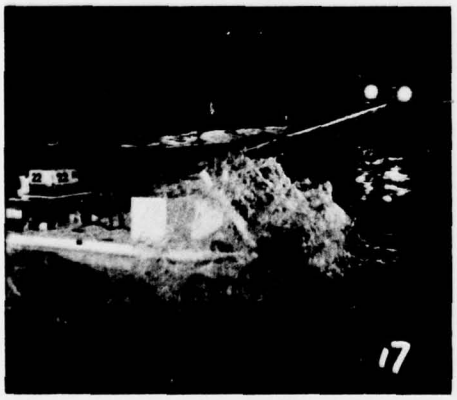
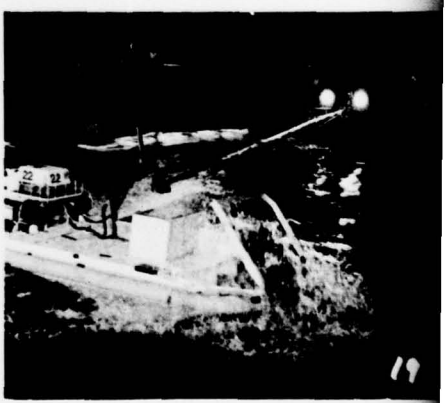

13


14


17


18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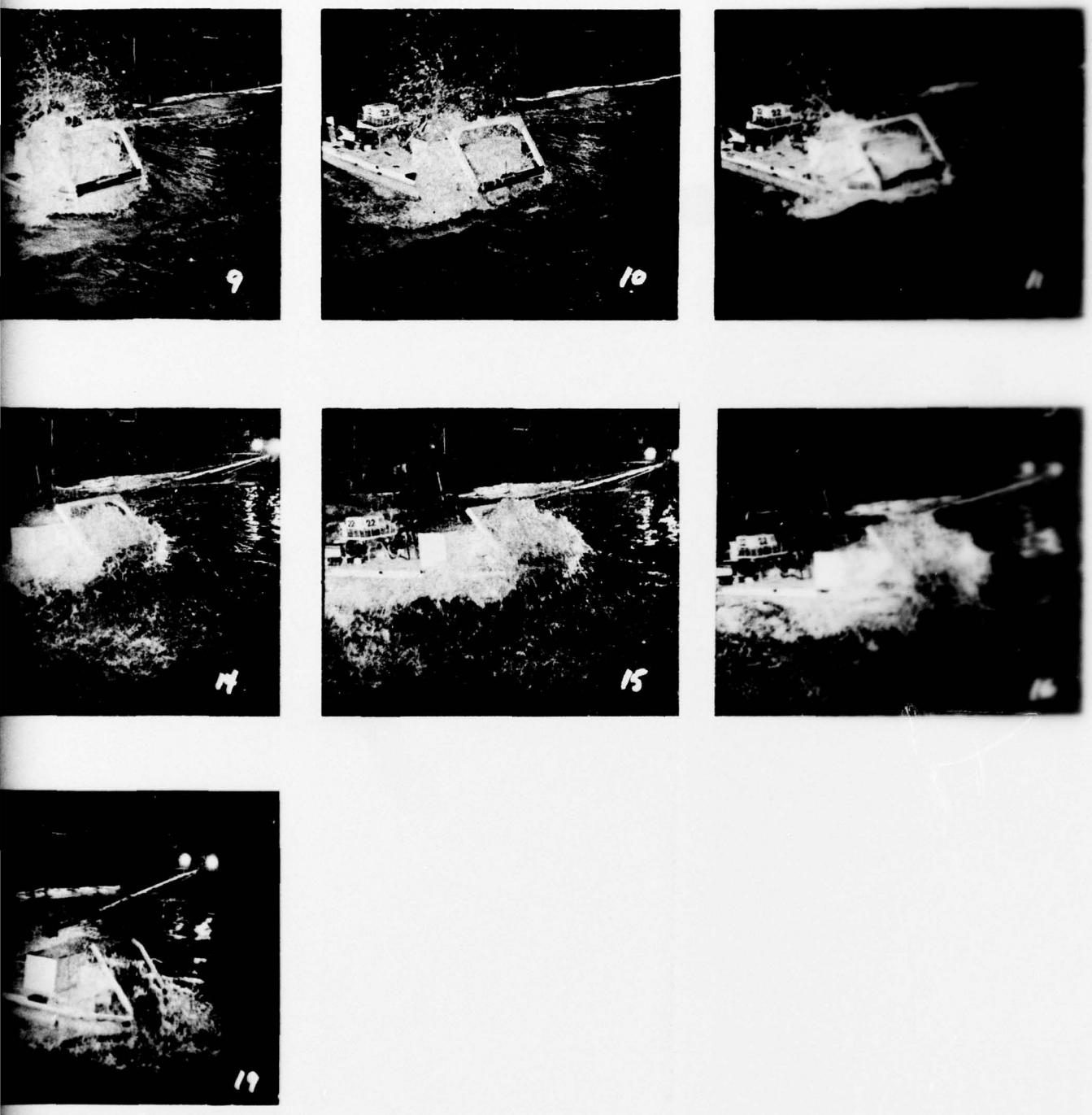


FIGURE 6. (Continued)
SEQUENCE CAMERA PICTURES FOR RUN NUMBER 22

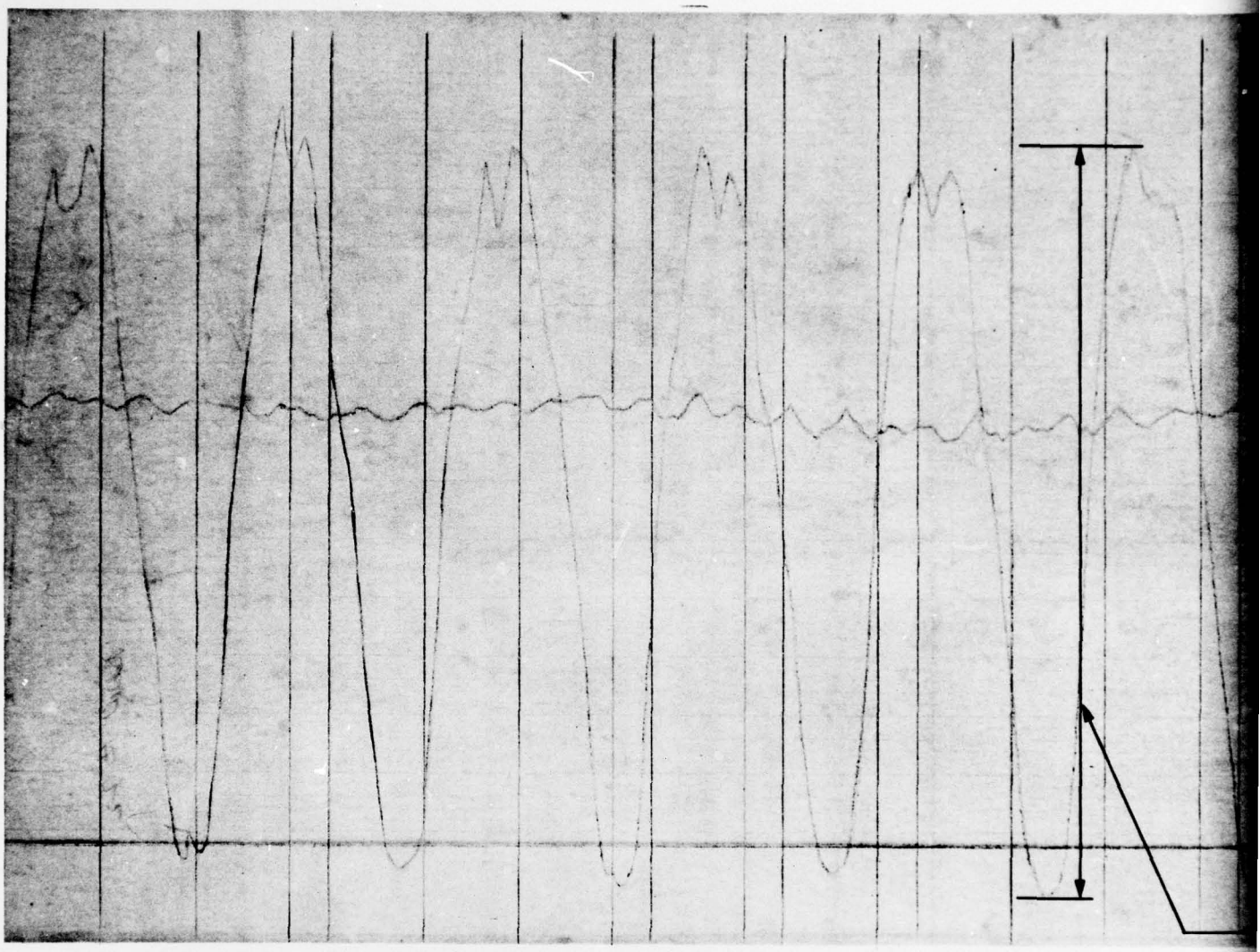


FIGURE 7

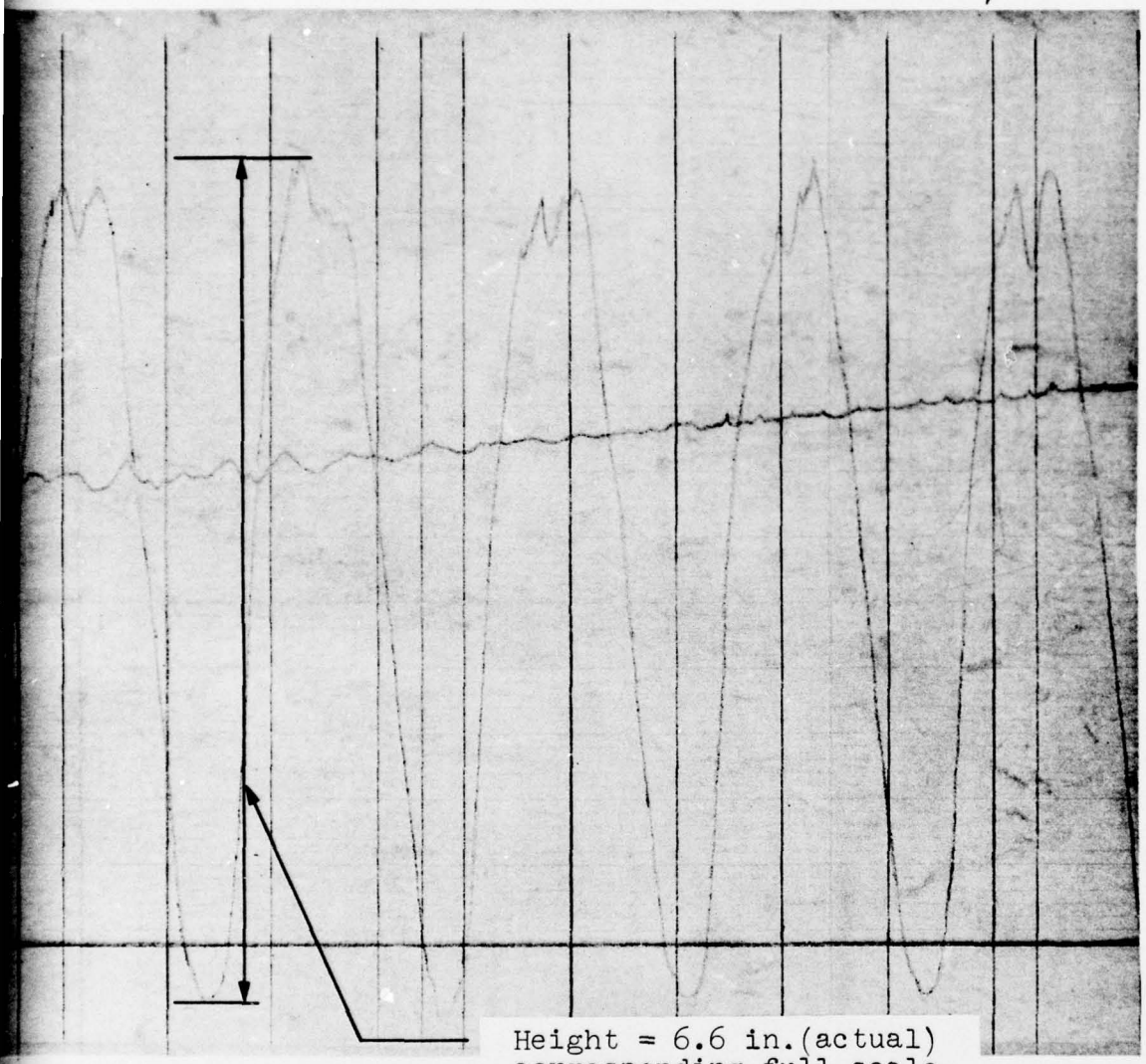


FIGURE 7. WAVE SENSOR DATA RECORDED DURING RUN NUMBER 22

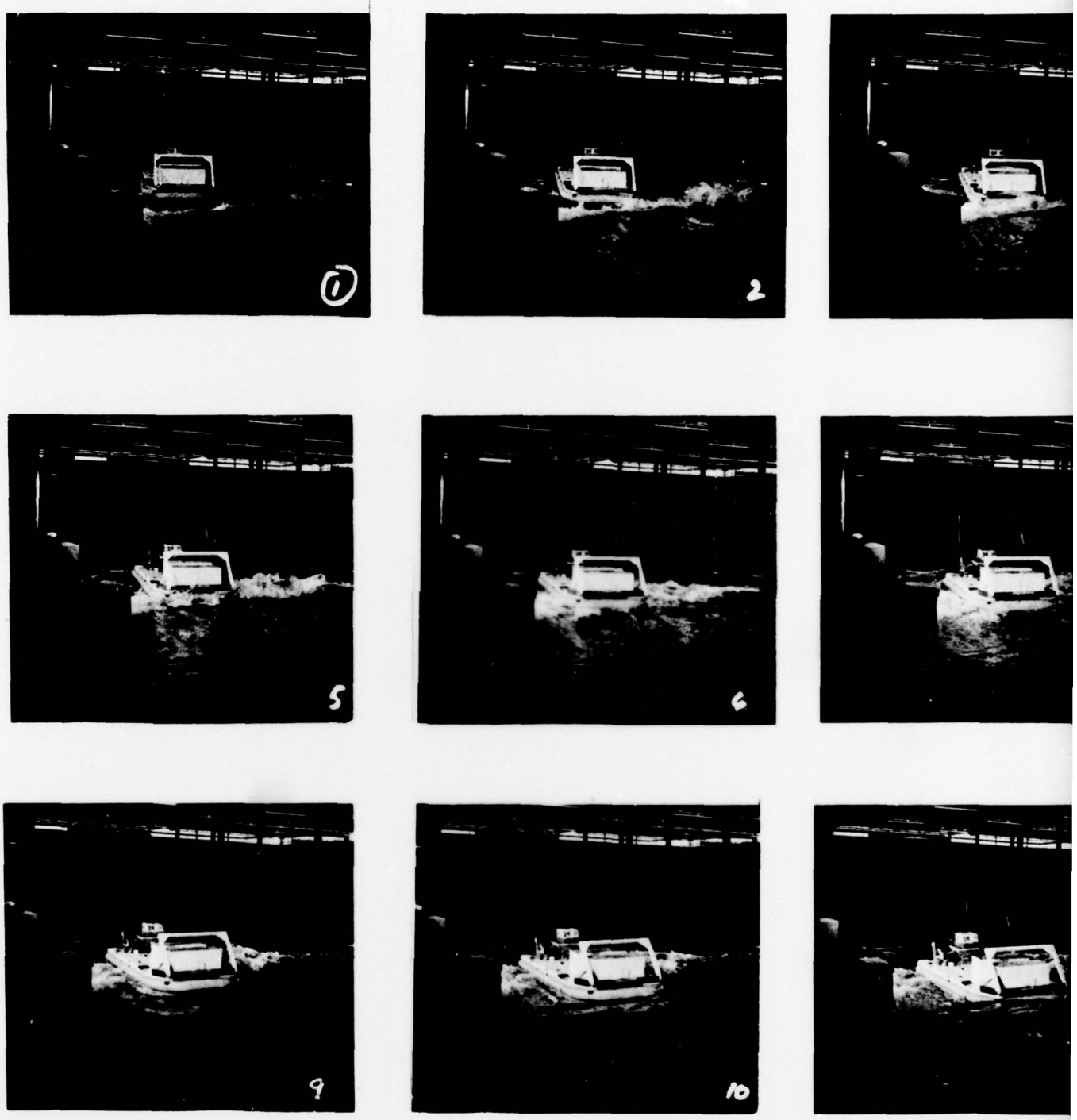
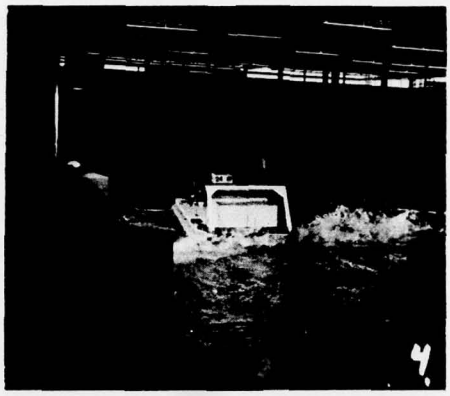
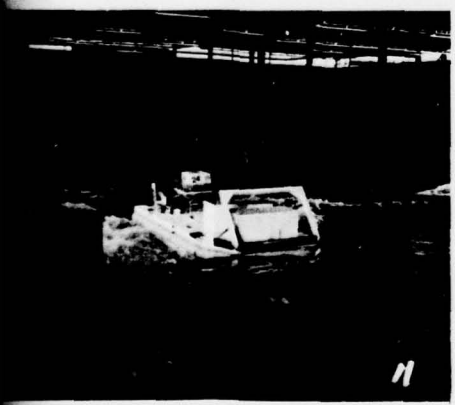
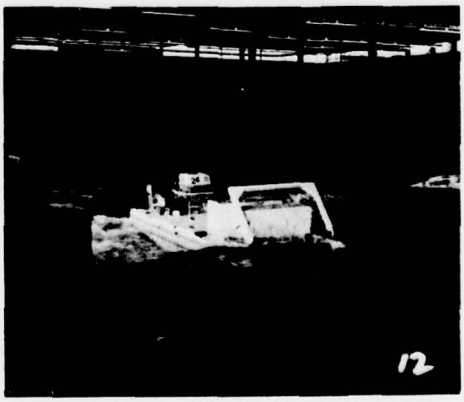


FIGURE 8. SEQUENCE CAMERA PICTURES FOR RUN

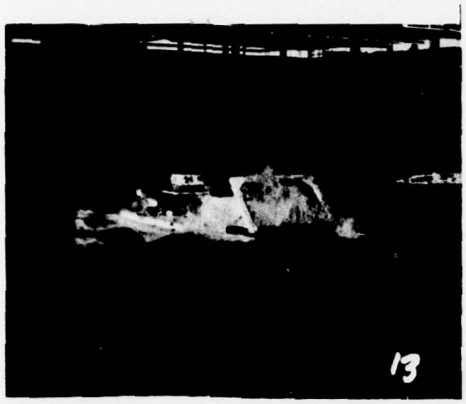


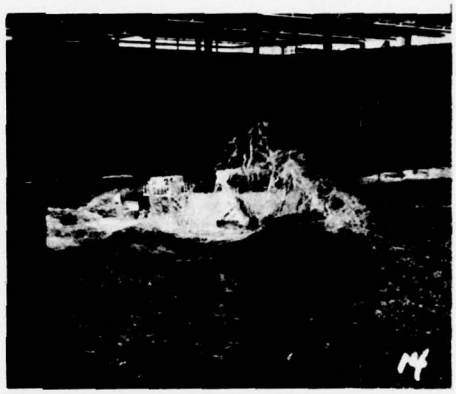


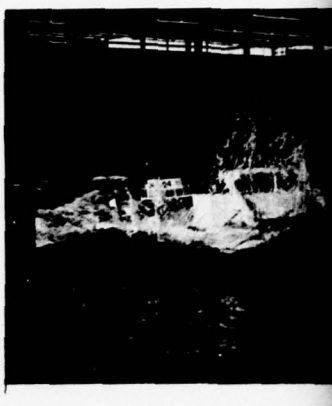


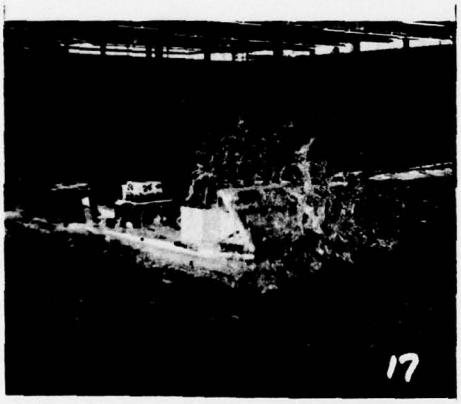
Seaward Test
W_G = 114,835 Lbs.
N_F = 945 RPM
L_{CG} = 2% Aft
Surf Height - 8 ft.
V = 16.6 MPH
(Entering Surf)
V = 7.7 MPH
(Entering Deep
Water)
Camera Speed is
10 frames per
second.

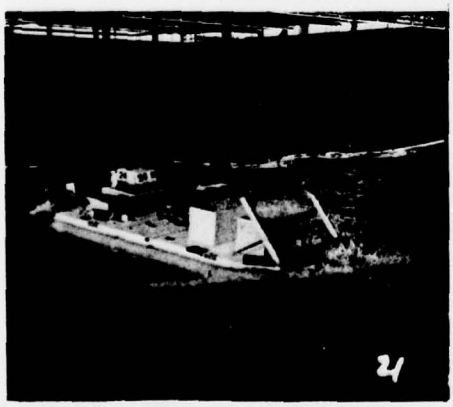
A PICTURES FOR RUN NUMBER 24

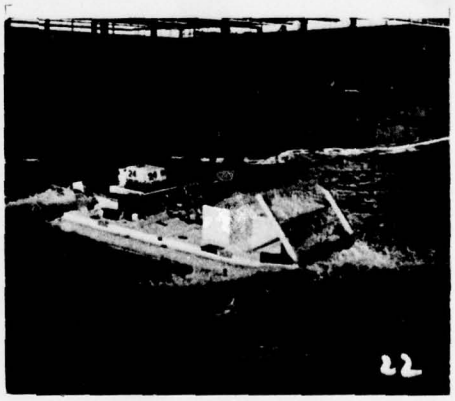












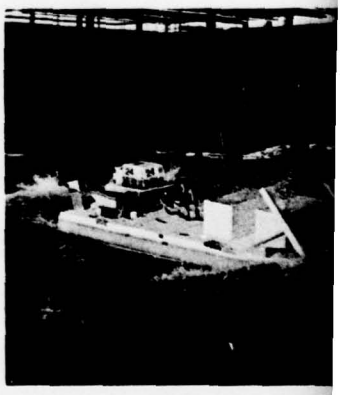
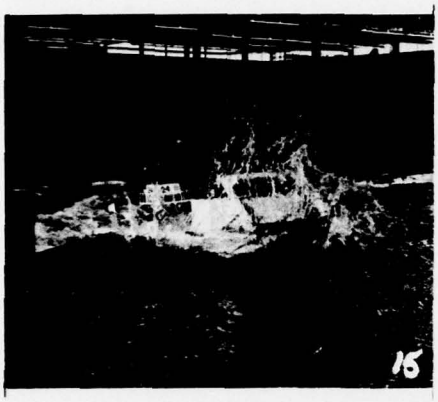
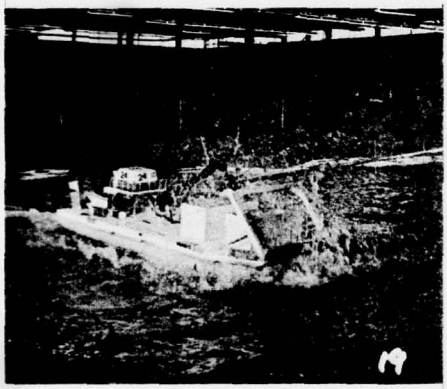


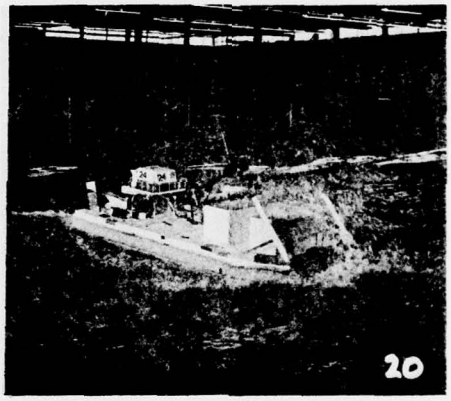
FIGURE 8 (CONT.). SEQUENCE CAMERA PICTURES FOR RUN NUMBER 24

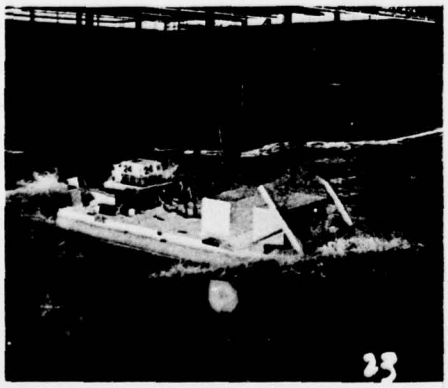
1

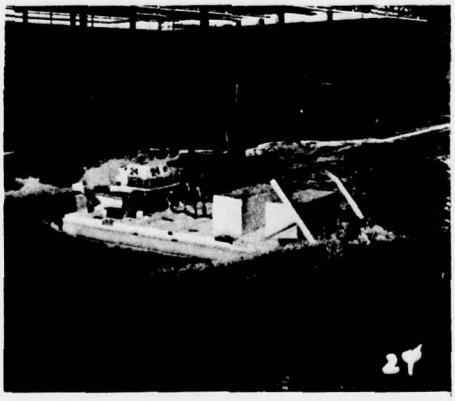
2



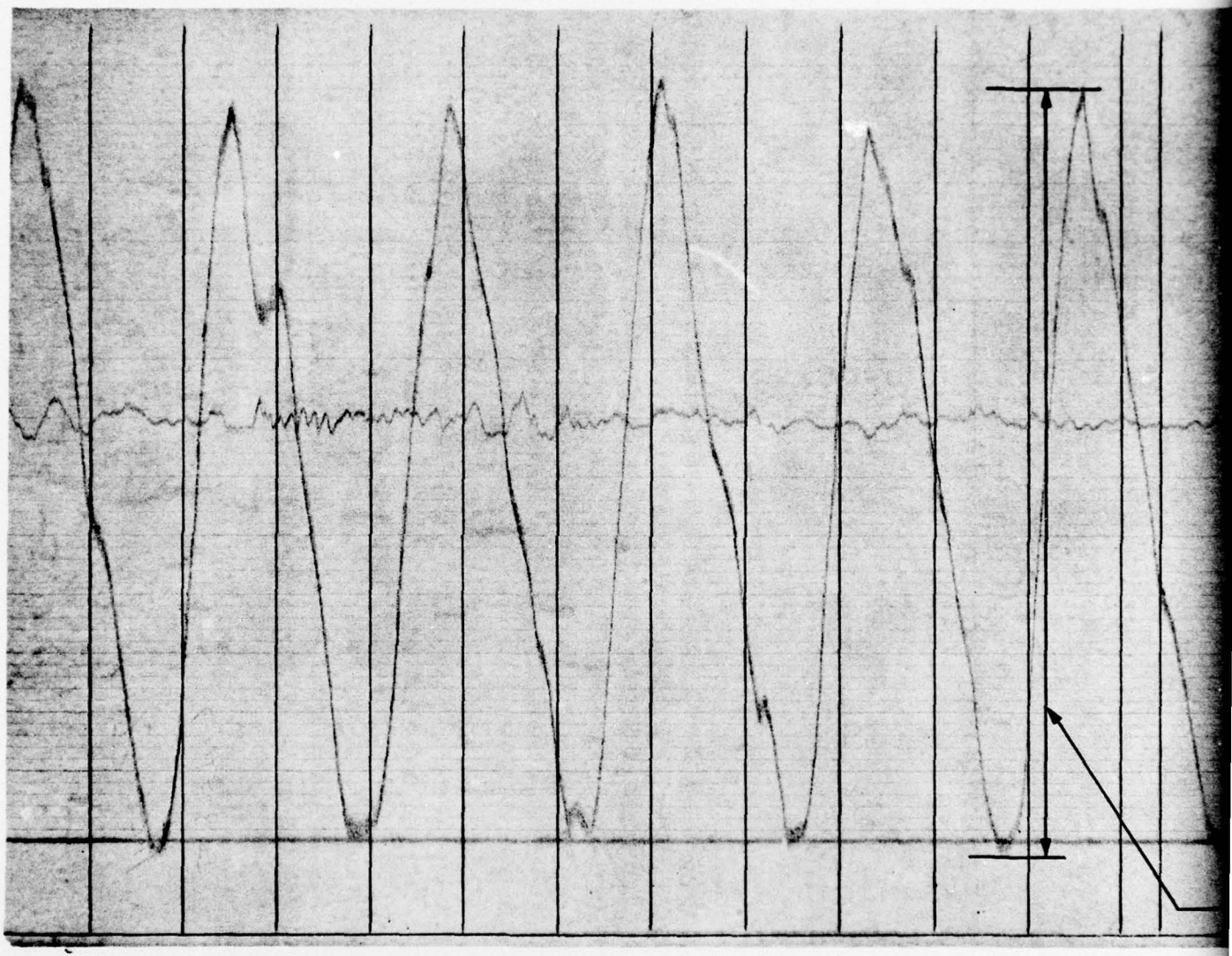








FOR RUN NUMBER 24



FI

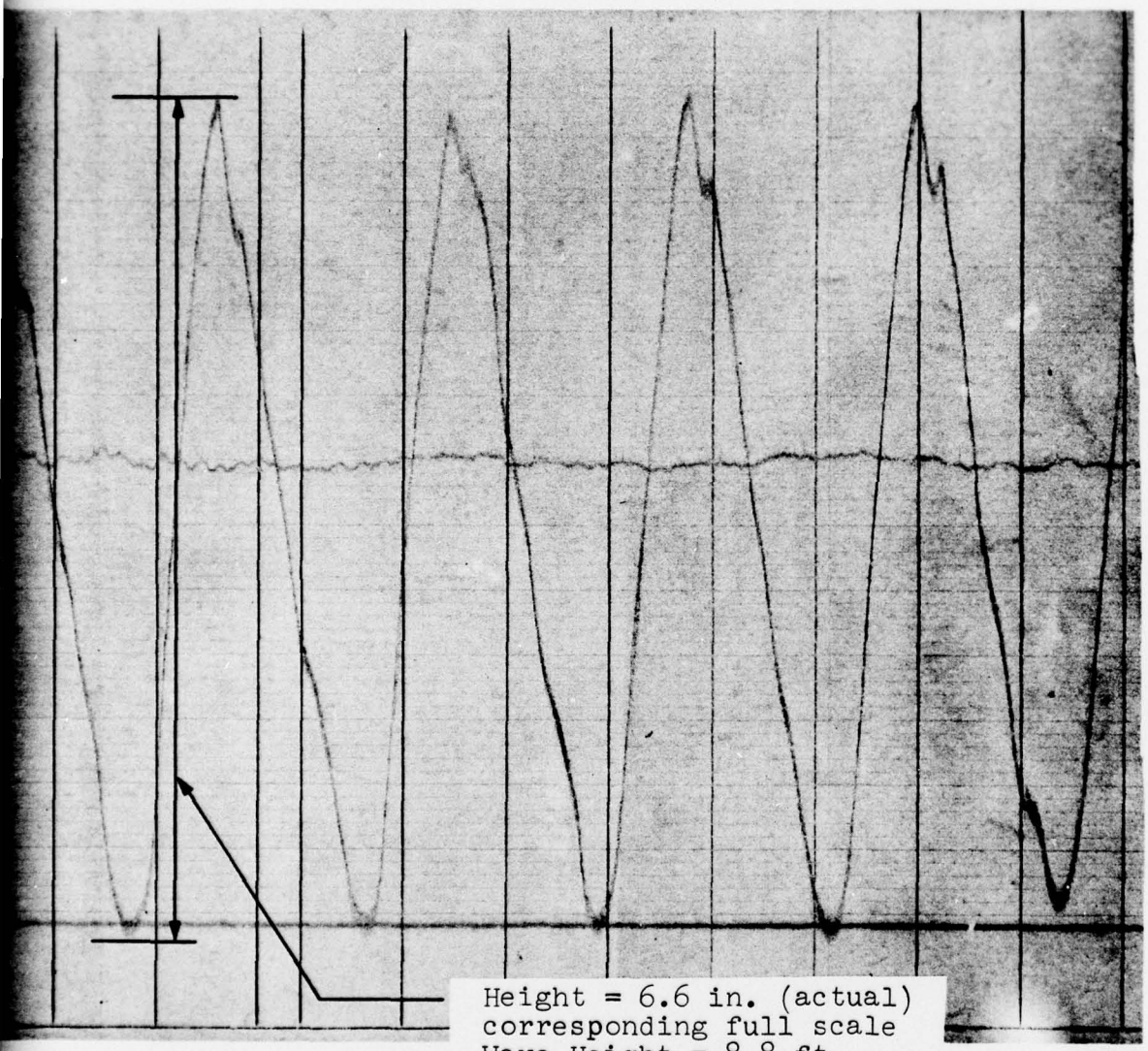


FIGURE 9. WAVE SENSOR DATA RECORDED DURING RUN NUMBER 24