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DEPTH, TRIM, HEADING, AND FLOODING OF WIGWAM TARGETS

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Report to the Scientific Director

DEPTH, TRIM, HEADING, AND FLOODING OF WIGWAM TARGETS

By

Raymond E. Converse, Jr.

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ABSTRACT

The primary purpose of the project described in this report was to determine at zero time the depth, the angles of roll and pitch, and the heading relative to the atomic device of each SQUAW target as well as the occurrence of flooding within each SQUAW compartment. At zero time the following readings were obtained:

SQUAW	Roll, deg	Pitch, deg	Depth,* ft	Flooding	Heading†
12		36° bow up	290	None	65° ± 3°
13	1° stbd.	3° bow down	265	None	0° ± 16°
29	4° stbd.	2° bow down	At the surface	None	21° ± 14°

* To the center of the centerline bulkhead.

† The angle between the axis of each SQUAW and the normal to the shock front as determined from the velocity-time records of Project 3.2.

Similar data also were obtained before and after the detonation of the atomic device. They are tabulated and discussed and the instrumentation is described in this report.

ACKNOWLEDGMENTS

Personnel from the Industrial Department of the David W. Taylor Model Basin designed and fabricated the equipment used for this project. The valuable contributions made by F. E. Frillman of this department are gratefully acknowledged.

Special thanks are also due to the many employees of the Naval Repair Facility and the Navy Electronics Laboratory, San Diego, Calif., who gave valuable assistance.

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DEPTH, TRIM, HEADING, AND FLOODING OF WIGWAM TARGETS

1 OBJECTIVES

The depth, the angles of roll and pitch, and the heading relative to the atomic device of each SQUAW target as well as the occurrence of flooding within each SQUAW compartment were to be determined at zero time. Other objectives were:

1. To determine if flooding occurred in any SQUAW compartment from the time the target left the outfitting yard until the test.
2. To provide information that would serve as a guide in the submergence and remote control of the target.
3. To record changes in the orientation or flooding of the targets after detonation of the device.

2 BACKGROUND

A primary purpose of Operation Wigwam was to determine the effect the detonation of an atomic device at great depth would have on three submarine targets, called "SQUAWS," submerged to the same depth but at different distances from the device.

In an attack on a submarine with an atomic device, as well as in an attack with a conventional weapon, the magnitude and character of the shock motions in the ship are functions of its depth and position relative to the device. Thus the location and orientation of the SQUAW targets relative to the device would have to be known in order to evaluate fully the responses of the targets.[1,2] Knowledge of the depth and orientation of each SQUAW was also required to guide in the submergence and remote control of each target.

Accordingly a project was set up to measure and record the depth, the angle of roll, the angle of pitch, and the heading of each SQUAW target as well as the occurrence of flooding in each SQUAW compartment.

3 INSTRUMENTATION

3.1 Pickups

(a) Depth Gauge. The depth of each target was measured with Bourns model 304 pressure gauges. This gauge is a Bourdon type transducer, the pressure element of the gauge being mechanically coupled by means of a lever to a wire-wound potentiometer (see Fig. 1). A four-arm bridge is employed in the recording circuit, the depth gauge being part of two arms of the bridge. Figure 2 is a schematic diagram of this circuit. All depth gauges were calibrated at

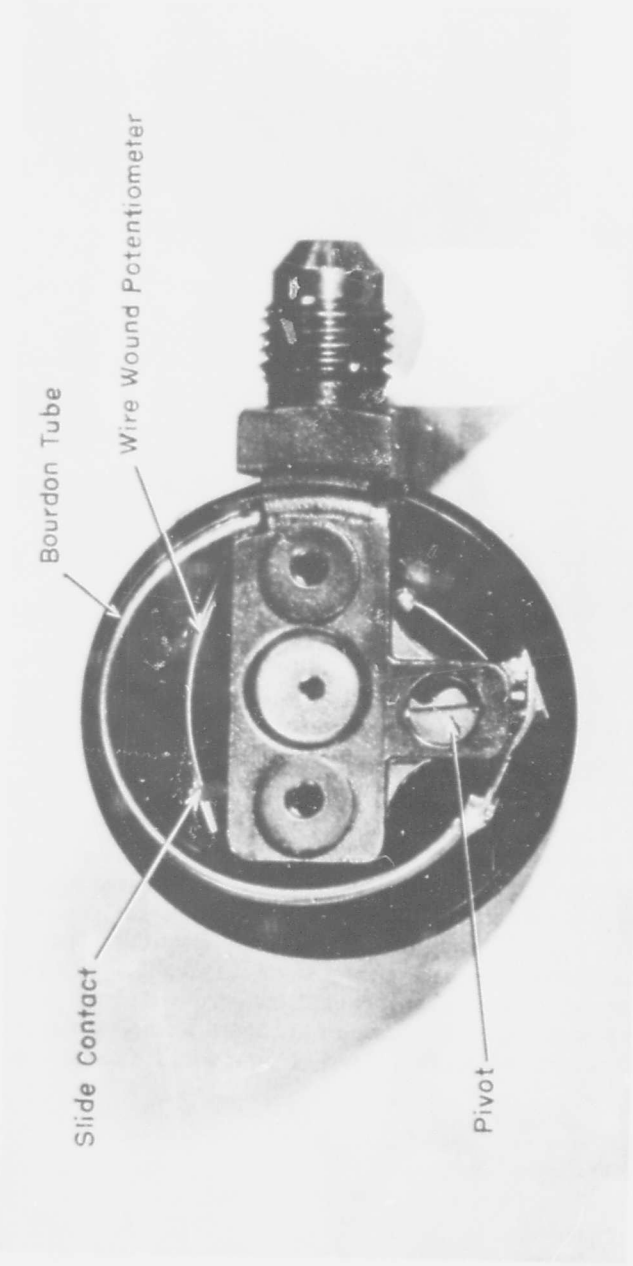

Fig. 1 — Bourns pressure pickup. The slide contact is part of a lever which is linked at its lower end to the Bourdon tube.

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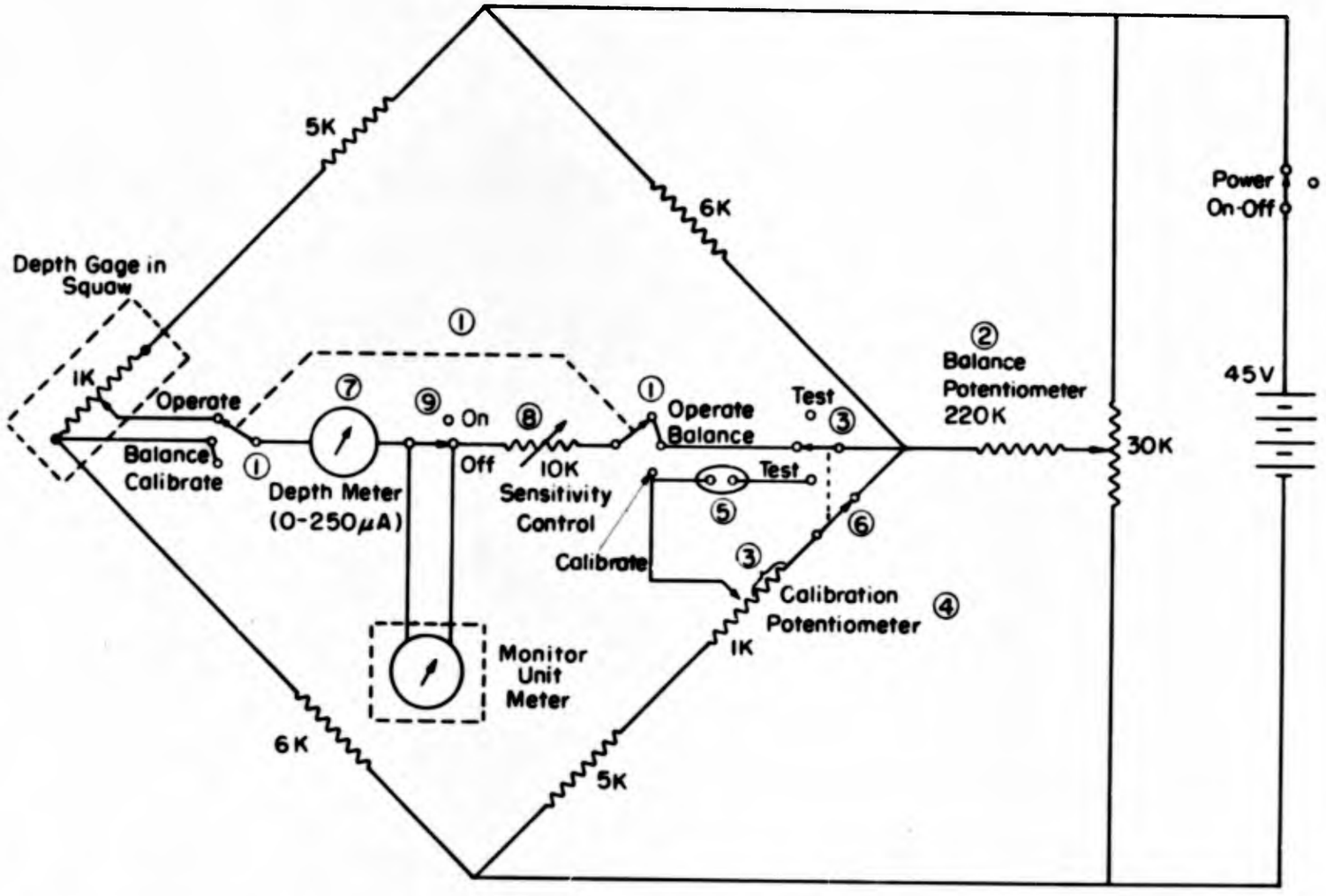

Fig. 2—Schematic diagram of depth-gauge circuit. To balance the depth-gauge circuit, switch 1 is thrown to "balance." This restores the bridge to the zero-depth state and permits balancing by means of potentiometer 2. The circuit is calibrated by means of calibration resistance 3 in potentiometer 4. The calibration resistance may be measured across terminals 5 when switch 6 is in the test position. By throwing switch 1 to "calibrate," the bridge is unbalanced by the calibration resistance, and depth meter 7 is made to read the corresponding depth by means of sensitivity control 8. The monitor unit meter is connected across switch 9.

the Model Basin in terms of change in output resistance per change in pressure. The depth calibration was calculated assuming the density of salt water to be 64 lb/ft^3.

A survey of the possible errors indicates that, for the conditions of this test, the probable error is ±5 ft.

(b) Roll and Pitch Gauges. Edcliff type C-3 and TMB type 215 indicators were used to measure the angle of roll and angle of pitch of the SQUAW targets. Each gauge consists essentially of a damped pendulum mechanically coupled to a wire-wound potentiometer (see Fig. 3).

A four-arm bridge is employed in the recording circuit; the potentiometer in the gauge comprises two arms of the bridge. A schematic diagram of the circuit is shown in Fig. 4. All roll and pitch gauges were calibrated in terms of change in resistance per change in angle. The probable error with this equipment is ±2°.

(c) Gyrocompass. The bearing of each target was measured by means of standard Mark XVIII gyrocompasses on the SQUAWS driving Mark XV compass repeaters on the YFNB's. The use of the gyrocompass was considered necessary for determining remotely the bearing of the submerged SQUAW. However, data from oscillograph records obtained from Project 3.2 could be used as additional aids in determining the heading of the SQUAW relative to the device.

(d) Flooding Indicators. The flooding indicators used to detect the occurrence of flooding in each SQUAW compartment were of the "go, no-go" type. The indicators, consisting of two contacts about 1 in. apart, were embedded in a dielectric material. The flooding meter and a battery were connected in series across the probes of each indicator; salt water coming in contact with both contacts completed the electrical circuit and caused an indication of "flooding" on the meter.

3.2 RPHDF Recording and Control Unit

All indicating, control, and calibration equipment and power sources for a single SQUAW target were housed in two RPHDF (i.e., roll, pitch, heading, depth, and flooding) indicator units and one compass repeater panel. These units were mounted in a standard relay rack as shown in Fig. 5. During the test the front panel of each of these three units was photographed at 3-sec intervals by an automatic camera. The camera was started and the lights were turned on at −15 sec by a telemetered signal. Two independent light sources were used to minimize the possibility of loss of records as a result of failure of either source. A typical recording made during the test is shown in Fig. 6.

(a) RPHDF Indicator Unit. An RPHDF indicator unit (Fig. 7) housed the controls, the power source, and the indicating meters for a roll gauge, a depth gauge, a pitch gauge, and four flooding indicators.

(b) Compass Repeater Panel. A compass repeater panel (Fig. 8) housed a Mark XV compass repeater, a clock, a zero-time indicator, and two meters that measure the voltages of the power sources operating the RPHDF recording unit.

(c) RPHDF Monitor Unit. The RPHDF monitor unit (Fig. 9) contained indicating instruments for one depth gauge, one roll gauge, one pitch gauge, and four flooding indicators. This unit was powered and completely controlled by an RPHDF indicator unit.

4 INSTALLATION

4.1 Pickups

In order to minimize loss of data, duplicate depth, roll, and pitch gauges were installed in each SQUAW target, and duplicate flooding gauges were installed in each compartment. Because of the complexity and cost of the gyrocompass installation, only one was used in each SQUAW.

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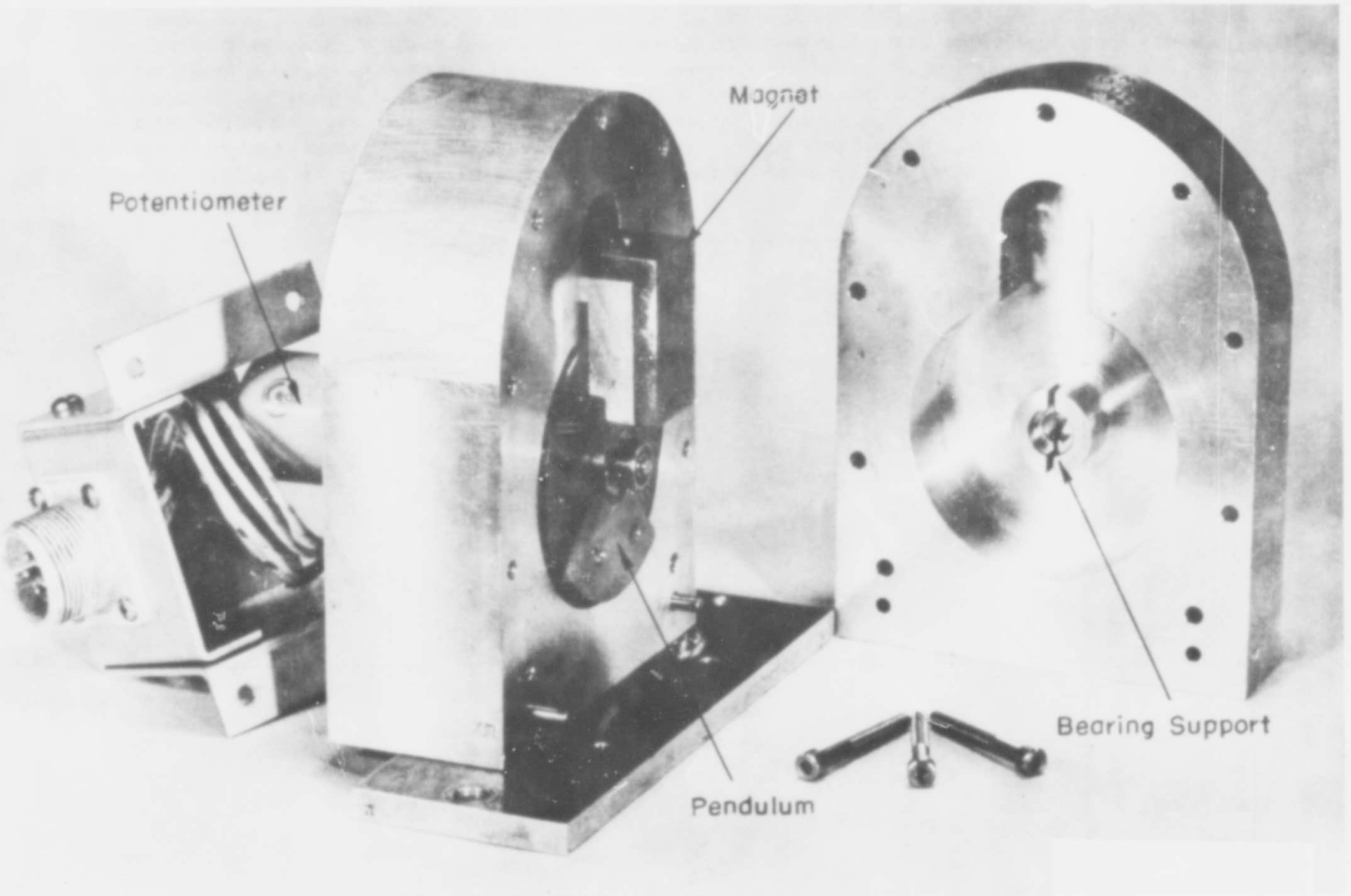

Fig. 3 — TMB model 215 angle indicator, partially disassembled, to measure roll and pitch of SQUAW targets. The pendulum consists of an eccentrically weighted copper disk which rotates on a shaft directly coupled to the shaft of the slide-wire potentiometer. Rotation of the disk produces a corresponding change in resistance. Oscillation of the disk is damped by eddy currents produced in it by the magnet.

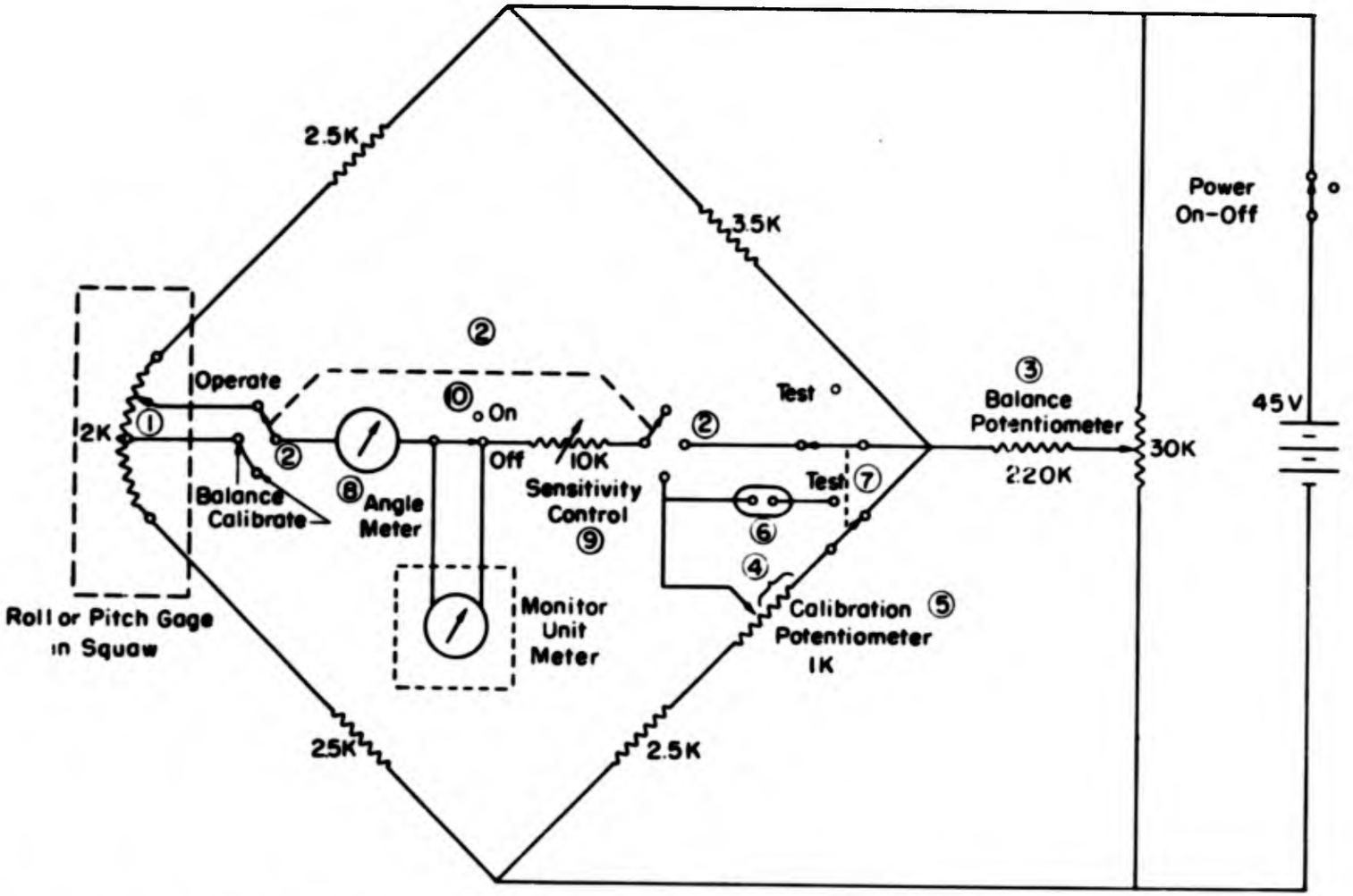

Fig. 4—Schematic diagram of roll and pitch gauge circuits. To permit balancing of the bridge circuit without leveling the gauge, the gauge potentiometer is equipped with center tap 1. The potentiometer was originally installed in the gauge so that for a zero roll or pitch angle the slider and the center tap were in juxtaposition. To balance the bridge circuit, switch 2 is thrown to "balance," and the bridge is then balanced by means of potentiometer 3. The circuit is calibrated by means of the calibration resistance 4 in potentiometer 5 which is part of one arm of the bridge circuit. The calibration resistance may be measured across terminals 6 when switch 7 is in the test position. By throwing switch 2 to "calibrate," the bridge is unbalanced by the calibration resistance, and angle meter 8 is made to read the corresponding angle by means of sensitivity control 9. The monitor unit meter is connected across switch 10.

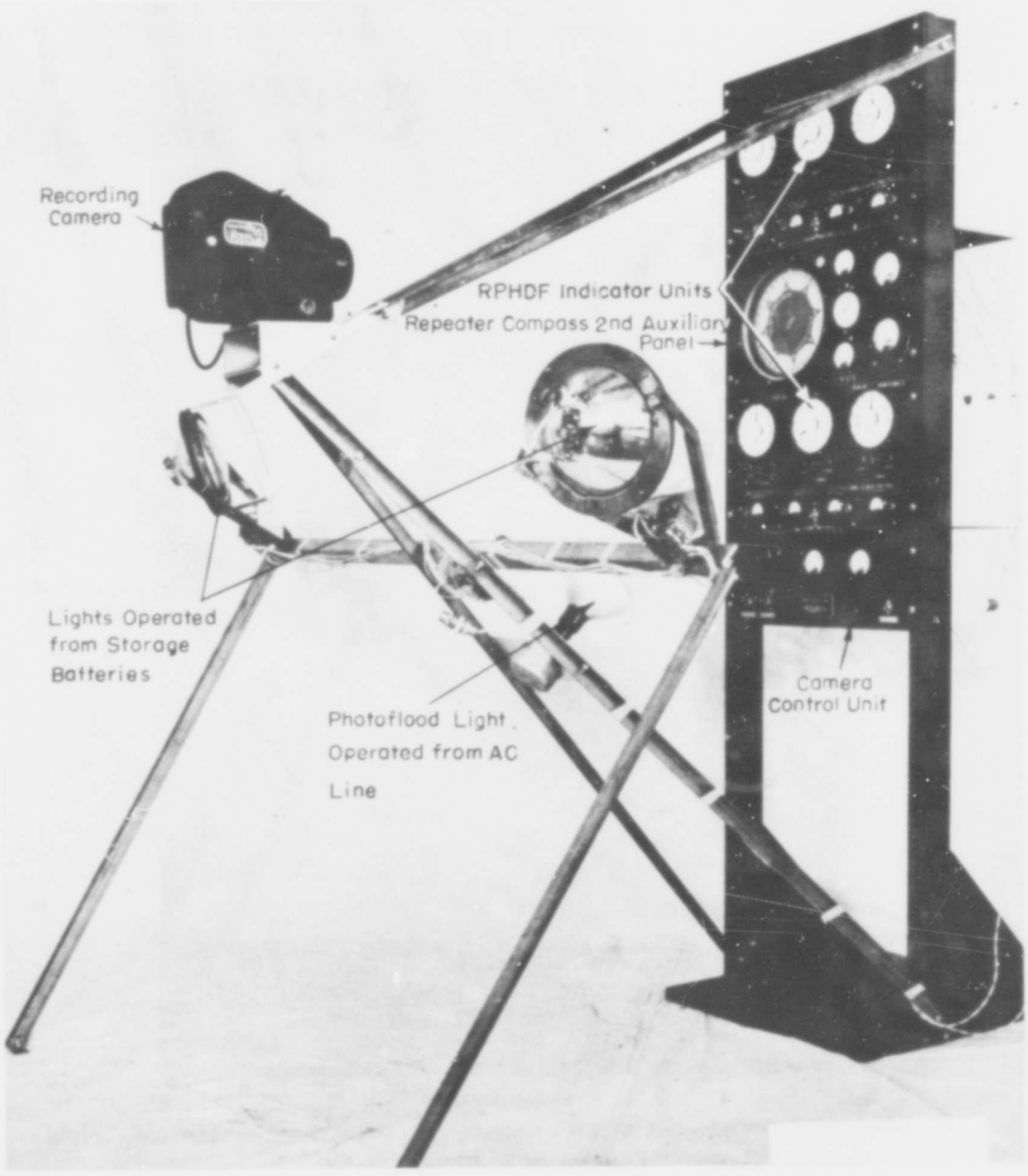

Fig. 5—RPHDF recording and control unit.

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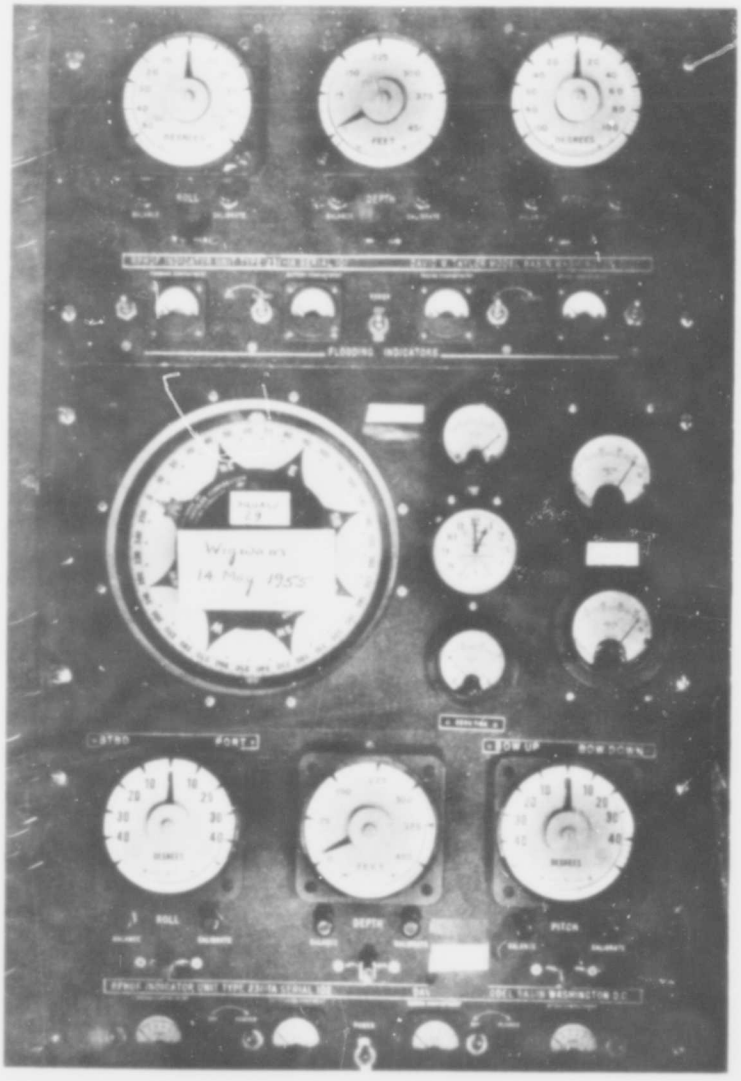

Fig. 6 — Typical RPHDF record. This is a typical photograph of the RPHDF indicating unit as taken by the associated camera during the test.

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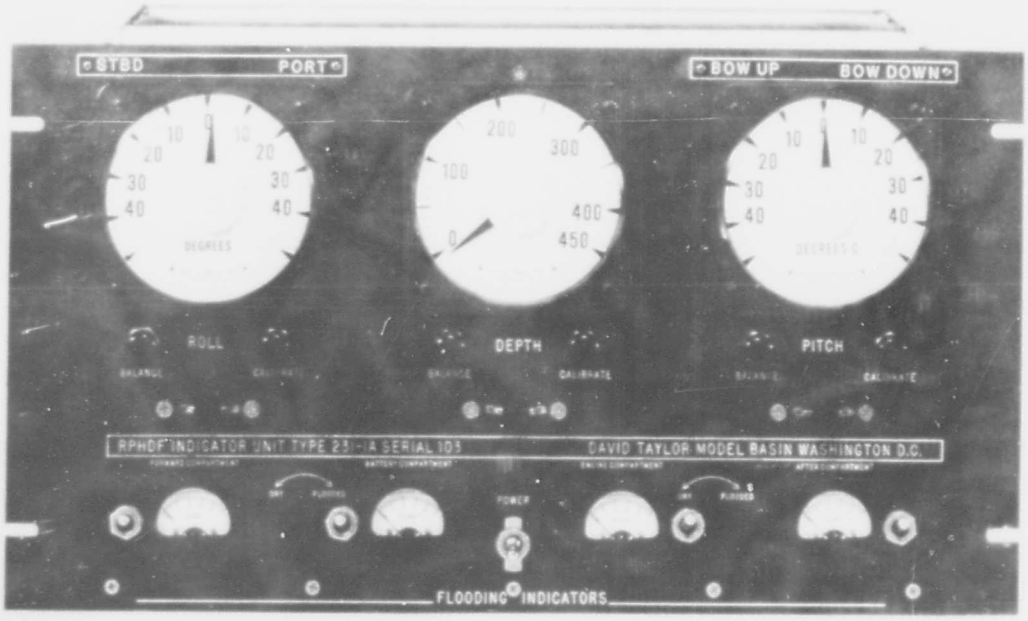

Fig. 7—RPHDF indicator unit. Each unit housed the balance and calibration controls and the indicating meters for one roll, one depth, and one pitch gauge. The unit also contained one flooding indicator for each SQUAW compartment.

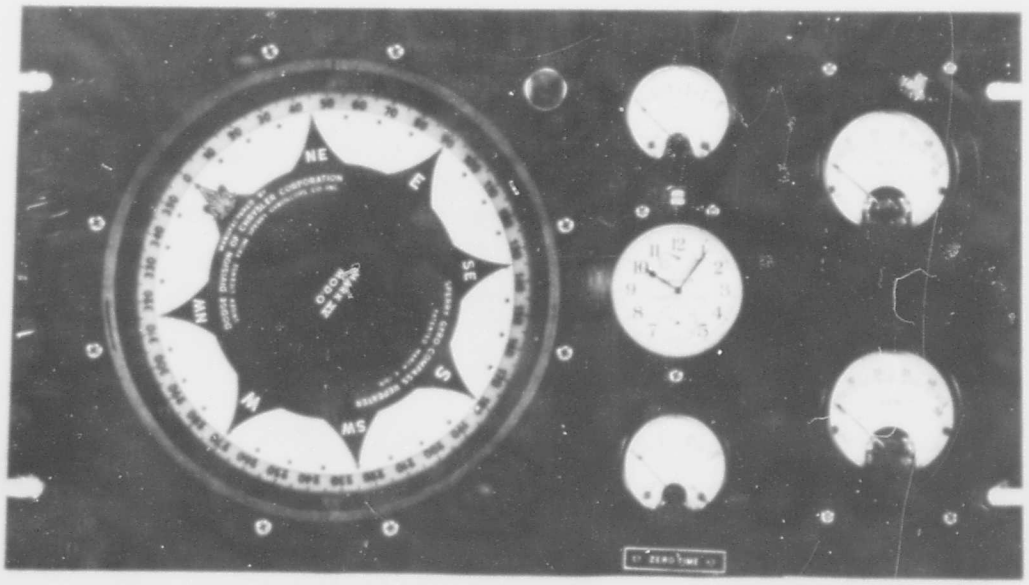

Fig. 8—Compass repeater panel. Each panel contained a Mark XV gyrocompass repeater, a clock, a zero-time indicator, and three meters reading the voltages of the batteries powering the RPHDF recording unit. The zero-time indicator was actuated by a telemetered signal.

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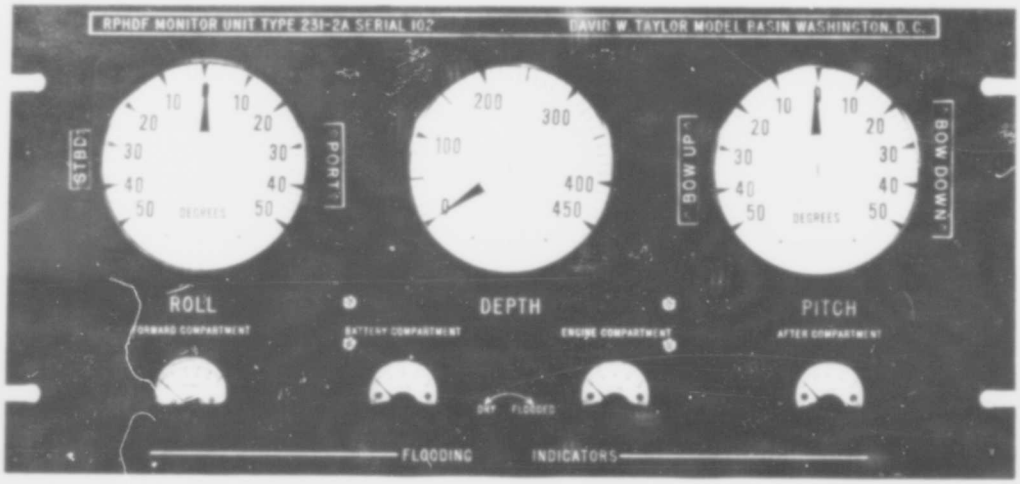

Fig. 9—RPHDF monitor unit. The unit contained a roll, a depth, a pitch, and four flooding meters. All operating controls were contained in the RPHDF indicator unit to which it was connected. A monitor unit was installed at the submergence-control station on each barge along with a compass repeater.

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(a) Depth Gauge. A depth gauge was installed in each end compartment of the SQUAWS in order to permit a second determination of the pitch angle of the target from the difference in depth. One depth gauge was installed on the spherical section in the forward cone at the center line. The second gauge was installed in the aft compartment 4.5 ft above the center line. The inlet for this gauge was located at the coaming of the access hatch.

(b) Roll and Pitch Gauges. The two roll and two pitch gauges were mounted on a steel plate welded to the top of the hard tank in the after compartment of each target as shown in Fig. 10. The plate was at the after end of the tank and on the port side.

(c) Gyrocompass. The master gyrocompass was installed on a platform attached to the after bulkhead in the engine compartment of each target as shown in Fig. 11.

Each master gyrocompass was powered by a 120-volt d-c source on the associated YFNB. Just prior to the shot this power was cut off. A 126-volt bank of storage batteries located in the SQUAW itself was then substituted as the power source by an automatic transfer switch. Figure 12 is a block diagram of this installation.

(d) Flooding Indicators. To increase the utility of the data, the two flooding indicators in each SQUAW compartment were set to detect different depths of flooding. The lower of the two flooding indicators in each compartment was approximately 2 in. above the shell plating at the keel, and the upper gauge was approximately 2 ft above the shell plating. In the forward compartment the indicators were located at frame 1; in the battery compartment, at frame 22; in the engine compartment, at frame 33; and in the after cone, at frame 52.

4.2 RPHDF Recording and Control Unit

An RPHDF recording and control unit was installed in each Project 3.2 instrument trailer on the YFNB's.[1] The instrument-trailer mounting had a natural frequency of about 5 cps. This mounting effectively isolated the RPHDF unit from the shock motions of the instrument barge produced by the detonation of the device. In addition, an RPHDF monitor unit with a compass repeater was installed at each SQUAW submergence-control station.

5 TEST RESULTS

As a result of unexpectedly strong winds and high swells en route to, and at, the test site, considerable damage was done to the target array and to the instrument cables joining the SQUAWS to the YFNB's. As a result of the continuous flexing, chafing, and pulling of these multiconductor cables, instrument leads in them were broken. Consequently, certain gauge circuits were opened and some instruments were rendered inoperative.

Because two duplicate and independent instrument sets were installed for each measurement, test data were obtained up to, and including, zero time, with the exception of the roll reading on SQUAW-12 and the reading of bearing on all three targets. The last roll reading obtained for SQUAW-12, at H−7 hr, showed that this target had a roll angle of less than 2° and was stable in position.

All repeater compasses were made inoperative owing to failure of the instrumentation cable; hence the angle between the axis of each SQUAW and the normal to the shock front was measured from the velocity-time records[1] of Project 3.2. All test data obtained on the three SQUAWS are presented in Tables 1 to 3.

6 DISCUSSION

6.1 SQUAW-12

On D−1 day, prior to submerging, the gauges indicated that SQUAW-12 was rolling approximately 10° to either side. The pitch angle varied from zero to 3° bow down. No flooding in any compartment was indicated.

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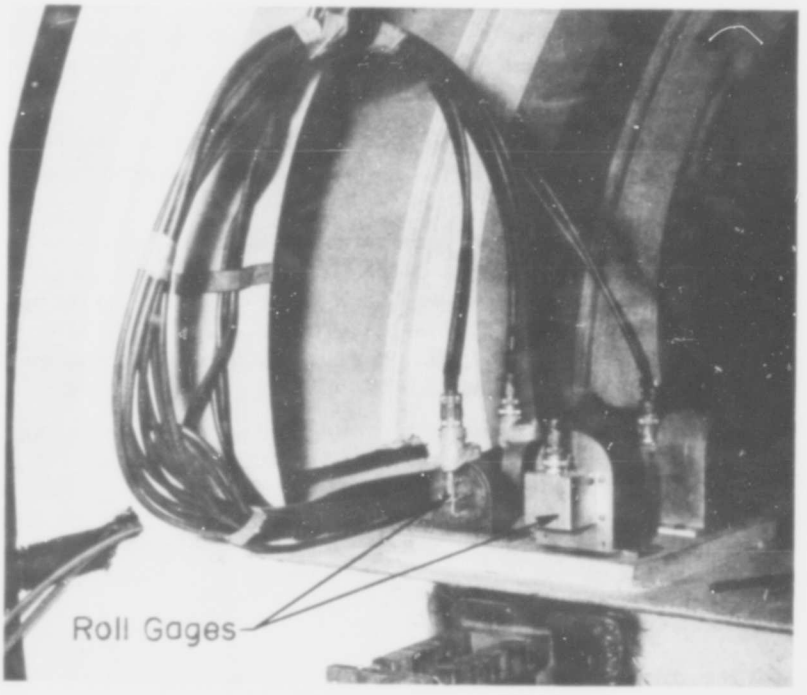

Fig. 10 — Typical installation of two roll and two pitch gauges in after cone. The gauges are bolted to a steel plate welded to the deck. Electrical cables connect the gauges to the RPHDF indicator unit.

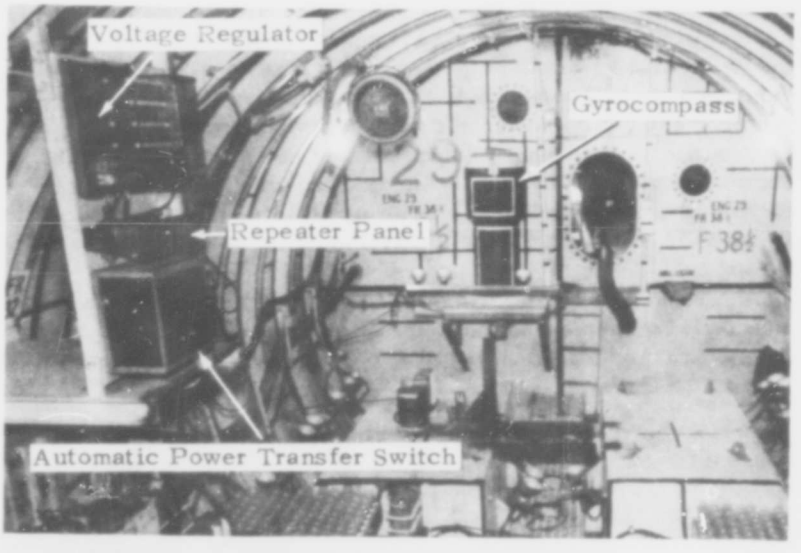

Fig. 11 — Gyrocompass installation.

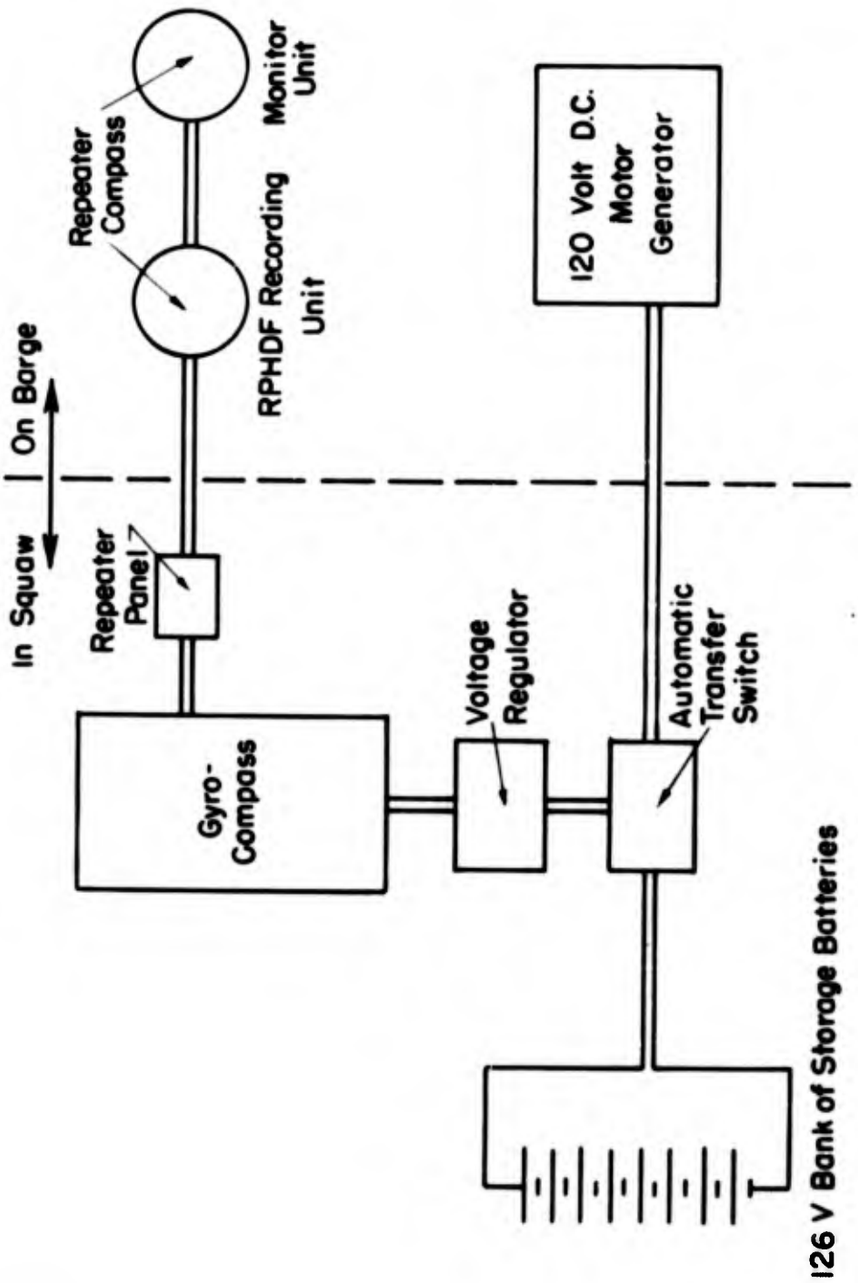

Fig. 12—Block diagram of gyrocompass installation.

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Table 1—RPHDF DATA FOR SQUAW-12

Event	Roll, deg	Pitch,[a] deg		Depth, ft		Flooding indication							
		First gauge	Second gauge	Forward cone	After cone	Forward cone		Battery compartment		Engine compartment		After cone	
						Low	High	Low	High	Low	High	Low	High
D–1 day:													
1100, prior to submergence	10 max	3 max	3 max	0	0	No	No	No	No	No	No	No	No
1130, just after submergence	0	–16	–16	260	220[b]	No	No	No	No	No	No	No	No
1300, during tow	8 port	–16	–16	260	—	No	No	No	Yes[c]	No	No	No	No
1600, during tow	0	+35	+35	250	—	No	No	No	Yes	No	No	No	No
D-day:													
0600, evacuation	0	+35	+35	250	—	No	No	No	Yes	No	No	No	No
1300–15 sec[d]	—	+36	+35	255	—	—	No	—	No	—	No	—	No
0 time	—	+36	+35	255	—	—	No	—	No	—	No	—	No
+3 sec[e]	—	+15	—	—	-	—	No	—	Yes	—	Yes	—	No
+6 sec	—	+35	—	—	—	—	No	—	Yes	—	Yes	—	No
+9 sec	—	—	—	—	—	—	No	—	Yes	—	Yes	—	No
+11 sec	—	+14[b]	—	—	—	—	No	—	Yes	—	Yes	—	No
+14 sec	—	+14[b]	—	—	—	—	No	—	Yes	—	Yes	—	No
+17 sec	—	+64[b]	—	—	—	—	No	—	Yes	—	Yes	—	No
+20 sec	—	+58[b]	—	—	—	—	No	—	Yes	—	Yes	—	No
+23 sec	—	+90	—	—	—	—	Yes	—	Yes	—	Yes	—	No
+25 sec	—	—	—	—	—	—	Yes	—	Yes	—	Yes	—	No
+57 sec	—	—	—	—	—	—	Yes	—	Yes	—	Yes	—	Yes

[a]Plus sign indicates bow up; minus sign indicates bow down. Inoperative gauges are indicated by —.
[b]Readings corrected since publication of Report ITR-1078.
[c]This indication of flooding was probably due to a short in the instrumentation cable.
[d]The following times are accurate to plus one minus zero seconds.
[e]The initial shock wave arrived at the SQUAW-12 at +1.1 sec.

Table 2—RPHDF DATA FOR SQUAW-13

Event	Roll,[a] deg	Pitch,[b,c] deg		Depth,[c] ft		Flooding indication							
		First gauge	Second gauge	Forward cone	After cone	Forward cone		Battery compartment		Engine compartment		After cone	
						Low	High	Low	High	Low	High	Low	High
D−1 day:													
1030, prior to submergence	10 max	−2	−2	0	0	No	No	No	No	No	No	Yes[d]	No
1100, just after submergence	0−10 P	−7[e]	−7[e]	270	260	No	No	No	No	No	No	Yes	No
D-day:													
0530, evacuation	0−5 S	−4 to −6	−4 to −6	280	—	No	No	No	No	No	No	No	No
1300−15 sec[f]	1 S	−4	−3	270	—	No	No	No	No	No	No	No	No
0 time	1 S	−4	−2	270	—	No	No	No	No	No	No	No	No
+3 sec[g]	1 S	−2	—	—	—	No	No	No	No	No	No	No	No
+6 sec	1 P	+6	—	—	—	No	No	No	No	No	No	No	No
+9 sec	5 S	−6	—	—	—	No	No	No	No	No	No	No	No
+12 sec	4 S	+10	—	—	—	No	No	No	No	No	No	No	No
+15 sec	8 S	−6	—	—	—	No	No	No	No	No	No	No	No
+18 sec	1 S	+7	—	—	—	No	No	No	No	No	No	No	No
+21 sec	3 S	+2	—	—	—	No	No	No	No	No	No	No	No
+24 sec	6 S	+2	—	—	—	No	No	No	No	No	No	No	No
+27 sec	5 S	+4	—	—	—	No	No	No	No	No	No	No	No
+30 sec	4 S	+3	—	—	—	No	No	No	No	No	No	No	No

[a]P indicates roll to port; S indicates roll to starboard.
[b]Plus sign indicates bow up; minus sign indicates bow down.
[c]Inoperative gauges are indicated by —.
[d]Intermittent indication of flooding.
[e]Readings corrected since publication of Report ITR-1078.
[f]The following times are accurate to plus one minus zero seconds.
[g]The initial shock wave arrived at the SQUAW-13 at +1.5 sec.

Table 3—RPHDF DATA FOR SQUAW-29[a]

Event	Roll,[b] deg		Pitch,[c] deg		Depth, ft	
	First gauge	Second gauge	First gauge	Second gauge	Forward cone	After cone
D-day:						
0430, prior to evacuation	5 max	5 max	0 to −1	0 to −1		
1300−15 sec[d]	2 P	1 P	−1	−1	SQUAW-29 at surface at all times	
0 time	5 S	3 S	−1	−2		
+ 3 sec[e]	5 P	6 P	0	0		
+ 5 sec	3 S	2 S	0	0		
+ 8 sec	2 S	1 S	0	0		
+ 11 sec	1 P	2 P	0	0		
+ 14 sec	0	1 S	−1	0		
+ 17 sec	2 S	1 S	0	0		
+ 20 sec	1 P	2 P	0	0		
+ 22 sec	3 S	2 S	0	0		
+ 25 sec	2 P	3 P	−2	0		
+ 28 sec	3 S	2 S	0	0		
+ 30 sec	0	0	−2	0		

[a]No flooding indicated at any time.
[b]P indicates roll to port; S indicates roll to starboard.
[c]Plus sign indicates bow up; minus sign indicates bow down.
[d]The following times are accurate to plus one minus zero seconds.
[e]The shock wave arrived at the SQUAW-29 at + 2.0 sec.

Table 4—ATTITUDE AND CONDITION OF SQUAWS AT ZERO TIME

SQUAW	Roll, deg	Pitch, deg	Depth,* ft	Flooding	Relative orientation†
12		36, bow up	290	None	55° ± 3°
13	1, stbd.	3, bow down	265	None	0° ± 16°
29	4, stbd.	2, bow down	At the surface	None	21° ± 14°

* To the center of the centerline bulkhead.
† The angle between the axis of the SQUAW and the normal to the shock front as determined from the velocity-time records[1] of Project 3.2.

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Immediately after submerging, the target appeared to be stable at a depth of 260 ft to the center of the spherical bow section. The pitch angle was 16° bow down, there was no perceptible roll, and there was no indication of flooding.

About 1 hr after submerging, this target suddenly acquired a steady list to port of 8°. This list persisted for 3 hr. At the end of this period the list was suddenly removed, and the pitch angle changed from 16° bow down to 35° bow up. The sudden list to port was apparently caused by the failure of the wire rope on the port side of the SQUAW, which was one of the two that supported the stern of the SQUAW from the after set of pontoons. These wire ropes had been installed at the test site to replace chains which had parted several days prior to the submergence. The removal of this list and the simultaneously acquired bow-up trim should then be due to the failure of the remaining wire rope at the starboard side aft. The only remaining support to the SQUAW was then applied by the two chains attached at the position of the forward bulkhead of the battery compartment. As a result, the stern sank to approximately 320 ft, and the bow rose to 250 ft. During this period the upper flooding indicator in the battery compartment intermittently indicated flooding. Inasmuch as the lower indicator showed dry and there was no other indication of flooding, it was concluded that this indication was spurious and probably due to an intermittent short in that particular flooding indicator circuit.

At zero time* the RPHDF record showed that the pitch angle for SQUAW-12 was 36° bow up and the depth was 255 ft at the bow. This corresponded to a depth of 290 ft to the center of the centerline bulkhead and 308 ft to the center of the bulkhead at the after end of the engine compartment. At this time all upper flooding indicators read dry. Owing to misalignment of the recording camera, no records were obtained from the lower flooding gauges during the test.

The first reading after the arrival of the shock wave was made at +3 sec, 2 sec after the arrival of the shock wave at this SQUAW. At this time the upper flooding indicators in the battery and in the engine compartments were indicating flooding. The depth gauge was inoperative from this time on.

At +20 sec only one pitch gauge and the upper flooding indicators appeared to be operative. At that time the upper flooding indicators in the two cone compartments still indicate dry. At +23 sec the flooding gauge in the forward cone showed flooding and the pitch gauge became inoperative. Inasmuch as the shock motions did not persist to this time, it may be concluded that flooding took place in the forward cone and that the pitch gauge became inoperative because water covered the instrumentation cable terminal board in that compartment. The fact that the after flooding indicator, connected through the same terminal board, did not indicate flooding may indicate broken instrumentation cable leads. That this gauge did indicate flooding at +57 sec suggests that the instrumentation cable parted at that time or when the SQUAW reached a depth of about 600 ft.

6.2 SQUAW-13

On D−1 day, prior to submergence, the gauges indicated that SQUAW-13 was rolling approximately 10° either way. The pitch angle was approximately 2° bow down. No flooding had been indicated by any indicator except the lower indicator in the aft cone, which had shown flooding when the ship was on an even keel from the time of departure from San Diego. It appears that this flooding indication was caused by about a gallon of rain water that had entered the compartment just prior to the final closing of the SQUAWS.

Immediately after submergence the target appeared to be stable at a depth of 270 ft to the center of the spherical bow section. The pitch angle was 7° bow down, the target rolled from zero to 14° port, and there was no change in the flooding indication.

At zero time the recordings show that for SQUAW-13 the pitch angle was 3° with the bow down, the angle of roll was 1° to starboard, and the depth was 270 ft at the bow. At this time all indicators indicated dry.

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*All times are measured from zero time, the instant of detonation of the device, and are accurate to within 1 sec.

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After the arrival of the shock wave, the pitch gauge showed as maximum readings 10° bow up and 6° bow down. The maximum angle of roll was 8° to starboard and 1° to port. These motions are probably due in part to motion of the supporting pontoons at the surface. The depth gauge became inoperative with the arrival of the shock wave. On all records taken after the arrival of the shock wave, all flooding indicators read dry.

6.3 SQUAW-29

As a result of damage to, and loss of, its supporting pontoons prior to the time for submergence, SQUAW-29 remained on the surface for the test.

At zero time the pitch angle of SQUAW-29 was 2° bow down, and the angle of roll was 4° to starboard. There was no appreciable change of any attitude reading during the test. There was no indication of flooding at any time.

7 SUMMARY

The first record obtained on SQUAW-12 after zero time was recorded at +3 sec, corresponding to 2 sec after the arrival of the initial shock wave. This record showed that flooding had occurred in both test compartments.

No indication of flooding or significant change in orientation was recorded on SQUAW-13 or SQUAW-29 during the test. Table 4 lists the data obtained at zero time.

REFERENCES

1. H. L. Rich, E. T. Habib, R. L. Bort, and F. Weinberger, Hull Response and Shock Motion, Part I, Background, Instrumentation, and Test Results, Operation Wigwam Report, Project 3.2(I), WT-1023, April 1956.
2. G. Chertock, A. E. Hirsch, R. W. Mayo, and T. F. Ogilvie, Operation Wigwam, Applied Pressure and Hull Response of Wigwam Targets, Report WT-1021.

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