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Report of Test

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NRL Report No. B-1757

23 July 1941

NAVY DEPARTMENT

Report of Test

on

Underwater Electric Log Equipment,

Contract NOs-71894

Submitted by

Bendix Aviation Corporation

Marine Division

Brooklyn, New York

NAVAL RESEARCH LABORATORY
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AUTHORIZATION FOR TEST

1. This problem was authorized by reference (a), and other references pertinent to this problem are listed as references (b) to (o), inclusive.

References: (a) BuShips ltr. N0s-71894 (3665) of 2 June 1941.
(b) Contract N0s-71984 - USS TERROR.
(c) Specification SGS(65)-151a of 1 February 1937.
(d) NRL Report B-1607 of 11 April 1940.
(e) NRL Report B-1697 of 25 February 1941.

Drawings:

- (f) CM5 S65-924 Alt. 2, (CAL-3000) Master Transmitter-Indicator.
- (g) CM5 S65-922 Alt. 2, (CAL-8200) Speed and Distance Indicator.
- (h) CM5 S65-925 Alt. 2, Sheet 1 (CAL-8220) Master Transmitter-Indicator - Interior Unit.
- (i) CM5 S65-925 Alt. 2, Sheet 2 (CAL-8220) Master Transmitter-Indicator - Main Force and Balance Arm Assembly.
- (j) CM5 S65-925 Alt. 2, Sheet 3 (CAL-8220) Master Transmitter-Indicator-Component Force-Driving and Follower Assembly.
- (k) CM5 S65-925 Alt. 2, Sheet 4 (CAL-8220) Master Transmitter-Indicator-Speed and Distance Transmission Assembly.
- (l) CM5 S65-925 Alt. 2, Sheet 5 (CAL-8220) Master Transmitter-Indicator-Pressure-Static Bellows Assembly.
- (m) CM5 S65-926 Alt. 3, (CAL-3270) Speed and Distance Indicator - Interior Unit.
- (n) CM5 S65-935 Alt. 1, (CAL-8272) Schematic Diagram.
- (o) CM5 S65-923 Alt. 2, (CAL-8100) Rodmeter and Seavalve Assembly.

OBJECT OF TEST

2. The object of this test was to determine conformance of the sample electric log equipment with specification, reference (c), (as modified by contract, reference (b)), and its suitability for Naval use.

ABSTRACT OF TEST

3. The subject log equipment was set up at this Laboratory in conjunction with suitable test apparatus and its performance was carefully observed for compliance with the specification. Following calibration by the manufacturer's representative, an initial accuracy test was made. Tests were then made to determine the effect of inclination, variation in supply voltage and frequency, endurance, shock, vibration and hydrostatic pressures. Additional accuracy tests were made on several occasions to isolate the errors resulting from the several test conditions. Observations were made in a

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dark room to determine the quality of the dial illumination. The test was concluded with a brief check against the drawings and an inspection of the equipment to determine compliance with those requirements of the specification which pertain to materials, design, and workmanship.

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Conclusions

(a) The Bendix Log fails to satisfy the specification requirements in many minor particulars, namely:

- (1) Errors in speed.
- (2) Errors in mileage.
- (3) Change in calibration after "endurance."
- (4) Minor derangements under shock.
- (5) Rupture of bellows under hydrostatic pressure.
- (6) Corrosion of bellows.
- (7) Excessive temperature rise of motor windings.
- (8) Change in "zero" position at rest.
- (9) Maximum rate of acceleration is 8 knots per minute, which is too slow for destroyer anti-submarine tactics.

On the other hand, the general performance of the Bendix Log on test was satisfactory. Errors were small, and no deficiencies were of sufficient magnitude to interrupt or seriously affect operation.

(b) This Log is a marked improvement over the equipment previously tested and reported by reference (e). It does not merit unqualified type approval, but is considered to be of adequate design and construction to warrant shipboard installation for service test. It is considered that, with further developments and refinements, the outstanding deficiencies can be overcome without changing the basic design.

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Recommendations

(a) It is recommended that that portion of the Bendix Log covered by this report be approved for this contract subject to correction of ruptured bellows and reconditioning of equipment prior to installation.

(b) It is recommended that type approval be withheld pending correction of outstanding deficiencies as demonstrated by further laboratory tests.

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DESCRIPTION OF MATERIAL UNDER TEST

4. This equipment consisted of three of the four instruments previously tested and reported under reference (e). The fourth instrument, a Master Mileage-Transmitter, is no longer required as the function which it previously fulfilled is now accomplished by additional mechanism incorporated in the Master Transmitter-Indicator. As submitted for this test the complete system consisted of the following units:

- 1 - Master Transmitter-Indicator, 25 knot.
- 1 - Speed and Distance Indicator, 25 knot.
- 1 - Air collector unit.
- 1 - Test weight.
- 1 - Test weight arm.
- 2 - Snubbers with connection tubes.

5. The Master Transmitter-Indicator submitted for this test has mechanism to enable it to indicate ship's speed in knots and to solve for distance traveled in nautical miles. The speed indicating mechanism has not been changed since the previous test. The mileage mechanism is new. Through synchro-transmission, it drives all mileage counters in the system. A description of the mechanism and the operation of this instrument is given under "Principles of the Bendix Log," paragraphs 8 to 13 inclusive.

6. The Master Transmitter-Indicator incorporates a new design of bellows as well as a number of minor mechanical changes to correct the deficiencies listed in reference (e). It is shown by photographs, Plates 15, 16, 17 and 18 and is covered, with some discrepancies, by drawings references (f), (h), (i), (j), (k), (l), and (n).

7. The Speed and Distance Indicators are repeaters equipped with "ring type lighting" for dial and pointer illumination. The pointers are positioned by type "M" Synchro-Motors and the odometers are driven by type "N" Synchro-Motors. These instruments are shown by photographs, Plates 15, 19, and 20 and are covered, with some discrepancies, by drawings, references (g), (m) and (n).

PRINCIPLES OF THE BENDIX LOG (See drawing reference (n))

8. A chamber #9, mounted below the water line of the ship, is divided in two parts by means of a flexible bellows. The upper part of the bellows is connected with the sea through the static aperture in the rod-meter and the lower part is connected to the dynamic pressure aperture. Forward motion of the ship will increase the pressure and the dynamic pressure aperture and this pressure will be transmitted to the lower part of the chamber. This will cause diaphragm #12 to move upward, forcing the contact arm #18 to pivot and causing the actuator motor #45 to start.

Through a train of gears #46 and #24, the actuator motor rotates the large master cam #25 which, in turn, causes the master spring arm #23 to pivot. Pivoting of this arm causes loading of the contact arm #18 through the large master spring #28. This loading forces the contact arm back to its initial position, at which point the contacts cut off the actuator motor. The speed mechanism of the log will then remain inactive and the pointer will remain stationary until the speed of the ship changes. An increase in speed will cause a recurrence of the described action. A decrease in pressure will cause the contact arm to pivot in the opposite direction and thus cause the actuator motor to run in the reverse direction of that described. This will rotate the cam so as to take the load off of the contact arm and allow it to return to its initial position.

9. Further loading of the contact arm for corrective purposes is obtained by using an auxiliary spring #21 and arm #19. This arm is caused to pivot by motion of slide #32. Thus, the loading of the contact arm by this spring will be dependent upon the angle at which the slide is set by the "B" adjustment. The motion of slide #32 is obtained by means of a nut riding on a threaded shaft which is rotated by the actuator motor #45 through gears #35.

10. The speed in knots is indicated on a dial #26 by means of a pointer #27 which is fastened to the shaft which carries the master cam #25. Synchro-generator #48, which is also geared to the shaft that carries the master cam, positions all other pointers in the system.

11. This log system is equipped with three adjustments; "A" adjustment #29, "B" adjustment #33, and "C" adjustment #16. The "C" adjustment merely affects the zero setting of the instrument. The "A" adjustment affects all readings of the log by the same percentage. The "B" adjustment affects the readings in a constant percentage rate of increase or decrease. That is, the larger the reading, the greater the effect of the "B" adjustment. By means of these three adjustments, it is possible to calibrate the log for pilot static rodmeters of different coefficients.

12. The primary portion of the distance mechanism consists of a threaded shaft #38, a friction roller and carriage #39, a constant speed disc #40, and a synchronous motor with internal reduction gear #41. As the threaded shaft #38 is caused to rotate by a change in the speed mechanism, due to a variation in ship's speed, the distance integrating roller #39 is caused to move radially along the surface of disc #40. Since the number of revolutions turned by screw #38 is governed by the speed of the ship, it follows that the position of #39 on #40 will also be a function of the speed of the ship. As it is arranged so as to be at the center of the disc when pointer #27 is at the zero speed position, roller #39 will be moved radially along #40 and will begin to rotate, being driven by the disc, when the ship begins to move forward. Also, since #40 rotates at a constant speed, it follows that the speed of roller #39 is also a function of ship's speed.

13. A shaft coupled to roller #39 is linked to one side of a differential gear assembly #57 through a loose-link coupling #42. The opposite

side of the differential is coupled through gears #58 to a shaded-pole induction motor #54, and a type "B" Synchro-transmitter #55. The spider gear assembly of the differential is coupled to the contact arm of a speed control rheostat #56 which is connected in series with the control winding of motor #54. As motor #54 drives one gear of the differential in a direction opposite to that of the gear driven by roller #39, the spider gear assembly will not be required to change position when the two input speeds are equal. Under this condition, the position of the rheostat contact arm will remain unchanged.

When the speed of the ship increases, roller #39 will drive its differential gear faster, causing the spider assembly to rotate and move the sliding contact of the control rheostat toward the minimum resistance position. This continues until the resulting increase in the speed of motor #54 is proportional to the speed change that has previously occurred in roller #39, at which time the spider and rheostat arm will become stationary.

A decrease in ship's speed produces a proportional reduction in the speed of motor #54 by a reversal of the action just described.

Any change in the speed of motor #54 produces a corresponding change in the speed of Synchro-transmitter #55 which drives all odometer type mileage counters in the system.

Two actuator motor limit switches and a synchronous motor cut-off switch are operated by piece #85 of roller assembly #38. The actuator motor switches operate at -0.2 and 25 knots and the synchronous motor cut-off switch operates at 0.5 knot.

METHOD OF TEST

14. The subject equipment was set up at this Laboratory in conjunction with suitable testing equipment. The Master Transmitter-Indicator was calibrated by the manufacturer's representative against the manometers of this equipment. These manometers had scales giving equivalent speeds in knots for a rodmeter coefficient of 0.957. A water manometer was used for speeds up to 8 knots and a mercury manometer was used for speeds between 8 and 25 knots. The static head under either condition was approximately 10 feet.

15. Immediately following the calibration, a complete accuracy test was conducted. The supply to the equipment was maintained at 115 volts, 60 cycles, controlled frequency.

16. Following this, accuracy tests were made with the equipment inclined 45 degrees left, right, forward, and backward.

17. Accuracy tests were then made with the supply maintained at 110% normal voltage at 5 cycles below normal frequency and 90% normal voltage at 5 cycles above normal frequency. In the supply to the syn-

chronous motor, only the voltage was varied as a frequency variation would introduce a proportionate error in the mileage counted.

18. The equipment was then subjected to a 500-hour endurance test during which the pressure differential applied to the bellows unit was varied to produce speed indications ranging from 0 to 25 knots and return at a rate of 1 cycle in 10 minutes. Except as noted, this test was made at room temperature.

19. After 400 hours of the endurance test, the Master Transmitter-Indicator and one Speed and Distance Indicator were placed in a heating cabinet and operated for 50 hours at 65°C. The temperature rises of several windings, not measured during the test reported by reference (e), were measured during this period.

20. Following this, an accuracy test was made and, as considerable error was noted, the master unit was recalibrated and another accuracy test was conducted in preparation for the shock and vibration tests.

21. Following the shock and vibration tests, (Master Transmitter-Indicator only), the errors were found to exceed the specified tolerances and the Master unit was again recalibrated. This calibration was checked by conducting a complete accuracy test.

22. An accuracy test was then conducted under conditions simulating those obtained on a submarine operating at a depth of 100 feet.

23. Next, the hydraulic parts of the Master Transmitter-Indicator were subjected to a hydrostatic pressure of 250 pounds per square inch as required by paragraph F-2m of reference (c). Following this, accuracy tests were made to determine the effect of the hydrostatic test.

24. The bellows unit of the hydraulic unit was removed for inspection and subjected to a 100-hour salt spray test.

25. No tests were made to determine the effectiveness of the test weight and auxiliary arm due to the failure of the bellows unit during the course of the regular type approval tests.

26. Following tests for dielectric strength and insulation resistance, and a brief check against the drawings, references (f) to (n) inclusive, an inspection was made of each unit to determine its conformance with the specifications relating to materials, design, and workmanship. In order to do this, the linkage between the hydraulic unit and the mechanism of the Master Transmitter-Indicator was uncoupled. Previous to this inspection, the linkage had not been disturbed.

RESULTS OF TESTS

27. The results of the tests, conducted as described under "Method of Test," follow:

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Requirements

Supply: Shall be designed to operate from a 115-volt, 60-cycle power source having operating tolerances of $\pm 10\%$ in both voltage and frequency.

Power requirements of equipment: (not specified).

Accuracy: Errors in indicated speed or recorded miles shall never exceed the following:

- 6 per cent at 4 knots
- 4 per cent at 6 knots
- 3 per cent at 9 knots
- 2 per cent at 16 knots
- 1 per cent at 20 knots and over.

(a) At start of test:
 Calibration:
 A = 3.06, B = +0.1, C = 2.15

(b) Inclined 45° left:
 Calibration:
 A = 3.06, B = +0.1, C = 2.20

(c) Inclined 45° right:
 Calibration:
 A = 3.06, B = +0.1, C = 2.20

(d) Inclined 45° forward:
 Calibration:
 A = 3.06, B = +0.1, C = 2.20

(e) Inclined 45° backward:
 Calibration:
 A = 3.06, B = +0.1, C = 2.20

(f) With supply of 103.5 volts, 65 cycles:
 Calibration:
 A = 3.06, B = +0.1, C = 2.64

Test Values

*Used 115-volt, 60-cycle controlled frequency source during tests. Equipment requires controlled frequency supply to synchronous motor of mileage system; none furnished.

Synchronous motor circuit: 3Y-3YY
19.0 watts, 0.215 ampere, .77 P.F.
Remainder of system: 103.6 watts, 3.90 amperes, .23 P.F. (at 12.5 knots indicated speed).

Knots - Satisfactory
Miles - Satisfactory
See Table 1 and Plate 1

Knots - Satisfactory
Miles - Satisfactory
See Table 2 and Plate 2

Knots - Satisfactory
Miles - Satisfactory
See Table 3 and Plate 3

Knots - Satisfactory
Miles - Satisfactory
See Table 4 and Plate 4

Knots - Satisfactory. See Table 5 and Plate 5.
*Miles - Errors at 16 knots and above exceed tolerances. See Table 5.

*Knots - Errors at 24 knots slightly exceed tolerance. See Table 6 and Plate 6.
Miles - Satisfactory
See Table 6.



<u>Requirements</u>	<u>Test Values</u>
(g) With supply of 126.5 volts 55 cycles: Calibration: A = 3.06, B = +0.1, C = 2.64	*Knots - Errors at 24 knots exceed tolerance. See Table 7 and Plate 7. *Miles - Errors at speeds of 24 and 25 knots exceed tolerance. See Table 7.
(h) After 450 hours of endurance test: Calibration: A = 3.06, B = +0.1, C = 2.64	*Knots and Miles - Many errors exceeding tolerance. See Table 8 and Plate 8.
(i) After 450 hours of endurance test and recalibration: A = 3.06, B = +0.4, C = 2.64	Knots - Satisfactory. See Table 9 and Plate 9. *Miles - Errors at 24 knots exceed tolerance. See Table 9.
(j) Following shock and vibration: Calibration: A = 3.06, B = +0.4, C = 2.64	*Knots - Errors at 4 and 24 knots exceed tolerances. See Table 10 and Plate 10. *Miles - Errors at 4 knots exceed tolerance. See Table 10.
(k) Following shock and vibration and recalibration: Calibration: A = 3.06, B = +0.4, C = 2.38	Knots - Satisfactory Miles - Satisfactory See Table 11 and Plate 11.
(l) At 100-foot submergence: Calibration: A = 3.06, B = +0.4, C = 2.38	Knots - Satisfactory Miles - Not recorded See Table 12a and Plate 12.
(m) Following hydrostatic test: Calibration: A = 3.06, B = +0.4, C = 2.38	*Knots - Errors at 4 to 6 knots exceed tolerances. Miles - Not recorded See Table 12b and Plate 13 Note: Bellows damaged - leaked.
(n) Following hydrostatic test and recalibration: A = 3.06, B = +0.4, C = 2.90	Knots - Satisfactory up to 16 knots (limit of test equip- ment due to bellows leak). Miles - Not recorded. See Table 12c and Plate 14.

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Requirements

Temperature rise: Not specified but the usual requirement for similar equipment is 35°C maximum rise at 65°C ambient temperature.

Endurance: The equipment shall be operated for 500 hours in accordance with paragraph F-2g.

Shock and Vibration: The equipment shall be reliably operative under the tests given in paragraph F-2i and shall sustain no damage.

Pressure test: The entire hydraulic system shall be subjected to a hydrostatic test of 250 pounds per square inch. There shall be no evidence of leakage. Paragraph F-2m.

Illumination: Shall be provided on all Class a speed indicators and shall be of uniform intensity, free from glare and shadows, etc. Dial illumination shall be subject to specific approval.

Control of illumination: Means shall be provided for readily varying the intensity from zero to full.

Time required for speed pointers to go up scale from zero: Not specified.

Dielectric and insulation tests: An alternating potential of 1500 volts, 60 cycles shall be applied between each terminal and ground for 1 minute. Following this, the insulation resistance at 500 volts shall be not less than 10 megohms.

Test Values

Shaded-pole induction motor in Master Transmitter-Indicator:
**Primary 38°C
**Secondary 42°C

Dial lighting transformer in Speed and Distance Indicator:
Primary 11.5°C
Secondary 11.5°C

Satisfactory operation except for necessity of recalibrating Master Transmitter-Indicator.

*Shock produced minor mechanical derangements, see "Comments on Results of Test." Change of "C" setting required to restore accuracy following shock and vibration test.

*Slight leaks at shut-off transfer cocks and at main gasket of hydraulic unit. Pointer was deflected up scale to 6.5 knots and leak developed in lower bellows. See "Comments on Results of Test."

One Speed and Distance Indicator observed in a dark room. Results satisfactory.

Rheostat with combined switch and small flexible resistor provide range of 2.5 to 6.2 volts and "off."

3 minutes, 20 seconds. (Down scale approximately the same.)

Satisfactory. (500 volts, 60 cycle alternating potential applied to low voltage circuits.)

<u>Requirements</u>	<u>Test Values</u>
Weights and dimensions: Shall not exceed the following: Master Transmitter - Height 90", width 18", depth 12". (No weight specified.) Speed and Distance Indicator: Height 12", width 12", depth 8". (No weight specified.)	Master Transmitter-Indicator Height 34", width 17", depth 11-5/8". Weight 144-3/4 lbs. Speed and Distance Indicator: Height 12-1/8", width 10-1/2", depth 8-1/2". Weight 37 lbs. and 15 ounces.
Material in Contact with Sea Water: All metal tubing, etc., in contact with salt water shall be of brass or bronze. Paragraph D-5.	*Bellows parts appear to be brass and are sealed after assembly by sweating with a tin-lead alloy.
Salt spray test: Not required, but applied to the bellows unit for 100 hours to demonstrate the effect of salt water on the dissimilar metals. The test cycle was a 3-minute period of salt spray (20% salt) followed by a 3-minute drying period during which heated air was blown on the sample. The temperature in either case was 55°C.	**Tin-lead alloy attacked due to galvanic corrosion. See "Comments on Results of Tests."
*Denotes non-compliance with the specification. **Denotes characteristic considered unsatisfactory.	

COMMENTS ON RESULTS OF TESTS

28. The following comments pertain to the test results:

(a) As shown by Table 1 and Plate 1, the initial accuracy of indicated knots and counted miles complied with the specification.

(b) Inclining the equipment 45 degrees forward, backward, right or left introduced no error in indicated knots great enough to exceed the tolerances of the specification. Backward inclination, however, caused the errors in counted miles to exceed the tolerances at several speeds, although the indicated knots were satisfactory. See Tables 2, 3, 4, and 5, and Plates 2, 3, 4 and 5.

(c) Tests with a supply of 103.5 volts, 65 cycles, produced no significant loss of accuracy within the range covered by the specification. The errors in indicated knots at 24 knots slightly exceeded the tolerances as shown by Table 6 and Plate 6.

(d) With a supply of 126.5 volts, 55 cycles, there was no significant loss of accuracy in indicated knots. The errors at 24 knots were positive and exceeded the tolerances. The errors in counted miles were

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negative and exceeded the tolerances at speeds of 24 knots and above. It was noted that, at speeds above 22 knots, the slider of the control rheostat in the Master Transmitter-Indicator had reached the end of its travel and that the safety clutch device was operating continuously. Test results are given by Table 7 and Plate 7.

(e) The equipment operated without failure throughout the endurance test. However, it was necessary to recalibrate the Master Transmitter-Indicator (by changing the "B" adjustment only) following an accuracy test conducted after 450 hours of the endurance test. The accuracy before recalibration is given by Table 8 and Plate 8 and the accuracy following recalibration is given by Table 9 and Plate 9.

(f) The Master Transmitter-Indicator successfully withstood the shock and vibration tests except for minor derangements. Under the shock test, the counter weights on arms #19 and #23 of drawing, reference (n), loosened and it was necessary to tighten their securing bolts several times. Also motor #54 stalled frequently following the first half of the shock test, apparently due to some shift of the motor mounting, causing the gears between the motor and Synchro #55 to bind intermittently. This trouble was not observed following the vibration test. Within the range covered by the specification, the errors in indicated knots, following shock and vibration, slightly exceeded the tolerances at 4 and 24 knots. At 4 knots, the error in counted miles also exceeded the tolerance. Test results are given by Table 10 and Plate 10. Table 11 and Plate 11 give the results of an accuracy test following recalibration to minimize errors and prepare the equipment for further tests.

(g) The test with the hydraulic unit operating under a static head simulating 100-foot submergence showed very little change in accuracy. Complete results are given by Table 12-a and Plate 12.

(h) The hydrostatic test of 250 pounds per square inch resulted in the failure of a sweated joint in the lower (small) bellows assembly, causing considerable leakage. The accuracy was also affected as is shown by Table 12-b and Plate 13. Slight leaks also occurred at the main gasket of the hydraulic assembly and at the cut-off transfer cocks.

(i) Following recalibration, the accuracy was satisfactory between the range of 4 and 16 knots, although the bellows was leaking constantly. The volume of water leaking from the bellows made tests at higher speeds impracticable. Table 12-c and Plate 14 give these results.

(j) At an ambient temperature of 65°C the temperature rises of the windings of the shaded-pole induction motor of the Master Transmitter-Indicator were 38°C and 42°C respectively. These values are above the 35°C maximum usually allowed.

(k) The results of the salt spray test demonstrate that, as at present constructed, the bellows unit will eventually fail due to galvanic corrosion. The combination of brass, copper, BE composition, or phosphor-bronze and a tin-lead alloy in sea water will result in corrosion of the

tin-lead alloy. An examination following this test verified the theory that the action is accelerated in the vicinity of large areas of protected (cathodic) metals. It was also noted that the action was even more pronounced at areas which did not dry during the drying period of the salt spray cycle. The use of a tin-lead alloy in this assembly is a technical violation of paragraph D-5 of specification, reference (c).

(l) The fact that the "C" (zero) adjustment had to be changed several times during the early part of the test is believed to indicate a progressive aging effect. However, between the test covered by Table 7 and the test covered by Table 9, the equipment operated for 400 hours without requiring a further change in "C" adjustment. It was necessary to change the "B"(slide) adjustment at the end of this period.

(m) There is also some evidence of a relaxation effect in the bellows. After the equipment has been at rest for some hours, the pointer assumes a "zero" position which does not coincide with the position which it assumes for "zero" after having been deflected to indicate the higher speeds. For example, the pointer indicated 0.4 knot after the equipment had been at rest for 16 hours and 0 knots immediately after the pointer had returned from 25 knots.

(n) It should be stated that, in changing the "C" adjustment, a setting was chosen which would minimize the errors in the vicinity of 3 knots and demonstrate the maximum accuracy of which the equipment was capable. Setting the "C" adjustment to indicate 0 at zero speed is somewhat less satisfactory and would result in larger errors at the low scale values. Without means to apply a pressure differential to the hydraulic unit (as might be the case in the Service), the characteristic covered by (m) would introduce an error in this setting.

(o) It was also noted that the rheostat used to control the speed of the shaded-pole induction meter in the mileage mechanism of the Master Transmitter-Indicator does not have a definite position for each ship's speed as might be expected when the operation of this mechanism is first considered. For example, it was observed on one occasion at zero ship's speed that the slider of the rheostat was in the maximum resistance position and the motor shaft was not running. When the ship's speed was raised, the motor began to run and the counters in the Speed and Distance indicators indicated mileage with usual accuracy at speeds between 1 and 11 knots without a change in rheostat position. This is taken as conclusive evidence that this motor does not furnish all of the power necessary to drive the type "B" synchro, some torque from the roller and disc being transmitted through the differential. At higher speeds, the position of the rheostat slider was definitely different for speed changes of 1 knot.

COMMENTS ON INSPECTION OF EQUIPMENT AND COMPARISON WITH DRAWINGS SUBMITTED

29. The following comments are the result of an examination to determine any defects and ascertain what changes would be desirable:

Master Transmitter-Indicator

(a) The comments covered by paragraphs 25a to 25m of report, reference (e), have been corrected except for (b) and (c) which could not be changed on the present instrument case.

(b) The white paint used in the dial graduations was cracked when the instrument was examined at the end of the test.

(c) The Barber-Coleman shaded-pole induction motor has sleeve bearings. As this motor runs at all times that the log is in operation (except at zero speed), the use of ball bearings for its rotor would be desirable.

(d) It was noted that four of the rubber bushings provided for the mounting lugs took a permanent set during the test. These were the upper front and the lower rear bushings, the ones subjected to the greatest pressure.

Speed and Distance Indicator

(a) The comments on this instrument as listed under paragraph 25 of reference (e), have been corrected except that the dial graduations were plated with cadmium instead of being filled with white paint. This plating tarnished badly on the instrument subjected to an ambient temperature of 65°C.

(b) The voltage to the dial lamps has been limited to approximately the recommended value of 6.0 volts by placing a "flexible resistor" of about 3.5 ohms in series with the dimming rheostat. The usual vitreous covered type would be preferable.

Comparison with Drawings

30. The following discrepancies were noted during a cursory check with the drawings submitted:

(a) Drawing CM5-S65-924 Alt. 2, (CAL-8000) Master Transmitter-Indicator. This drawing apparently covers a proposed modification. Such features as the lengthened hydraulic unit studs, large clearance hole for bellows linkage, bevel gear type differential, method of mounting shaded-pole induction motor, strengthened mounting lugs, and doweling of case cover were not provided on the instrument submitted.

(b) Drawing CM5-S65-922 Alt. 2 (CAL-8200) Speed and Distance Indicator. This drawing is apparently in agreement with the sample submitted except that it does not show the "flexible resistor" now used in series with the dimming rheostat.

(c) Drawing CM5-S65-925 Alt. 2 (CAL-8220) Master Transmitter-Indicator - 5 sheets. Sheets 1 to 4 of this set are apparently based on drawing S65-924 Alt. 2 and have the same discrepancies. Sheet 5 covers the

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the Pressure-Static Bellows Assembly of the equipment submitted, except that it shows piece 6 as a B.E. casting. In the subject equipment this part is of formed brass.

(d) Drawing CM5-S65-926 Alt. 3 (CAL-8270) Speed and Distance Indicator - Interior Unit. This drawing appears to check with the sample submitted.

(e) Drawing CM5-S65-935 Alt. 1 (CAL-8272) Schematic Diagram. This drawing appears to check with the sample submitted except that the resistor in series with the dimming rheostat in the Speed and Distance Indicator is not shown. The windings of the shaded-pole induction motor could be more clearly shown.

(f) Drawing CM5-S65-923 Alt. 2 (CAL-8100) Rodmeter and Seavalve Assembly. This drawing covers material that was not submitted to this Laboratory for test.

CONCLUSIONS

31. The Bendix Log fails to satisfy the specification requirements in many minor particulars, namely:

- (a) Errors in speed.
- (b) Errors in mileage.
- (c) Change in calibration after "endurance."
- (d) Minor derangements under shock.
- (e) Rupture of bellows under hydrostatic pressure.
- (f) Corrosion of bellows.
- (g) Excessive temperature rise of motor windings.
- (h) Change in "zero" position at rest.
- (i) Maximum rate of acceleration is 8 knots per minute, which is too slow for destroyer anti-submarine tactics.

On the other hand, the general performance of the Bendix Log on test was satisfactory. Errors were small, and no deficiencies were of sufficient magnitude to interrupt or seriously affect operation.

32. This Log is a marked improvement over the equipment previously tested and reported by reference (e). It does not merit unqualified type approval, but is considered to be of adequate design and construction to warrant shipboard installation for service test. It is considered that, with further developments and refinements, the outstanding deficiencies can be overcome without changing the basic design.

TABLE 1

Accuracy Test of Underwater Log
 Conducted before all other tests
 All Conditions normal

A - Accelerating
 D - Decelerating
 Supply - 115 volts, 60 cycles,
 controlled frequency.

Settings for calibration: A = 3.06 B = +0.1 C = 2.15

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicators Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error	in Counted Miles*
0	-	0	-	0	-	0	-	-	-
1A	-	0.89	-11.00	0.83	-17.00	0.85	-15.00	-	-0.50
1D	-	0.90	-10.00	0.91	-9.00	0.90	-10.00	-	+5.89
2A	-	1.97	-1.50	1.92	-4.00	1.92	-4.00	-	+5.10
2D	-	1.99	-0.50	2.00	0	1.99	-0.50	-	+7.00
3A	-	2.99	-0.33	2.96	-1.33	2.97	-1.00	-	+5.00
3D	-	3.00	0	3.04	+1.33	3.02	+0.66	-	+5.60
4A	6	3.96	-1.00	3.92	-2.0	3.91	-2.25	-	+3.06
4D	6	3.98	-0.50	4.00	0	3.99	-0.25	-	+2.47
5A	-	4.93	-1.40	4.91	-1.80	4.90	-2.00	-	+1.05
5D	-	4.94	-1.20	4.97	-0.60	4.94	-1.20	-	+1.17
6A	4	5.98	-0.33	5.95	-0.83	5.96	-0.66	-	+1.33
6D	4	6.00	0	6.00	0	5.99	-0.16	-	+2.08
8A	-	7.90	-1.25	7.86	-1.75	7.86	-1.75	-	-0.83
8D	-	7.93	-0.87	7.93	-0.87	7.92	-1.00	-	+0.50
9A	3	8.90	-1.11	8.90	-1.11	8.89	-1.22	-	-0.55
9D	3	8.93	-0.78	8.97	-0.33	8.94	-0.66	-	+0.36
16A	2	15.90	0.62	15.88	-0.75	15.83	-1.066	-	+0.11
16D	2	16.00	0	15.98	-0.12	15.95	-0.31	-	+1.45
20A	1	19.91	-0.45	19.88	-0.60	19.83	-0.85	-	-0.16
20D	1	20.00	0	19.93	-0.35	19.90	-0.50	-	+0.55
24A	1	24.12	+0.50	24.02	+0.08	24.01	+0.04	-	+0.72
24D	1	24.14	+0.60	24.08	+0.33	24.09	+0.38	-	+0.84
25A	1	24.99	-0.04	24.82	-0.72	24.82	-0.72	-	-0.39
25D	1	24.99	-0.04	24.82	-0.72	24.81	-0.76	-	-0.16

* Counted miles of No. 1 and No. 2 Repeater always equal.

TABLE 2

Accuracy Test of Underwater Log
 Conducted with all equipment Inclined 45° Left

Settings for calibration - A = 3.06 B = + 0.1 C = 2.20

A - Accelerating
 D - Decelerating
 Supply - 115 Volts, 60 cycles
 controlled frequency.

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicators Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	in Counted Miles*	Per Cent Error in Counted Miles*
0	-	-0.20	-	-0.11	-	-0.12	-	-	-
1A	-	0.88	-12.00	0.83	-17.00	0.85	-15.00	-	+5.08
1D	-	0.85	-15.00	0.88	-12.00	0.87	-13.00	-	+2.83
2A	-	1.83	- 8.50	1.81	- 9.50	1.80	-10.00	-	+1.61
2D	-	1.84	- 8.00	1.89	- 5.50	1.87	- 6.50	-	+3.47
3A	-	2.89	- 3.66	2.85	- 5.00	2.87	- 4.33	-	+2.39
3D	-	2.89	- 3.66	2.91	- 3.00	2.90	- 3.34	-	+3.28
4A	6	3.91	- 2.25	3.89	- 2.75	3.88	- 3.00	-	+2.61
4D	6	3.90	- 2.50	3.94	- 1.50	3.91	- 2.25	-	+3.12
5A	-	4.93	- 1.40	4.90	- 2.00	4.89	- 2.20	-	+1.91
5D	-	4.91	- 1.80	4.99	- 0.20	4.92	- 1.60	-	+2.44
6A	4	5.89	- 1.83	5.84	- 2.66	5.84	- 2.66	-	+1.08
6D	4	5.89	- 1.83	5.90	- 1.67	5.89	- 1.83	-	+1.25
8A	-	7.83	- 2.12	7.81	- 2.38	7.81	- 2.38	-	-0.25
8D	-	7.87	- 1.62	7.89	- 1.38	7.87	- 1.62	-	-0.08
9A	3	8.89	- 1.22	8.90	- 1.11	8.89	- 1.22	-	-0.66
9D	3	8.92	- 0.89	8.93	- 0.78	8.92	- 0.89	-	+0.66
16A	2	15.88	- 0.75	15.84	- 1.00	15.82	- 1.12	-	+1.25
16D	2	15.90	- 0.63	15.89	- 0.68	15.87	- 0.81	-	-0.83
20A	1	19.96	- 0.20	19.90	- 0.50	19.88	- 0.60	-	-1.08
20D	1	19.96	- 0.20	19.90	- 0.50	19.88	- 0.60	-	-1.17
24A	1	24.10	+ 0.42	24.00	0	24.00	0	-	-0.08
24D	1	24.13	+ 0.54	24.06	+ 0.25	24.05	+ 0.21	-	+0.22
25A	1	25.00	0	24.87	- 0.52	24.85	- 0.60	-	-0.69
25D	1	25.00	0	24.88	- 0.48	24.84	- 0.64	-	-0.64

* Counted miles of No. 1 and No. 2 Repeaters always equal.

TABLE 3

Accuracy Test of Underwater Log
 Conducted with all equipment inclined 45° Right

A - Accelerating
 D - Decelerating
 Supply - 115 volts, 60 cycles,
 controlled frequency.

Settings for calibration - A = 3.06 B = +0.1 C = 2.20

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicators Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error in Counted Miles*	
0	-	-0.22	-	-0.11	-	-0.12	-	-	-
1A	-	0.78	-22.0	0.72	-28.0	0.73	-27.0	-14.53	+ 1.44
1D	-	0.79	-21.0	0.81	-19.0	0.80	-20.0	+ 2.11	+ 1.22
2A	-	1.81	- 9.50	1.77	-11.50	1.75	-12.50	+ 2.89	+ 3.33
2D	-	1.82	- 9.00	1.86	- 7.00	1.82	- 9.00	+ 2.97	+ 2.36
3A	-	2.86	- 4.66	2.85	- 5.00	2.85	- 5.00	+ 1.50	+ 1.87
3D	-	2.85	- 5.00	2.89	- 3.66	2.88	- 4.00	+ 0.36	+ 0.50
4A	6	3.89	- 2.75	3.88	- 3.00	3.85	- 3.75	+ 0.31	+ 0.47
4D	6	3.89	- 2.75	3.91	- 2.25	3.90	- 2.50	+ 0.05	+ 0.36
5A	-	4.91	- 1.80	4.90	- 2.00	4.89	- 2.20	+ 0.31	+ 0.47
5D	-	4.90	- 2.00	4.92	- 1.60	4.90	- 2.00	+ 0.05	+ 0.36
6A	4	5.90	- 1.66	5.89	- 1.83	5.88	- 2.00	+ 0.05	+ 0.36
6D	4	5.90	- 1.66	5.92	- 1.33	5.90	- 1.66	+ 0.05	+ 0.36
8A	-	7.88	- 1.50	7.88	- 1.50	7.87	- 1.63	+ 0.05	+ 0.36
8D	-	7.88	- 1.50	7.91	- 1.12	7.90	- 1.25	+ 0.05	+ 0.36
9A	3	8.98	- 0.22	8.99	- 0.11	8.98	- 0.22	+ 0.05	+ 0.36
9D	3	9.00	0	9.00	0	9.00	0	+ 0.05	+ 0.36
16A	2	15.99	- 0.06	15.93	- 0.44	15.91	- 0.56	+ 0.05	+ 0.36
16D	2	16.00	0	16.00	0	15.98	- 0.12	+ 0.05	+ 0.36
20A	1	19.99	- 0.05	19.91	- 0.45	19.90	- 0.50	+ 0.05	+ 0.36
20D	1	20.00	0	20.00	0	19.98	- 0.10	+ 0.05	+ 0.36
24A	1	24.18	+ 0.75	24.06	+ 0.25	24.06	+ 0.25	+ 0.05	+ 0.36
24D	1	24.21	+ 0.87	24.12	+ 0.50	24.13	+ 0.54	+ 0.05	+ 0.36
25A	1	24.99	- 0.04	24.82	- 0.72	24.81	- 0.76	+ 0.05	+ 0.36
25D	1	24.99	- 0.04	24.82	- 0.72	24.80	- 0.80	+ 0.05	+ 0.36

* Counted miles of No. 1 and No. 2 Repeaters always equal.

TABLE 4

Accuracy Test of Underwater Log
 Conducted with all equipment inclined 45° Forward

Settings for calibration: A = 3.06 B = + 0.1 C = 2.20

A - Accelerating
 D - Decelerating
 Supply - 115 volts, 60 cycles,
 controlled frequency.

Manometer Simulated Knots	Allowable Error in speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicators Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error in Counted Miles *	
0	-	-0.10	-	0.10	-	0.11	-	-	-
1A	-	1.17	+17.00	1.11	+11.00	1.12	+12.00	+21.00	+21.00
1D	-	1.02	+ 2.00	1.07	+ 7.00	1.05	+ 5.00	+12.71	+12.71
2A	-	1.98	- 1.00	1.94	- 3.00	1.96	- 2.00	+ 4.84	+ 4.84
2D	-	1.90	- 5.00	1.91	- 4.50	1.90	- 5.00	+ 5.14	+ 5.14
3A	-	2.90	- 3.34	2.98	- 0.67	2.99	- 0.33	+ 5.94	+ 5.94
3D	-	2.99	- 0.33	3.00	0	3.00	0	+ 5.44	+ 5.44
4A	6	3.98	- 0.50	3.95	- 1.25	3.97	- 0.75	+ 2.78	+ 2.78
4D	6	3.98	- 0.50	3.99	- 0.25	3.98	- 0.50	+ 0.72	+ 0.72
5A	-	4.98	- 0.40	4.96	- 0.80	4.95	- 1.00	+ 1.17	+ 1.17
5D	-	4.98	- 0.40	4.99	- 0.20	4.93	- 1.60	+ 0.83	+ 0.83
6A	4	5.98	- 0.33	5.93	- 1.17	5.93	- 1.17	+ 0.61	+ 0.61
6D	4	5.98	- 0.33	5.98	- 0.33	5.95	- 0.83	+ 0.61	+ 0.61
8A	-	7.92	- 1.00	7.90	- 1.25	7.90	- 1.25	- 0.14	- 0.14
8D	-	7.91	- 1.12	7.95	- 0.63	7.92	- 1.00	+ 0.06	+ 0.06
9A	3	9.00	0	8.98	- 0.22	9.00	0	+ 0.22	+ 0.22
9D	3	9.00	0	9.01	+ 0.11	9.00	0	+ 0.51	+ 0.51
16A	2	15.98	- 0.13	15.94	- 0.38	15.92	- 0.50	- 0.61	- 0.61
16D	2	16.00	0	16.00	0	15.98	- 0.13	+ 0.11	+ 0.11
20A	1	20.02	+ 0.10	19.98	- 0.10	19.95	- 0.25	- 0.06	- 0.06
20D	1	20.00	0	19.96	- 0.20	19.92	- 0.40	- 0.33	- 0.33
24A	1	24.20	+ 0.83	24.10	+ 0.42	24.10	+ 0.42	+ 0.47	+ 0.47
24D	1	24.24	+ 1.00	24.10	+ 0.42	24.12	+ 0.50	+ 0.50	+ 0.50
25A	1	24.96	- 0.16	24.85	- 0.60	24.82	- 0.72	- 0.89	- 0.89
25D	1	24.95	- 0.20	24.84	- 0.64	24.82	- 0.72	- 0.92	- 0.92

* Counted miles of No. 1 and No. 2 Repeaters always equal.

TABLE 5

Accuracy Test of Underwater Log
 Conducted with all equipment inclined 45° Backward
 Settings for calibration - A = 3.06 B = +0.1 C = 2.20

A - Accelerating
 D - Decelerating
 Supply - 115 volts, 60 cycles,
 controlled frequency.

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter			Indicator No. 1			Indicator No. 2			Indicators Nos. 1 & 2		
		Indicated Knots	Per Cent Error	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error
0	-	-0.20	-	-	-0.19	-	-	-0.02	-	-	-	-	-
1A	-	0.55	-45.0	-	0.56	-44.0	-	0.57	-43.0	-	-	-	-39.60
1D	-	0.58	-42.0	-	0.61	-39.0	-	0.60	-40.0	-	-	-	-43.90
2A	-	1.74	-13.0	-	1.71	-14.5	-	1.71	-14.5	-	-	-	- 4.50
2D	-	1.74	-13.0	-	1.79	-10.5	-	1.78	-11.0	-	-	-	- 3.39
3A	-	2.79	- 7.0	-	2.80	- 6.70	-	2.80	- 6.70	-	-	-	- 0.47
3D	-	2.81	- 6.3	-	2.85	- 5.00	-	2.85	- 5.00	-	-	-	- 0.17
4A	6	3.85	- 3.75	-	3.82	- 4.50	-	3.81	- 4.75	-	-	-	+ 0.58
4D	6	3.85	- 3.75	-	3.90	- 2.50	-	3.88	- 3.00	-	-	-	+ 0.97
5A	-	4.81	- 3.80	-	4.81	- 4.80	-	3.80	- 4.80	-	-	-	- 0.06
5D	-	4.83	- 3.40	-	4.87	- 2.60	-	4.86	- 2.80	-	-	-	+ 0.22
6A	4	5.83	- 2.84	-	5.80	- 3.33	-	5.80	- 3.33	-	-	-	0
6D	4	5.83	- 2.84	-	5.88	- 2.00	-	5.86	- 2.33	-	-	-	+ 0.11
8A	-	7.81	- 2.38	-	7.81	- 2.38	-	7.81	- 2.38	-	-	-	- 0.22
8D	-	7.84	- 2.00	-	7.87	- 1.63	-	7.85	- 1.87	-	-	-	- 0.33
9A	3	8.90	- 1.12	-	8.91	- 1.00	-	8.90	- 1.12	-	-	-	- 0.58
9D	3	8.89	- 1.33	-	8.90	- 1.12	-	8.89	- 1.33	-	-	-	- 0.56
16A	2	15.92	- 0.50	-	15.91	- 0.56	-	15.89	- 0.69	-	-	-	- 2.04
16D	2	15.92	- 0.50	-	15.92	- 0.50	-	15.90	- 0.62	-	-	-	- 1.95
20A	1	19.95	- 0.25	-	19.89	- 0.55	-	19.86	- 0.70	-	-	-	- 1.72
20D	1	20.00	0	-	19.96	- 0.20	-	19.91	- 0.45	-	-	-	- 1.22
24A	1	24.16	+ 0.67	-	24.01	+ 0.04	-	24.01	+ 0.04	-	-	-	- 0.14
24D	1	24.22	+ .91	-	24.12	+ 0.50	-	24.15	+ 0.63	-	-	-	+ 0.28
25A	1	25.00	0	-	24.85	- 0.60	-	24.83	- 0.68	-	-	-	- 1.11
25D	1	25.00	0	-	24.85	- 0.60	-	24.83	- 0.68	-	-	-	- 1.09

*Counted miles of No. 1 and No. 2 Repeaters always equal.

TABLE 6

Accuracy Test of Underwater Log
Conducted with Supply of 103.5 Volts, 65 Cycles.

A - Accelerating
D - Decelerating

Supply to synchronous
motor - 103.5 Volts, 60
Cycles, controlled frequency.

Settings for calibration - A = 3.06 B = +0.1 C = 2.64

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicators Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error	in Counted Miles*
0	-	+0.10	-	+0.08	-	+0.08	-	-	-
1A	-	0.97	-3.0	0.92	-8.0	0.93	-7.0	+13.80	+13.80
1D	-	1.00	0	1.06	+6.0	1.02	+2.0	+15.39	+15.39
2A	-	1.93	-3.5	1.90	-5.0	1.89	-5.5	+ 5.58	+ 5.58
2D	-	1.94	-3.0	1.93	-3.5	1.94	-3.0	+ 9.25	+ 9.25
3A	-	2.99	-0.33	2.97	-1.0	2.97	-1.0	+ 4.58	+ 4.58
3D	-	3.00	0	3.07	+2.33	3.05	+1.66	+ 6.84	+ 6.84
4A	6	4.00	0	3.92	-2.0	3.92	-2.0	+ 3.06	+ 3.06
4D	6	4.01	+0.25	4.07	+1.75	4.04	+1.0	+ 4.69	+ 4.69
5A	-	5.00	0	4.95	-1.0	4.95	-1.0	+ 2.22	+ 2.22
5D	-	5.00	0	5.01	+0.20	5.01	+0.20	+ 2.52	+ 2.52
6A	4	5.98	-0.33	5.91	-1.50	5.90	-1.67	+ 1.47	+ 1.47
6D	4	5.99	-0.16	6.00	0	5.99	-0.16	+ 2.03	+ 2.03
8A	-	7.99	-0.12	7.94	-0.75	7.94	-0.75	+ 1.17	+ 1.17
8D	-	8.00	0	8.02	+0.25	8.00	0	+ 1.89	+ 1.89
9A	3	8.99	-0.11	8.99	-0.11	8.98	-0.22	+ 2.11	+ 2.11
9D	3	9.00	0	9.00	0	9.00	0	+ 1.83	+ 1.83
16A	2	16.00	0	15.98	-0.13	15.98	-0.13	+ 0.39	+ 0.39
16D	2	16.01	+0.06	16.07	+0.44	16.02	+0.13	+ 0.61	+ 0.61
20A	1	20.00	0	19.99	-0.05	19.98	-0.10	0	0
20D	1	20.01	+0.05	20.01	+0.05	20.00	0	+ 0.11	+ 0.11
24A	1	24.27	+1.13	24.13	+0.54	24.18	+0.75	+ 0.81	+ 0.81
24	1	24.29	+1.21	24.20	+0.84	24.21	+0.88	+ 0.89	+ 0.89
25	1	25.00	0	24.84	+0.64	24.83	+0.68	- 0.64	- 0.64
25	1	25.00	0	24.83	+0.68	24.82	+0.72	- 0.75	- 0.75

*Counted miles of No. 1 and No. 2 Repeaters always equal.

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TABLE 7

Accuracy Test of Underwater Log
 Conducted with Supply of 126.5 Volts, 55 Cycles

A - Accelerating
 D - Decelerating
 Supply - 115 V., 60 cycles,
 controlled frequency.

Settings for calibration - A = 3.06 B = +0.1 C = 2.64

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicators Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error	in Counted Miles*
0	-	+0.10	-	+0.09	-	+0.09	-	-	-
1A	-	0.91	-9.0	0.89	-11.0	0.88	-12.0	-	+5.70
1D	-	0.98	-2.0	0.98	-2.0	0.97	-3.0	-	+14.90
2A	-	1.91	-4.5	1.90	-5.0	1.90	-5.0	-	+3.70
2D	-	1.92	-4.0	1.92	-4.0	1.91	-4.5	-	+7.42
3A	-	2.99	-0.33	2.93	-2.33	2.94	-2.0	-	+3.80
3D	-	2.99	-0.33	3.00	0	2.99	-0.33	-	+5.02
4A	6	3.98	-0.5	3.93	-1.75	3.93	-1.75	-	+3.28
4D	6	3.99	-0.25	4.00	0	3.99	-0.25	-	+3.80
5A	-	4.99	-0.20	4.93	-1.4	4.92	-1.6	-	+3.22
5D	-	5.00	0	4.99	-0.20	4.95	-1.0	-	+3.14
6A	4	5.98	-0.33	5.92	-1.33	5.92	-1.33	-	+1.50
6D	4	6.03	+0.50	6.07	+1.16	6.05	+0.83	-	+3.00
8A	-	8.00	0	7.98	-0.25	7.97	-0.38	-	+1.06
8D	-	8.00	0	7.93	-0.88	8.01	+0.125	-	+1.39
9A	3	8.99	-0.11	9.00	0	8.98	-0.22	-	+0.84
9D	3	9.00	0	9.01	+0.11	9.00	0	-	+1.11
16A	2	16.01	+0.06	16.00	0	15.98	-0.12	-	+0.56
16D	2	16.00	0	15.99	-0.06	15.97	-0.19	-	+0.34
20A	1	20.09	+0.45	20.00	0	20.00	0	-	+0.84
20D	1	20.09	-0.45	20.03	+0.15	20.02	+0.10	-	+0.81
24A	1	24.37	+1.54	24.22	+0.92	24.27	+1.13	-	-5.29
24D	1	24.39	+1.62	24.25	+1.04	24.29	+1.21	-	-5.76
25A	1	25.00	0	24.85	-0.60	24.83	-0.68	-	-11.28
25D	1	25.00	0	24.85	-0.60	24.83	-0.68	-	-11.72

*Counted miles of No. 1 and No. 2 repeaters always equal.

TABLE 8

Accuracy Test of Underwater Log
Conducted After 450 Hours of Endurance

A - Accelerating
D - Decelerating
Supply - 115 volts, 60 cycles,
controlled frequency.

Settings for calibration - A = 3.06 B = +0.1 C = 2.64

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicators Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error	in Counted Miles*
0	-	0.42	-	0.40	-	0.41	-	-	-
1A	-	1.29	+29.00	1.26	+26.00	1.25	+25.00	+20.45	+20.45
1D	-	1.29	+29.00	1.29	+29.00	1.29	+29.00	+17.55	+17.55
2A	-	2.30	+15.00	2.28	+14.00	2.28	+14.00	+15.98	+15.98
2D	-	2.30	+15.00	2.32	+16.00	2.30	+15.00	+16.57	+16.57
3A	-	3.40	+13.33	3.38	+12.66	3.37	+12.33	+13.61	+13.61
3D	-	3.45	+15.00	3.45	+15.00	3.44	+14.66	+14.86	+14.86
4A	6	4.43	+10.75	4.40	+10.00	4.40	+10.00	+10.28	+10.28
4D	6	4.43	+10.75	4.47	+11.75	4.43	+10.75	+11.86	+11.86
5A	-	5.45	+9.00	5.43	+8.60	5.40	+8.00	+8.08	+8.08
5D	-	5.52	+10.40	5.50	+10.00	5.49	+9.80	+10.00	+10.00
6A	4	6.42	+7.00	6.40	+6.66	6.40	+6.66	+6.75	+6.75
6D	4	6.43	+7.16	6.47	+7.84	6.43	+7.16	+7.22	+7.22
8A	-	8.34	+4.25	8.32	+4.00	8.32	+4.00	+3.19	+3.19
8D	-	8.38	+4.75	8.38	+4.75	8.37	+4.63	+3.66	+3.66
9A	3	9.40	+4.45	9.41	+4.55	9.40	+4.45	+2.97	+2.97
9D	3	9.47	+5.22	9.48	+5.33	9.47	+5.22	+3.44	+3.44
16A	2	16.33	+2.06	16.33	+2.06	16.40	+2.50	+1.61	+1.61
16D	2	16.39	+2.44	16.39	+2.44	16.36	+2.25	+2.22	+2.22
20A	1	20.37	+1.85	20.30	+1.50	20.30	+1.50	+1.33	+1.33
20D	1	20.41	+2.05	20.35	+1.75	20.33	+1.65	+1.83	+1.83
24A	1	24.59	+2.46	24.48	+2.00	24.47	+1.96	+1.53	+1.53
24D	1	24.68	+2.83	24.59	+2.46	24.58	+2.42	+2.14	+2.14
25A	1	24.95	-0.20	24.80	-0.80	24.79	-0.84	-1.58	-1.58
25D	1	24.95	-0.20	24.80	-0.80	24.79	-0.84	-1.53	-1.53

*Counted miles of No. 1 and No. 2 repeaters always equal.

TABLE 9

Accuracy Test of Underwater Log
 Conducted After 450 Hours of Endurance and Recalibration

A - Accelerating
 D - Decelerating
 Supply - 115 volts,
 60 cycles, controlled
 frequency.

Settings for calibration - A = 3.06 B = +0.4 C = 2.64

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicator's Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error	in Counted Miles*
0	-	0.15	-	0.18	-	0.16	-	-	
1A	-	0.91	-9.00	0.91	-9.00	0.90	-10.00	-10.00	+2.81
1D	-	0.95	-5.00	0.96	-4.00	0.96	-4.00	-4.00	+3.08
2A	-	1.95	-2.50	1.88	-6.00	1.88	-6.00	-6.00	-4.47
2D	-	1.95	-2.50	1.97	-1.50	1.96	-2.00	-2.00	-1.50
3A	-	3.00	0	2.98	-0.66	2.98	-0.66	-0.66	-2.94
3D	-	3.00	0	3.00	0	3.00	0	0	-1.25
4A	6	4.02	+0.50	4.00	0	4.00	0	0	0
4D	6	4.00	0	4.02	+0.50	4.01	+0.25	+0.25	-1.00
5A	-	5.00	0	5.00	0	5.00	0	0	-0.47
5D	-	5.01	+0.20	5.05	+1.00	5.03	+0.60	+0.60	-0.83
6A	4	6.02	+0.33	6.01	+0.16	6.01	+0.16	+0.16	+0.11
6D	4	6.01	+0.16	6.03	+0.50	6.01	+0.16	+0.16	+0.03
8A	-	7.99	-0.12	8.00	0	7.97	-0.37	-0.37	-1.64
8D	-	8.00	0	8.00	0	7.99	-0.12	-0.12	-1.14
9A	3	9.07	+0.78	9.07	+0.78	9.05	+0.56	+0.56	-1.28
9D	3	9.03	+0.33	9.04	+0.44	9.02	+0.22	+0.22	-0.69
16A	2	16.02	+0.12	16.00	0	15.99	-0.08	-0.08	0
16D	2	16.04	+0.25	16.01	+0.06	16.00	0	0	-0.19
20A	1	20.00	0	19.93	-0.35	19.90	-0.50	-0.50	-0.08
20D	1	20.00	0	19.98	-0.10	19.93	-0.35	-0.35	-0.22
24A	1	24.18	+0.75	24.05	+0.20	24.05	+0.20	+0.20	+0.39
24D	1	24.21	+0.88	24.11	+0.46	24.13	+0.54	+0.54	+0.58
25A	1	24.95	-0.20	24.80	-0.80	24.80	-0.80	-0.80	+1.42
25D	1	24.95	-0.20	24.80	-0.80	24.80	-0.80	-0.80	-1.33

*Counted miles of No. 1 and No. 2 repeaters always equal.

TABLE 10

Accuracy Test of Underwater Log
Conducted After Shock and Vibration

A - Accelerating
D - Decelerating
Supply - 115 volts, 60 cycles,
controlled frequency.

Settings for calibration - A = 3.06 B = 0.4 C = 2.64

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicators Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Per Cent Error in Counted Miles*	
0	-	1.25	-	1.25	-	1.26	-	-	-
1A	-	1.57	+57.00	1.51	+51.00	1.51	+51.00	+51.00	+43.50
1D	-	1.61	+61.00	1.60	+60.00	1.60	+60.00	+60.00	+45.60
2A	-	2.31	+15.50	2.28	+14.00	2.28	+14.00	+14.00	+16.80
2D	-	2.41	+20.50	2.42	+21.00	2.40	+20.00	+20.00	+20.40
3A	-	3.38	+12.66	3.37	+12.33	3.34	+11.33	+11.33	+12.50
3D	-	3.35	+11.66	3.37	+12.33	3.35	+11.66	+11.66	+12.40
4A	6	4.21	+ 5.25	4.18	+ 4.50	4.17	+ 4.25	+ 4.25	+ 6.70
4D	6	4.27	+ 6.75	4.24	+ 6.00	4.23	+ 5.75	+ 5.75	+ 7.75
5A	-	5.19	+ 3.80	5.13	+ 2.60	5.11	+ 2.20	+ 2.20	+ 4.05
5D	-	5.19	+ 3.80	5.21	+ 4.20	5.19	+ 3.90	+ 3.90	+ 4.85
6A	4	6.10	+ 1.67	6.08	+ 1.33	6.07	+ 1.17	+ 1.17	+ 2.16
6D	4	6.11	+ 1.83	6.12	+ 2.00	6.11	+ 1.83	+ 1.83	+ 3.34
8A	-	7.93	+ 0.88	7.90	+ 1.25	7.90	+ 1.25	+ 1.25	- 1.22
8D	-	7.99	+ 0.13	8.00	0	7.97	+ 0.38	+ 0.38	+ 0.08
9A	3	9.15	+ 1.67	9.15	+ 1.67	9.12	+ 1.33	+ 1.33	+ 1.61
9D	3	9.22	+ 2.44	9.23	+ 2.56	9.22	+ 2.44	+ 2.44	+ 2.72
16A	2	16.04	+ 0.25	16.03	+ 0.19	16.00	0	0	- 0.06
16D	2	16.11	+ 0.69	16.12	+ 0.75	16.09	+ 0.56	+ 0.56	+ 0.64
20A	1	20.01	+ 0.05	19.98	- 0.10	19.96	- 0.20	- 0.20	- 0.14
20D	1	20.07	+ 0.35	20.01	+ 0.05	20.00	0	0	+ 0.22
24A	1	24.28	+ 1.17	24.12	+ 0.50	24.16	+ 0.66	+ 0.66	+ 0.58
24D	1	24.30	+ 1.25	24.19	+ 0.79	24.21	+ 0.88	+ 0.88	+ 0.86
25A	1	24.95	- 0.20	24.81	- 0.76	24.80	- 0.80	- 0.80	- 1.03
25D	1	24.95	- 0.20	24.81	- 0.76	24.80	- 0.80	- 0.80	- 0.97

*Counted miles of No. 1 and No. 2 repeaters always equal.

TABLE 11

Accuracy Test of Underwater Log
Conducted After Shock and Vibration and Recalibration

Settings for calibration - A = 3.06 B = +0.4 C = 2.38

A - Acceleration
D - Deceleration
Supply - 115 volts,
60 cycles,
controlled frequency.

Manometer Simulated Knots	Allowable Error in Speed and Distance in Per Cent	Master Transmitter		Indicator No. 1		Indicator No. 2		Indicators Nos. 1 & 2	
		Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error	Indicated Knots	Per Cent Error
0	-	0.39	-24.00	0.39	-30.00	0.39	-30.00	-	-53.40
1A	-	0.76	-3.00	0.70	-3.00	0.70	-6.00	-	+5.75
1D	-	0.97	-5.00	0.97	-7.50	0.94	-7.50	-	-2.47
2A	-	1.90	-3.50	1.85	-3.50	1.85	-4.00	-	+0.61
2D	-	1.93	-0.33	1.93	-2.34	1.92	-1.66	-	+0.28
3A	-	2.99	+0.66	2.93	+2.00	2.95	+1.00	-	+1.80
3D	-	3.02	+1.00	3.06	+0.75	3.03	+0.50	-	+2.94
4A	6	4.04	+2.25	4.03	+2.25	4.02	+2.25	-	+3.58
4D	6	4.09	+1.80	4.09	+1.20	4.09	+0.60	-	+2.00
5A	-	5.09	+2.00	5.06	+2.20	5.03	+1.80	-	+0.36
5D	-	5.10	+1.50	5.11	+1.17	5.09	+0.67	-	+1.56
6A	4	6.09	+1.67	6.07	+1.67	6.04	+1.50	-	+2.84
6D	4	6.10	+0.25	6.10	+0.13	6.09	+0.13	-	+0.86
8A	-	8.02	+0.75	8.01	+0.88	8.01	+0.38	-	+1.25
8D	-	8.06	+2.22	8.07	+2.11	8.03	+1.78	-	+2.22
9A	3	9.20	+1.89	9.19	+2.22	9.16	+2.00	-	+2.22
9D	3	9.17	+0.69	9.20	+0.50	9.18	+0.38	-	+0.70
16A	2	16.11	+0.45	16.08	+0.75	16.06	+0.63	-	+0.83
16D	2	16.12	+0.40	16.12	0	16.10	0	-	+0.17
20A	1	20.09	+1.04	20.00	+0.25	20.00	+0.15	-	+0.33
20D	1	20.08	+1.00	20.05	+0.42	20.03	+0.54	-	+0.64
24A	1	24.25	+0.20	24.10	-0.80	24.13	+0.71	-	+0.70
24D	1	24.24	-0.20	24.15	-0.80	24.17	-0.80	-	-0.95
25A	1	24.95	-0.20	24.80	-0.80	24.80	-0.80	-	-0.89
25D	1	24.95	-0.20	24.80	-0.80	24.80	-0.80	-	-0.89

*Counted miles of No. 1 and No. 2 repeaters always equal.

TABLE 13

Calibration data for manometers used during tests:

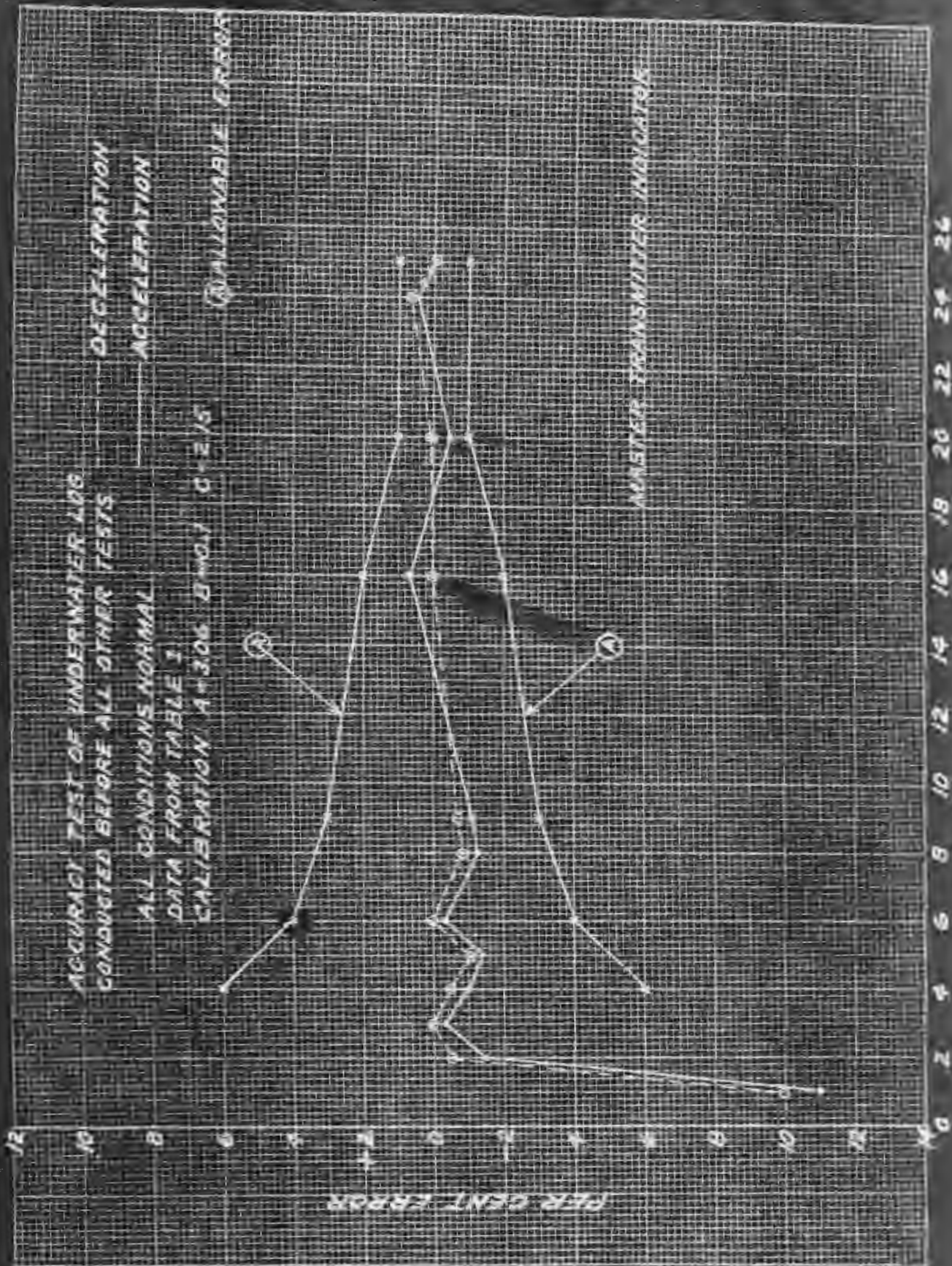
1/2 Mercury U-Tube Deflection for $C = .957$
for Fresh Water (Rodmeter and U-Tube)

<u>Knot</u>		<u>Inches</u>	<u>Knot</u>		<u>Inches</u>
1.	-	.02313	21.	-	10.20196
2.	-	.09253	22.	-	11.19671
3.	-	.20820	23.	-	12.23773
4.	-	.37014	24.	-	13.32501
5.	-	.57834	25.	-	14.45856
6.	-	.83281	26.	-	15.63838
7.	-	1.13355	27.	-	16.86447
8.	-	1.48056	28.	-	18.13682
9.	-	1.87383	29.	-	19.45544
10.	-	2.31337	30.	-	20.82033
11.	-	2.79918	31.	-	22.23149
12.	-	3.33125	32.	-	23.68891
13.	-	3.90960	33.	-	25.19260
14.	-	4.53421	34.	-	26.74256
15.	-	5.20508	35.	-	28.33878
16.	-	5.92223	36.	-	29.98128
17.	-	6.68564	37.	-	31.67004
18.	-	7.49532	38.	-	33.40506
19.	-	8.35127	39.	-	35.18636
20.	-	9.25348	40.	-	37.01392

Deflection in Water

1.	-	.580820	4.	-	9.293120
2.	-	2.323280	5.	-	14.520500
3.	-	5.227380	8.	-	37.172480

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ACCURACY TEST OF UNDERWATER LOG
 CONDUCTED BEFORE ALL OTHER TESTS
 ALL CONDITIONS NORMAL
 DATA FROM TABLE I
 CALIBRATION A-306 B-401 C-215

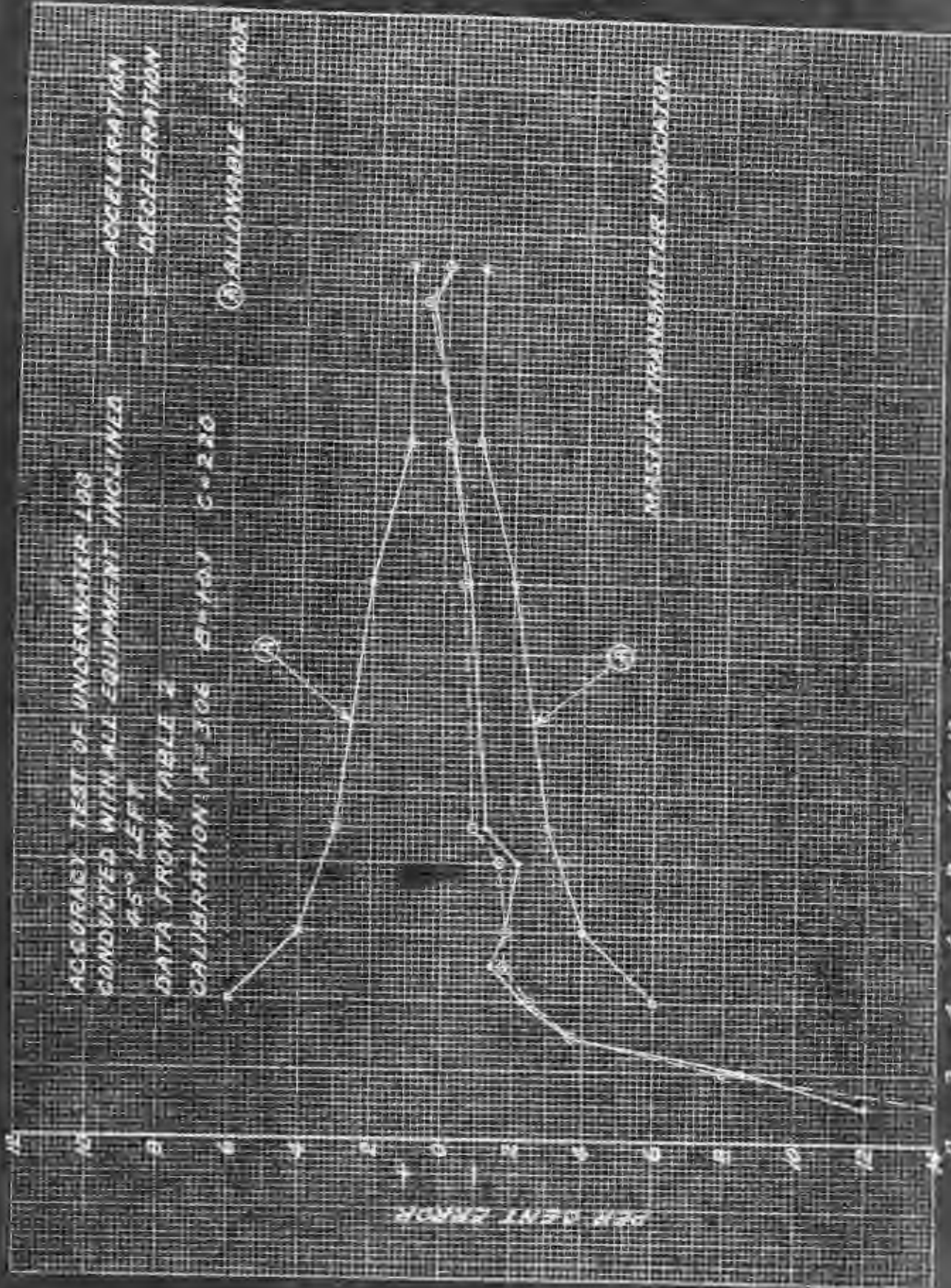
NAVY'S TRANSMITTER INFORMATION

PLATE I

ACCURACY TEST OF UNDERWATER LOG
 CONDUCTED WITH ALL EQUIPMENT INCLUDING
 45° LEFT
 DATA FROM TABLE 2
 CALIBRATION 1-306 B-10V C-230

ACCELERATION
 DECELERATION

① ALLOWABLE ERROR



0 2 4 6 8 10 12 14 16 18 20 22 24 26
 SIMULATED VELOCITY IN KNOTS

PLATE 2