

B

11 April 1940

NRL Report No. B-1607

NAVY DEPARTMENT

FR-1607

Report of Test

on

"SAL" Electric Log Equipment

Exhibited by

Bendix Aviation Corporation, Marine Division.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 6 Tables - 4 Plates - 9
Authorization: BuEng.ltr. S65-5/L5 (2-12-SS) of 17 February 1940.
Date of Test: 25 February to 7 April 1940.

Tested by:

J. R. Coomes, Senior Engineering Aide.

G. K. C. Hardesty, Senior Engineering Aide.

Reviewed by:

W. B. Roberts, Chief Engineering Aide,
Chief of Section.

J. E. Chapman, Lieutenant Commander, USN.

Approved by:

H. G. Bowen, Rear Admiral, USN, Director.

Distribution Unlimited

Distribution:

BuEng. (5)
BuC&R

Approved for
Public Release

ejh

Table of Contents

<u>Subject</u>	<u>Page</u>
Authorization for Test	1
Object of Test	1
Abstract of Test	1
Conclusions	1-a
Recommendations	1-b
Description of Material under Test	2
Principles of the System	2
Method of Test	3
Results of Tests	4
Conclusions	6

Appendices

Accuracy of Speed Indicator Before and After the Endurance Test	Table 1
Accuracy of Speed Indicator After Endurance Test. Master Unit Inclined 45°	2
Accuracy of Speed Indicator After Endurance, Shock, and Vibration Tests	3
Accuracy of Speed Indicator After Endurance, Shock, Vibration and Hydrostatic Tests	4
Accuracy of Speed Indicator Before Endurance Test. From Table 1	Plate 1
Accuracy of Speed Indicator After Endurance Test. From Table 1	2
Accuracy of Speed Indicator After Endurance Test, Master Unit Inclined 45 Degrees. From Table 2 .	3
Accuracy of Speed Indicator After Endurance, Shock, and Vibration Tests. From Table 3	4
Accuracy of Speed Indicator After Endurance, Shock, Vibration, and Hydrostatic Tests. From Table 4.	5
Pressures in Centimeters of H ₂ O and Hg developed at Speeds of 0 to 25 Knots	6
Schematic Diagram of "SAL" Log Equipment	7
Photograph of Master Unit	8
Photograph of Equipment Submitted as Set Up for Test	9

AUTHORIZATION FOR TEST

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

Reference: (a) BuEng.ltr. S65-5(2-12-SS) of 17 February 1940.
(b) Specification SGS(65)-151a of 1 February 1937.
(c) Instruction Book for "Sal" Log - Bulletin No. 368
U.S.S. DOLPHIN-SS169.

OBJECT OF TEST

2. The object of this test was to determine conformance of the sample log equipment with the specifications, reference (b), and its suitability for Naval use on surface vessels or submarines.

ABSTRACT OF TEST

3. The sample log equipment was set up at this Laboratory and subjected to those parts of the specifications which were considered applicable. These included accuracy, endurance, shock, vibration, inclination, and hydrostatic tests. Additional accuracy tests were made on several occasions to isolate the errors resulting from the several test conditions.

Conclusions

(a) Except when the master unit was inclined as required by paragraph E-12h, the accuracy of the indicated speed was at all times within the limits given by the specification; that is, within 6 per cent at 4 knots, 4 per cent at 6 knots, 3 per cent at 9 knots, 2 per cent at 16 knots, and 1 per cent at 20 knots and over. However, it appears that, had no changes been made in the "C" (zero) setting, the errors would have accumulated and exceeded the tolerance at the lower speeds. No tolerance is specified for speeds below 4 knots, where the greatest errors occur. The sensitivity of the mechanism places the lower limit of reliable operation at about 1.5 knots.

(b) Inclining the master unit 45 degrees in any direction produced large positive errors, exceeding the tolerance at low speeds, which indicates that gimbaling would be necessary to bring results within specification tolerances for speeds below 10 knots.

(c) The progressive change in the "C" (zero) setting necessary to maintain accuracy throughout the test is not considered serious, due to the ease with which this error may be detected and corrected.

(d) The performance of the speed indicator, while the hydrostatic pressure was being built up to 250 pounds per square inch, as required by paragraph F-2m, casts some doubt on the accuracy of the system as applied to submarines operating below the surface. All accuracy tests were made with a static head of 8 feet of water or less.

(e) The cause of the failure of the total mileage mechanism was not ascertained. Before failure it recorded a total of 4423 miles.

Recommendations

(a) Although this equipment did not comply with the specification requirements for inclined operation at simulated speeds under 10 knots, it appears to possess greater sensitivity at low speeds than any equipment previously tested. It is therefore recommended that the manufacturer be invited to modify it for a standard voltage and frequency supply, using approved components, and submit it for a complete test.

(b) It is also recommended that the Laboratory be authorized to develop test equipment which will make it possible to conduct accuracy and endurance tests under conditions simulating the pressure conditions encountered in submarine service and use it when conducting future tests on log systems applicable to submarines.

DESCRIPTION OF MATERIAL UNDER TEST

4. The equipment submitted for test consisted of a master speed and total mileage indicator and an auxiliary case containing fuses, control switches, and several control circuit components. A wooden box containing spare parts, special tools, and calibrating weights was also furnished.

5. The master unit, shown by photograph, Plate 8, and the auxiliary control case, shown by photograph, Plate 9, are similar to the equipment covered by instruction book, reference (c). Only minor mechanical changes were noted.

6. A schematic diagram given as Plate 7, will be found useful in connection with a description of the principles of operation given in the following paragraphs.

PRINCIPLES OF THE SYSTEM

7. A chamber mounted below the waterline of the ship is divided in two parts by means of a flexible bellows. That part of the chamber containing the upper part of the bellows is connected with the sea through the static aperture in the hull of the ship. Because of its position below the waterline, a certain water pressure acts downward on the inside of the bellows diaphragm. That part of the chamber containing the lower part of the bellows is connected with the sea through the Pitot aperture at the bottom of the Pitot tube which in turn extends 20" to 24" below the hull of the ship. Because of the relative positions of the chamber, static aperture, and pressure aperture, no motion will take place in the diaphragm when the ship is at rest.

8. Motion of the diaphragm will occur when the ship takes on a forward motion, since the pressure will increase in the lower part of the chamber. The diaphragm will move upward, forcing the contact arm to pivot, and causing the actuator motor to start. Rotation of the actuator motor rotates the large master cam which, in turn, causes the master spring arm to pivot. Pivoting of this arm causes loading of the contact arm through the large master spring. This loading forces the contact arm back to its initial position, automatically shutting off the actuator motor. The log will then remain inactive until a further increase in pressure causes a recurrence of the above-mentioned operation. A decrease in pressure will cause the actuator motor to operate in a reverse direction, thus rotating the cam so as to take a load off of the contact arm and allow the contact arm to return to its initial position.

9. Further loading of the contact arm for corrective purposes is obtained by using an auxiliary spring and arm. This arm is caused to pivot by motion of a slide. 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 the slide is obtained by means of a nut riding on a thread which is rotated by the actuator motor. The speed in knots is indicated on a dial by means of a pointer fastened to the shaft which carries the master cam.

10. This log system is equipped with three adjustments: "A" adjustment, "B" adjustment, and "C" adjustment. 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 either in a constant percentage rate of increase or a constant percentage rate of 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 Pitot tubes of different coefficients.

METHOD OF TEST

11. The equipment submitted was set up at this Laboratory with the assistance of the exhibitor's representative. The log calibration was adjusted for minimum error after several trial runs using the pressure differentials given in a data table furnished with the equipment and given as Plate o. A water manometer was used for simulated speeds up to 9 knots and a mercury manometer was used for the higher rates. As the rated supply, 50 volts, 50 cycles, was not available, a supply of 55 volts, 60 cycles was substituted as recommended by the exhibitor's representative.

12. The master unit was subjected to the following tests in the order given:

- Accuracy
- Endurance
- Accuracy
- Accuracy with master unit inclined 45 degrees
- Shock and vibration
- Accuracy
- Hydrostatic test of 250 pounds per square inch applied simultaneously to both sides of diaphragm
- Accuracy

13. During the endurance test the pressure differential was varied to produce indicated speeds ranging from 0 to 25 knots and return at a rate of one cycle in five minutes. This departure from the test described by the specification was necessary as the follow-up motor did not operate fast enough to permit a one minute cycle. The equipment was lubricated several times during the period of this test.

14. When the test was discontinued after 400 hours by oral request of the Bureau of Engineering, it was noted that the total mileage counter indicated nearly 4400 miles. No accuracy test was made on the total mileage apparatus due to its early failure following the endurance test.

15. As the equipment tested was of a preliminary nature for which a number of changes are contemplated, many of the usual tests were omitted. These included supply voltage and frequency variations, current consumption, insulation resistance, dielectric strength and watertightness.

RESULTS OF TESTS

16. The results of the initial accuracy test are given by Table 1 and curves, Plate 1. This test was made several days after the equipment was calibrated, using the following settings: "A₁" = 2.35, "A₂" = 2.35,

"B" = +0.3, "C" = 1.25. It now appears that the negative errors given for speeds below 2 knots could have been somewhat reduced by a change in the "C" (zero) setting. However, some large errors would remain due to the lack of sensitivity in this region,

17. The following are examples of the results obtained at low simulated speeds using the calibration settings given.

(a) With the pointer at 0, the pressure differential was slowly increased to the equivalent of 1 knot. The pointer did not move until the mounting board, Plate 9, was struck sharply. The pointer moved in short jerks upon each impact and finally reached a value of 0.75 knot.

(b) Again starting with the pointer at 0, the pressure differential was slowly increased to the equivalent of 1.2 knots before the pointer moved. It stopped at 0.25 knot.

18. Using the procedure given in the preceding paragraph, the following results were obtained:

<u>Simulated Speed</u>	<u>Indicated Speed</u>	<u>Indicated Speed when Vibrated</u>
1.0	0.0	0.75
1.5	1.2	1.4
2.0	1.8	2.0
2.5	2.4	2.5
3.0	2.9	3.0
3.5	3.4	3.5
4.0	3.9	4.0
5.0	4.95	5.0
6.0	5.95	6.0

Note: The sensitivity was satisfactory at higher values and vibration did not produce a readable change in indications.

19. With the original calibration setting, the accuracy test was repeated after the endurance test. Table 1 gives the results of this test. As the need for a change of "C" adjustment was then apparent, it was changed to 1.44 and the accuracy test was repeated. The necessity for this change is mentioned in the instruction book, reference (c), page 58, but its cause is not explained. The results are given in Table 1 and curves, Plate 2.

20. The results obtained during the accuracy tests with the master unit inclined 45 degrees are given as Table 2. Curves, Plate 3,

give the results when the master unit was inclined 45 degrees to the right. The other results were not plotted as they were substantially the same for any direction of inclination. It will be noted that the resulting errors are all positive and range from approximately 120 per cent at 1 knot to approximately 1 per cent at 18 knots.

21. The operation of the master unit during the shock and vibration test was satisfactory. However, the results of an accuracy test following the shock and vibration test given by Table 3, showed that adjustment of the "C" setting was again necessary. The results of a retest with this setting changed to 1.75 are given by Table 3 and curves, Plate 4.

22. When a hydrostatic pressure of 250 pounds per square inch was slowly being built up on both sides of the bellows diaphragm, the pointer advanced from 0 to 3 knots. Small leaks were observed at the "S" and "P" valve stems and at a small hole in the rear of the drain valve.

23. The results of the accuracy test following this are given in Table 4. The results of a retest after a necessary change of the "C" setting to 2.1 are given by Table 1 and curves, Plate 5.

CONCLUSIONS

24. Except when the master unit was inclined as required by paragraph E-12h, the accuracy of the indicated speed was at all times within the limits given by the specification; that is, within 6 per cent at 4 knots, 4 per cent at 6 knots, 3 per cent at 9 knots, 2 per cent at 16 knots, and 1 per cent at 20 knots and over. However, it appears that, had no changes been made in the "C" (zero) setting, the errors would have accumulated and exceeded the tolerance at the lower speeds. No tolerance is specified for speeds below 4 knots, where the greatest errors occur. The sensitivity of the mechanism places the lower limit of reliable operation at about 1.5 knots.

25. Inclining the master unit 45 degrees in any direction produced large positive errors, exceeding the tolerance at low speeds, which indicates that gimbaling would be necessary to bring results within specification tolerances for speeds below 10 knots.

26. The progressive change in the "C" (zero) setting necessary to maintain accuracy throughout the test is not considered serious, due to the ease with which this error may be detected and corrected.

27. The performance of the speed indicator, while the hydrostatic pressure was being built up to 250 pounds per square inch as required by paragraph F-2m, casts some doubt on the accuracy of the system as applied to submarines operating below the surface. All accuracy tests were made with a static head of 8 feet of water or less.

28. The cause of the failure of the total mileage mechanism was not ascertained. Before failure it recorded a total of 4423 miles.

TABLE 1

ACCURACY TEST OF LOG SPEED INDICATOR

Simulated Velocity in Knots	Before Endurance				After Endurance				After Endurance			
	"C" Setting 1.25				"C" Setting 1.25				"C" Setting 1.44			
	Accelerating Indicated Knots	Decelerating Indicated Knots	% Error		Accelerating Indicated Knots	Decelerating Indicated Knots	% Error		Accelerating Indicated Knots	Decelerating Indicated Knots	% Error	
0	-0.3	-0.3	-	-0.4	-0.3	-	-	-0.2	-0.1	-	-	-
1.0	0.75	0.8	-20.0	-0.2	-0.1	-120.0	-110.0	0.5	1.0	50.0	0	0
1.5	1.2	1.45	-20.0	1.0	1.3	-33.3	-13.3	1.5	1.6	0	0	+6.6
2.0	1.8	1.95	-10.0	1.9	1.9	-5.0	-5.0	2.0	2.1	0	0	+5.0
2.5	2.4	2.5	-4.0	2.4	2.5	-4.0	0	2.5	2.6	0	0	+4.0
3.0	2.9	3.0	-3.3	2.95	3.0	-1.7	0	3.0	3.1	0	0	+3.3
3.5	3.4	3.5	-3.0	3.45	3.5	-1.4	0	3.5	3.6	0	0	+3.0
4.0	3.9	4.0	-2.5	4.0	4.0	0	0	4.0	4.1	0	0	+2.5
4.5	4.45	4.5	-1.1	4.5	4.5	0	0	4.5	4.6	0	0	+2.2
5.0	5.0	5.0	0	5.0	5.0	0	0	5.1	5.1	0	0	+2.0
6.0	5.95	6.0	-0.83	6.0	6.0	0	0	6.1	6.15	+2.0	+1.66	+2.5
7.0	7.0	7.1	0	7.0	7.0	0	0	7.1	7.15	+1.43	+1.43	+2.1
8.0	8.0	8.05	0	8.0	8.1	0	+1.2	8.15	8.2	+1.87	+1.87	+2.5
9.0	9.05	9.2	+0.55	9.2	9.2	+2.2	+2.2	9.2	9.2	+2.2	+2.2	+2.2
10.0	10.05	10.0	+0.50	10.1	10.1	+1.0	+1.0	10.1	10.1	+1.0	+1.0	+1.0
11.0	11.0	10.95	0	11.1	11.1	+0.9	+0.9	11.0	11.0	0	0	0
12.0	12.0	12.0	0	12.1	12.1	+0.8	+0.8	12.15	12.15	+1.25	+1.25	+1.25
13.0	13.0	13.0	0	13.1	13.0	+0.7	0	13.15	13.1	+1.15	+1.15	+1.15
14.0	14.0	14.0	0	14.0	14.0	0	0	14.1	14.0	+0.71	+0.71	0
15.0	15.0	15.0	0	15.0	15.1	0	+0.7	15.1	15.1	+0.66	+0.66	+0.66
16.0	16.1	16.1	+0.63	16.1	16.1	+0.7	+0.7	16.15	16.15	+0.94	+0.94	+0.94
17.0	17.0	17.0	0	17.1	17.15	+0.6	+0.9	17.15	17.15	+0.88	+0.88	+0.88
18.0	18.1	18.1	+0.55	18.15	18.15	+0.8	+0.8	18.15	18.20	+0.83	+0.83	+1.11
19.0	19.0	19.0	0	19.0	19.1	0	+0.5	19.0	19.1	0	0	+0.55
20.0	20.0	20.0	0	20.1	20.0	+0.5	0	20.0	20.0	0	0	0
21.0	21.0	21.0	0	21.0	21.0	0	0	21.0	21.0	0	0	0
22.0	22.0	22.05	0	22.0	22.1	0	+0.5	22.0	22.1	0	0	+0.45

(Continued)

TABLE 1 (Continued)

Simulated Velocity in Knots	Before Endurance			After Endurance			After Endurance				
	"C" Setting 1.25			"C" Setting 1.25			"C" Setting 1.44				
	Accelerating Indicated Knots	% Error	Decelerating Indicated Knots	Accelerating Indicated Knots	% Error	Decelerating Indicated Knots	Accelerating Indicated Knots	% Error	Decelerating Indicated Knots		
23.0	0	0	23.0	0	0	23.1	+0.4	23.1	+0.4	23.0	0
24.0	0	0	24.0	0	0	24.0	0	24.1	+0.4	24.0	0
25.0	0	0	25.0	0	0	25.0	0	25.1	+0.4	25.0	0

TABLE 2

ACCURACY TEST OF LOG SPEED INDICATOR AFTER ENDURANCE
WITH CASE OF MASTER UNIT INCLINED

Simu- lated Veloc- ity in Knots	45° Right				45° Left			
	"C" Setting 1.44				"C" Setting 1.44			
	Accelerating		Decelerating		Accelerating		Decelerating	
	Indicated	%	Indicated	%	Indicated	%	Indicated	%
	Knots	Error	Knots	Error	Knots	Error	Knots	Error
0	1.87	-	1.80	-	2.10	-	2.10	-
1.0	2.00	+100.0	2.15	+115.0	2.30	+130.0	2.40	+140.0
1.5	2.30	+ 53.3	2.40	+ 60.0	2.60	+ 73.3	2.65	+ 76.6
2.0	2.70	+ 35.0	2.70	+ 35.0	2.80	+ 40.0	3.00	+ 50.0
2.5	3.10	+ 24.0	3.20	+ 28.0	3.20	+ 28.0	3.30	+ 32.0
3.0	3.50	+ 16.6	3.50	+ 16.6	3.65	+ 21.7	3.70	+ 23.3
3.5	4.00	+ 14.3	4.00	+ 14.3	4.10	+ 17.1	4.10	+ 17.1
4.0	4.40	+ 10.0	4.50	+ 12.5	4.60	+ 15.0	4.60	+ 15.0
4.5	4.80	+ 6.6	4.90	+ 8.8	5.00	+ 11.1	5.00	+ 11.1
5.0	5.30	+ 6.0	5.40	+ 8.0	5.50	+ 10.0	5.50	+ 10.0
6.0	6.30	+ 5.0	6.35	+ 5.9	6.40	+ 6.6	6.50	+ 8.3
7.0	7.25	+ 3.6	7.30	+ 4.3	7.40	+ 5.7	7.50	+ 7.2
8.0	8.25	+ 3.2	8.30	+ 3.7	8.40	+ 5.0	8.50	+ 6.3
9.0	9.30	+ 3.3	9.35	+ 3.9	9.40	+ 4.4	9.50	+ 5.5
10.0	10.20	+ 2.0	10.20	+ 2.0	10.20	+ 2.0	10.25	+ 2.5
11.0	11.20	+ 1.8	11.15	+ 1.4	11.20	+ 1.8	11.25	+ 2.3
12.0	12.20	+ 1.7	12.15	+ 1.2	12.25	+ 2.1	12.25	+ 2.1
13.0	13.20	+ 1.6	13.20	+ 1.6	13.25	+ 1.9	13.25	+ 1.9
14.0	14.15	+ 1.7	14.20	+ 1.5	14.20	+ 1.5	14.25	+ 1.6
15.0	15.20	+ 1.3	15.20	+ 1.3	15.25	+ 1.7	15.25	+ 1.7
16.0	16.20	+ 1.2	16.20	+ 1.2	16.20	+ 1.2	16.30	+ 1.9
17.0	17.15	+ 0.9	17.15	+ 0.9	17.20	+ 1.2	17.30	+ 1.8
18.0	18.15	+ 0.8	18.20	+ 1.1	18.25	+ 1.4	18.30	+ 1.6
19.0	19.10	+ 0.5	19.20	+ 1.0	19.10	+ 0.5	19.20	+ 1.0
20.0	20.00	0	20.10	+ 0.5	20.15	+ 0.7	20.15	+ 0.7
21.0	21.00	0	21.10	+ 0.5	21.20	+ 1.0	21.20	+ 1.0
22.0	22.00	0	22.15	+ 0.7	22.15	+ 0.7	22.20	+ 1.0
23.0	23.00	0	23.10	+ 0.4	23.15	+ 0.6	23.20	+ 0.8
24.0	24.00	0	24.10	+ 0.4	24.15	+ 0.6	24.15	+ 0.6
25.0	25.00	0	25.10	+ 0.4	25.10	+ 0.4	25.10	+ 0.4

(Continued)

TABLE 2 (Continued)

ACCURACY TEST OF LOG SPEED INDICATOR AFTER ENDURANCE
WITH CASE OF MASTER UNIT INCLINED

Simu- lated Veloc- ity in Knots	45° Forward				45° Backward			
	"C" Setting 1.44				"C" Setting 1.44			
	Accelerating		Decelerating		Accelerating		Decelerating	
	Indicated Knots	% Error	Indicated Knots	% Error	Indicated Knots	% Error	Indicated Knots	% Error
0	2.00	-	2.10	-	1.90	-	2.00	-
1.0	2.20	+120.0	2.25	+125.0	2.20	+120.0	2.30	+130.0
1.5	2.50	+ 66.6	2.60	+ 73.3	2.50	+ 66.6	2.50	+ 66.6
2.0	2.80	+ 40.0	2.90	+ 45.0	2.80	+ 40.0	2.80	+ 40.0
2.5	3.20	+ 28.0	3.25	+ 30.0	3.15	+ 26.0	3.20	+ 28.0
3.0	3.65	+ 21.7	3.70	+ 23.3	3.60	+ 20.0	3.65	+ 21.7
3.5	4.10	+ 17.1	4.10	+ 17.1	4.00	+ 14.3	4.00	+ 14.3
4.0	4.50	+ 12.5	4.50	+ 12.5	4.50	+ 12.5	4.50	+ 12.5
4.5	5.00	+ 11.1	5.00	+ 11.1	5.00	+ 11.1	5.00	+ 11.1
5.0	5.50	+ 10.0	5.50	+ 10.0	5.40	+ 8.0	5.50	+ 10.0
6.0	6.40	+ 6.6	6.40	+ 6.6	6.40	+ 6.6	6.50	+ 8.3
7.0	7.35	+ 5.0	7.40	+ 5.7	7.40	+ 5.7	7.40	+ 5.7
8.0	8.30	+ 3.7	8.40	+ 5.0	8.40	+ 5.0	8.40	+ 5.0
9.0	9.40	+ 4.4	9.40	+ 4.4	9.40	+ 4.4	9.40	+ 4.4
10.0	10.25	+ 2.5	10.25	+ 2.5	10.25	+ 2.5	10.30	+ 3.0
11.0	11.20	+ 1.8	11.20	+ 1.8	11.20	+ 1.8	11.25	+ 2.3
12.0	12.25	+ 2.1	12.20	+ 1.7	12.30	+ 2.5	12.25	+ 2.1
13.0	13.25	+ 1.9	13.20	+ 1.6	13.25	+ 1.9	13.25	+ 1.9
14.0	14.20	+ 1.5	14.20	+ 1.5	14.20	+ 1.5	14.25	+ 1.6
15.0	15.20	+ 1.3	15.20	+ 1.3	15.20	+ 1.3	15.20	+ 1.3
16.0	16.25	+ 1.7	16.25	+ 1.7	16.20	+ 1.2	16.25	+ 1.7
17.0	17.20	+ 1.2	17.25	+ 1.5	17.20	+ 1.2	17.25	+ 1.5
18.0	18.25	+ 1.4	18.25	+ 1.4	18.25	+ 1.4	18.25	+ 1.4
19.0	19.15	+ 0.8	19.15	+ 0.8	19.10	+ 0.5	19.15	+ 0.8
20.0	20.10	+ 0.5	20.10	+ 0.5	20.00	0	20.15	+ 0.7
21.0	21.10	+ 0.5	21.15	+ 0.7	21.10	+ 0.5	21.15	+ 0.7
22.0	22.10	+ 0.5	22.10	+ 0.5	22.10	+ 0.5	22.10	+ 0.5
23.0	23.10	+ 0.4	23.10	+ 0.4	23.10	+ 0.4	23.10	+ 0.4
24.0	24.10	+ 0.4	24.10	+ 0.4	24.00	0	24.10	+ 0.4
25.0	25.10	+ 0.4	25.00	0	25.00	0	25.10	+ 0.4

TABLE 3

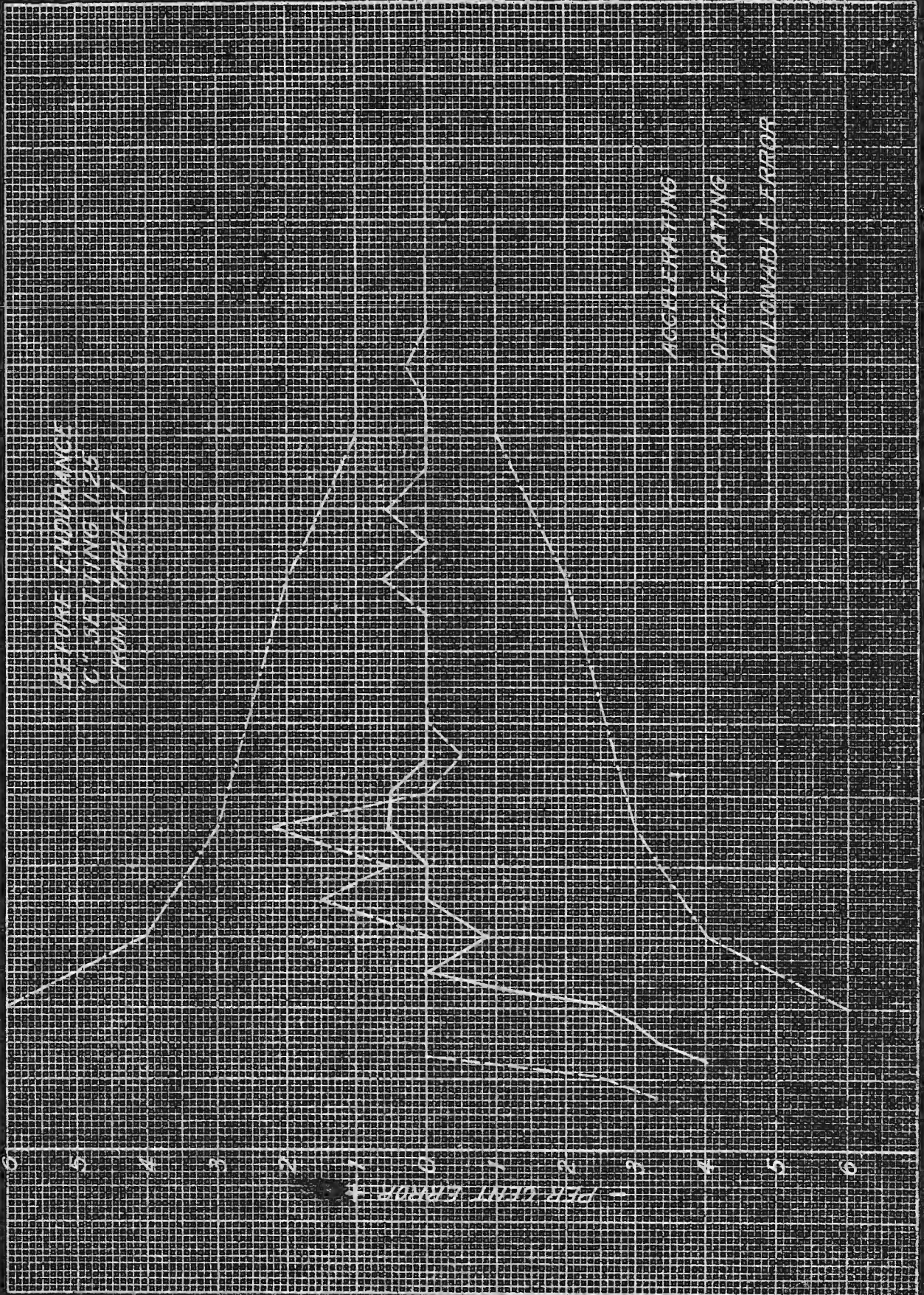
ACCURACY TEST OF LOG SPEED INDICATOR
AFTER SHOCK AND VIBRATION

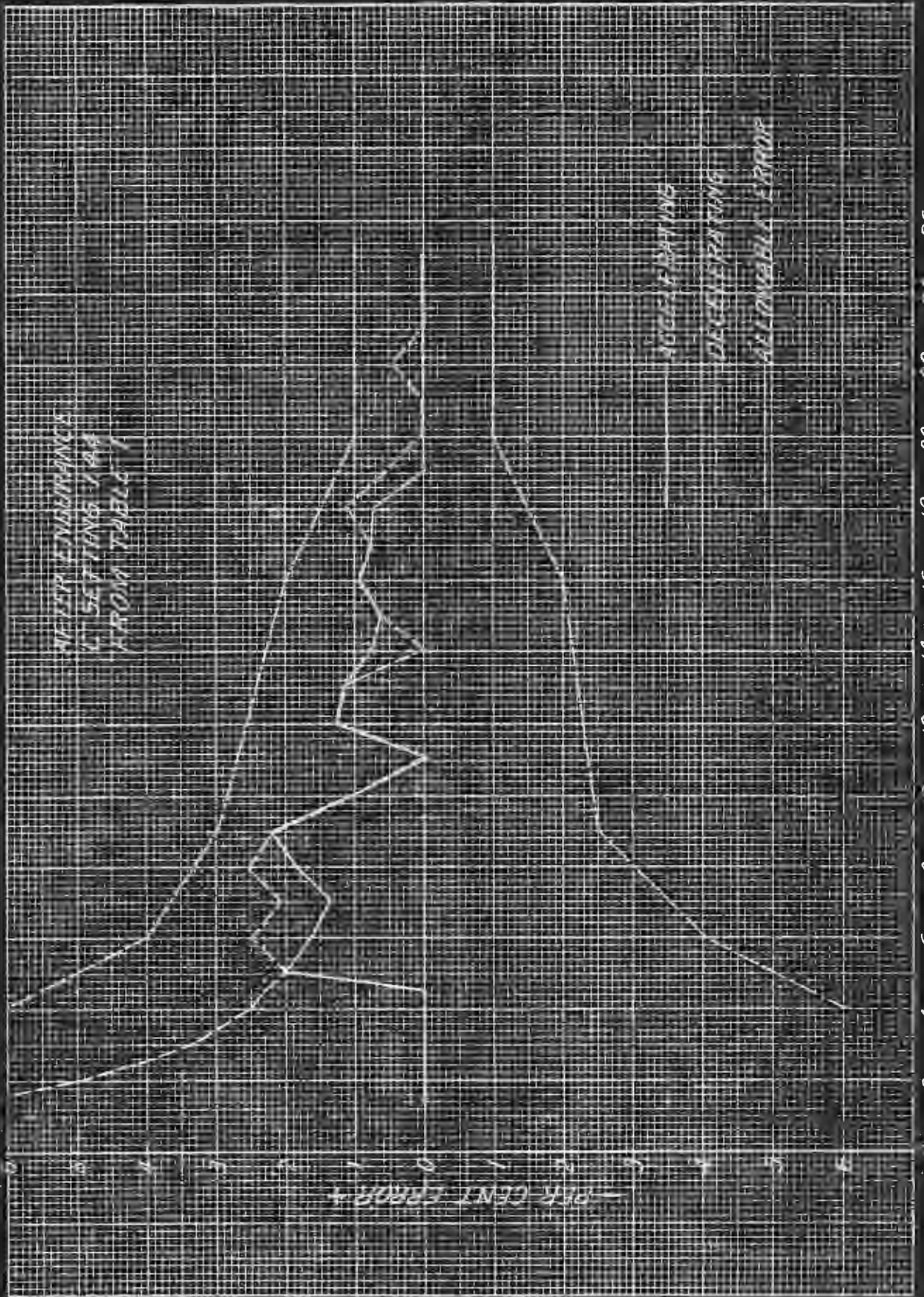
Simu- lated Veloc- ity in Knots	<u>"C" Setting 1.44</u>				<u>"C" Setting 1.75</u>			
	<u>Accelerating</u>		<u>Decelerating</u>		<u>Accelerating</u>		<u>Decelerating</u>	
	<u>Indicated</u> <u>Knots</u>	<u>%</u> <u>Error</u>	<u>Indicated</u> <u>Knots</u>	<u>%</u> <u>Error</u>	<u>Indicated</u> <u>Knots</u>	<u>%</u> <u>Error</u>	<u>Indicated</u> <u>Knots</u>	<u>%</u> <u>Error</u>
0	-0.7	-	-0.7	-	0	-	-0.1	-
1.0	-0.5	-150.0	-0.4	-140.0	0.4	-60.0	1.0	0
1.5	0	-100.0	0.7	-60.0	1.6	+6.6	1.6	+6.6
2.0	1.6	-20.0	1.5	+25.0	2.0	0	2.0	0
2.5	2.2	-12.0	2.25	-10.0	2.65	+6.0	2.6	+4.0
3.0	2.85	-5.0	2.8	-6.6	3.0	0	3.0	0
3.5	3.35	-4.3	3.4	-3.3	3.5	0	3.6	+3.0
4.0	3.9	-2.5	3.9	-2.5	4.1	+2.5	4.1	+2.5
4.5	4.5	0	4.5	0	4.65	+3.2	4.6	+2.2
5.0	5.0	0	5.0	0	5.1	+2.0	5.15	+3.0
6.0	6.0	0	6.0	0	6.1	+1.6	6.10	+1.6
7.0	7.0	0	7.0	0	7.1	+1.4	7.15	+2.1
8.0	8.0	0	8.1	+1.2	8.15	+1.9	8.15	+1.9
9.0	9.1	+1.1	9.15	+1.4	9.2	+2.2	9.25	+2.8
10.0	10.0	0	10.0	0	10.1	+1.0	10.1	+1.0
11.0	11.0	0	11.0	0	11.15	+1.4	11.0	0
12.0	12.15	+1.3	12.0	0	12.15	+1.3	12.15	+1.3
13.0	13.0	0	13.0	0	13.15	+1.2	13.15	+1.2
14.0	14.1	+0.7	14.0	0	14.15	+1.1	14.1	+0.7
15.0	15.1	+0.7	15.0	0	15.15	+1.0	15.15	+1.0
16.0	16.15	+0.9	16.1	+0.7	16.15	+0.9	16.2	+1.2
17.0	17.1	+0.6	17.1	+0.6	17.15	+0.9	17.15	+0.9
18.0	18.1	+0.6	18.15	+0.8	18.15	+0.8	18.2	+1.1
19.0	19.0	0	19.0	0	19.0	0	19.1	+0.5
20.0	20.0	0	20.0	0	20.0	0	20.1	+0.5
21.0	21.0	0	21.0	0	21.0	0	21.0	0
22.0	22.0	0	22.0	0	22.0	0	22.1	+0.5
23.0	23.0	0	23.0	0	23.0	0	23.1	+0.4
24.0	24.0	0	24.0	0	24.0	0	24.1	+0.4
25.0	25.0	0	25.0	0	25.0	0	25.1	+0.4

TABLE 4

ACCURACY TEST OF LOG SPEED INDICATOR
AFTER HYDROSTATIC TEST

Simu- lated Veloc- ity in Knots	<u>"C" Setting 1.75</u>				<u>"C" Setting 2.1</u>			
	<u>Accelerating</u>		<u>Decelerating</u>		<u>Accelerating</u>		<u>Decelerating</u>	
	<u>Indicated</u>	<u>%</u>	<u>Indicated</u>	<u>%</u>	<u>Indicated</u>	<u>%</u>	<u>Indicated</u>	<u>%</u>
	<u>Knots</u>	<u>Error</u>	<u>Knots</u>	<u>Error</u>	<u>Knots</u>	<u>Error</u>	<u>Knots</u>	<u>Error</u>
0	-0.7	-	-0.6	-	-0.25	-	-0.2	-
1.0	-0.5	-150.0	-0.5	-150.0	-0.2	-120.0	1.0	0
1.5	-0.1	-107.0	0.1	-93.3	1.5	0	1.5	0
2.0	1.4	-30.0	1.5	-25.0	2.0	0	2.1	+5.0
2.5	2.1	-16.0	2.2	-12.0	2.5	0	2.6	+4.0
3.0	2.75	-8.3	2.85	-5.0	3.0	0	3.1	+3.3
3.5	3.25	-7.4	3.3	-5.7	3.6	+3.0	3.6	+3.0
4.0	3.8	-5.0	3.8	-5.0	4.1	+2.5	4.0	0
4.5	4.3	-4.4	4.4	-2.2	4.6	+2.2	4.6	+2.2
5.0	5.0	0	5.0	0	5.15	+3.0	5.1	+2.0
6.0	6.0	0	6.0	0	6.1	+1.6	6.1	+1.6
7.0	7.0	0	7.0	0	7.15	+2.1	7.15	+2.1
8.0	8.0	0	8.0	0	8.15	+1.9	8.2	+2.5
9.0	9.1	+1.1	9.1	+1.1	9.2	+2.2	9.2	+2.2
10.0	10.0	0	10.0	0	10.1	+1.0	10.0	0
11.0	11.0	0	11.0	0	11.1	+0.9	11.0	0
12.0	12.1	+0.8	12.0	0	12.2	+1.7	12.15	+1.3
13.0	13.0	0	13.0	0	13.15	+1.2	13.1	+0.8
14.0	14.0	0	14.0	0	14.15	+1.1	14.1	+0.7
15.0	15.0	0	15.1	+0.7	15.15	+1.0	15.15	+1.0
16.0	16.15	+0.9	16.1	+0.7	16.2	+1.2	16.2	+1.2
17.0	17.1	+0.6	17.1	+0.6	17.15	+0.9	17.15	+0.9
18.0	18.1	+0.5	18.15	+0.8	18.15	+0.8	18.2	+0.8
19.0	19.0	0	19.0	0	19.1	+0.5	19.1	+0.5
20.0	20.0	0	20.0	0	20.0	0	20.0	0
21.0	21.0	0	21.0	0	21.0	0	21.1	+0.5
22.0	22.0	0	22.0	0	22.1	+0.5	22.15	+0.7
23.0	23.0	0	23.0	0	23.0	0	23.1	+0.4
24.0	24.0	0	24.0	0	24.0	0	24.1	+0.4
25.0	25.0	0	25.0	0	25.0	0	25.0	0





0 2 4 6 8 10 12 14 16 18 20 22 24 26

SIMULATED VELOCITY IN KNOTS

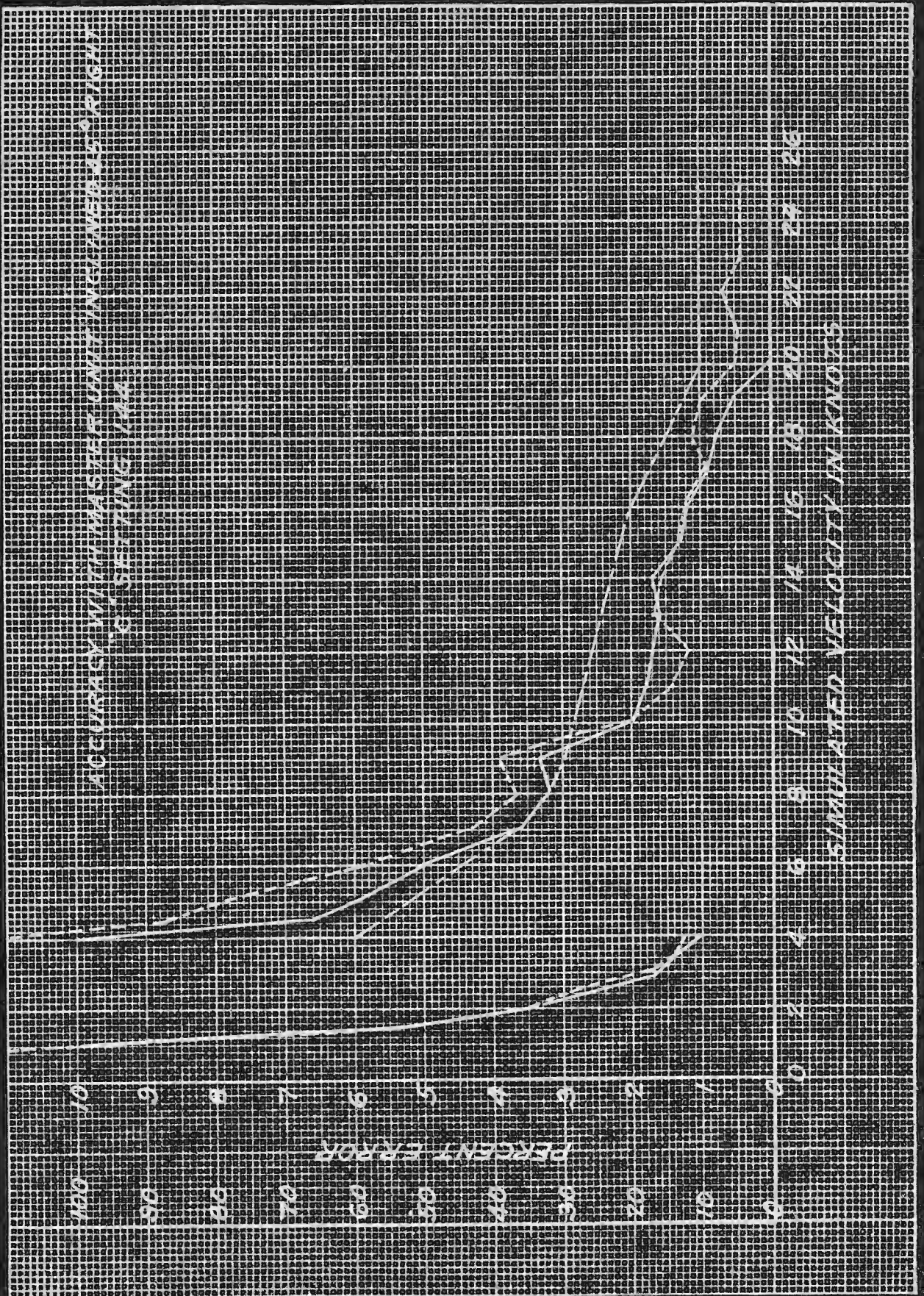
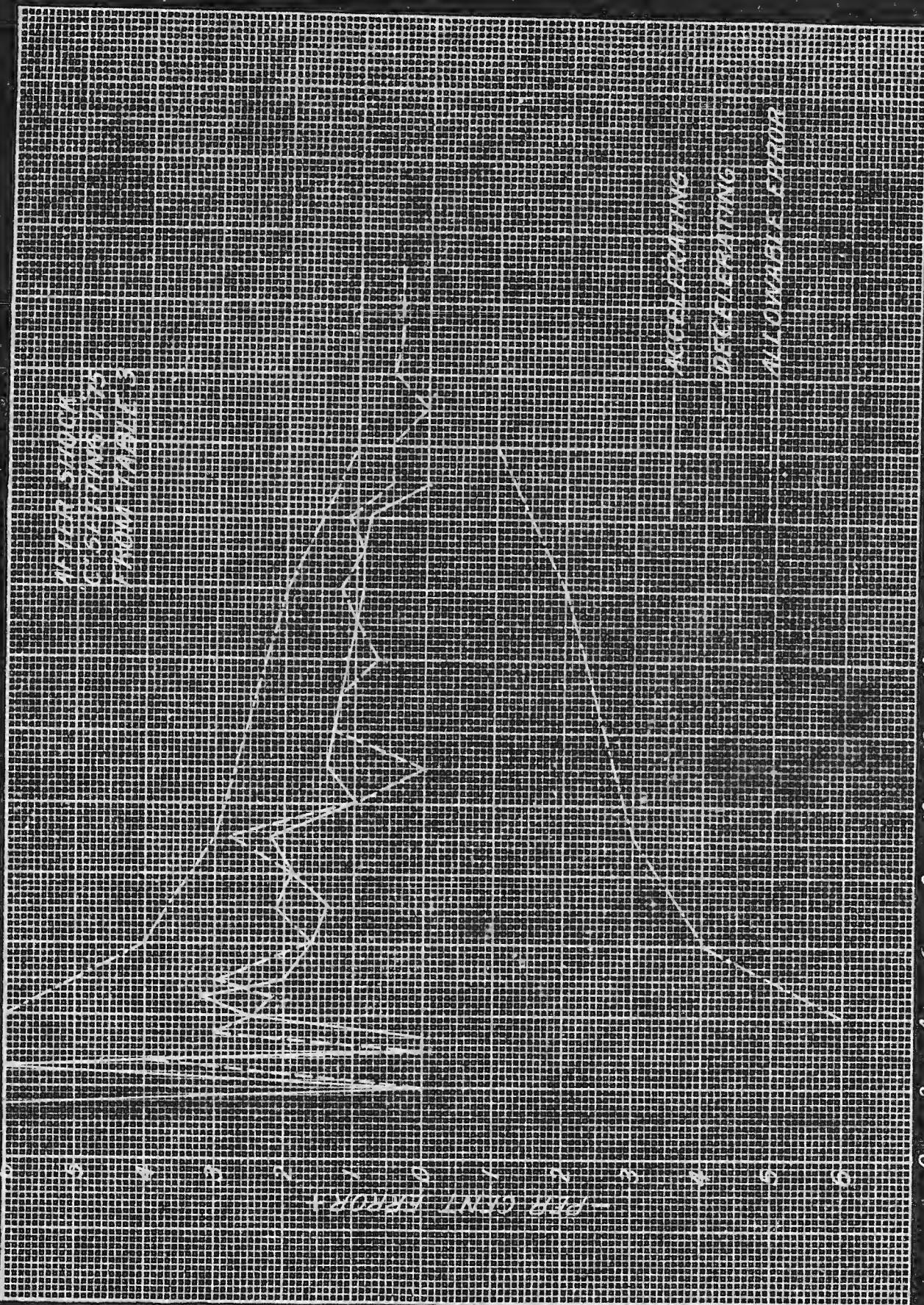


PLATE 3



WIND VELOCITY
WIND DIRECTION
WIND VELOCITY

0 2 4 6 8 10 12 14 16 18 20 22 24 26

SIMULATED VELOCITY IN KNOTS

KNOPSKALOR (H₂O:Hg = 12.90) h = 1.3475 v²

K =	1.00		0.98	
	H ₂ O cm.	Hg mm.	H ₂ O cm.	Hg mm.
1	1.35	1.04	1.32	1.02
1.5	3.03	2.35	2.97	2.30
2	5.39	4.18	5.28	4.09
	8.42	6.53	8.25	6.40
3	12.13	9.40	11.88	9.21
	16.51	12.80	16.17	12.54
4	21.56	16.71	21.13	16.38
	27.29	21.15	26.74	20.73
5	33.69	26.11	33.01	25.59
	40.76	31.60	39.95	30.97
6	48.51	37.60	47.54	36.85
	56.93	44.13	55.79	43.25
7	66.03	51.18	64.71	50.16
	75.80	58.76	74.28	57.58
8	86.24	66.85	84.52	65.52
	97.36	75.47	95.41	73.96
9	109.15	84.61	106.96	82.92
	121.61	94.27	119.18	92.39
10	134.75	104.46	132.06	102.37
	148.56	115.16	145.59	112.86
11	163.05	126.39	159.79	123.87
	178.21	138.14	174.64	135.38
12	194.04	150.42	190.16	147.41
	210.55	163.21	206.34	159.95
13	227.73	176.53	223.17	173.00
	245.58	190.37	240.67	186.57
14	264.11	204.74	258.83	200.64
	283.31	219.62	277.65	215.23
15	303.19	235.03	297.12	230.33
	323.74	250.96	317.26	245.94
16	344.96	267.41	338.06	262.06
	366.86	284.39	359.52	278.70
17	389.43	301.88	381.64	295.84
	412.67	319.90	404.42	313.50
18	436.59	338.44	427.86	331.67
	461.18	357.51	451.96	350.36
19	486.45	377.09	476.72	369.54
	512.39	397.20	502.14	389.26
20	539.00	417.83	528.22	409.47
	566.29	438.98	554.96	430.20
21	594.25	460.66	582.36	451.44
	622.88	482.85	610.42	473.20
22	652.19	505.57	639.15	495.46
	682.17	528.82	668.53	518.24
23	712.83	552.58	698.57	541.53
	744.16	576.87	729.27	565.33
24	776.16	601.68	760.64	589.64
	808.84	627.01	792.66	614.47
25	842.19	652.86	825.34	639.80
	876.21	679.23	858.69	665.65

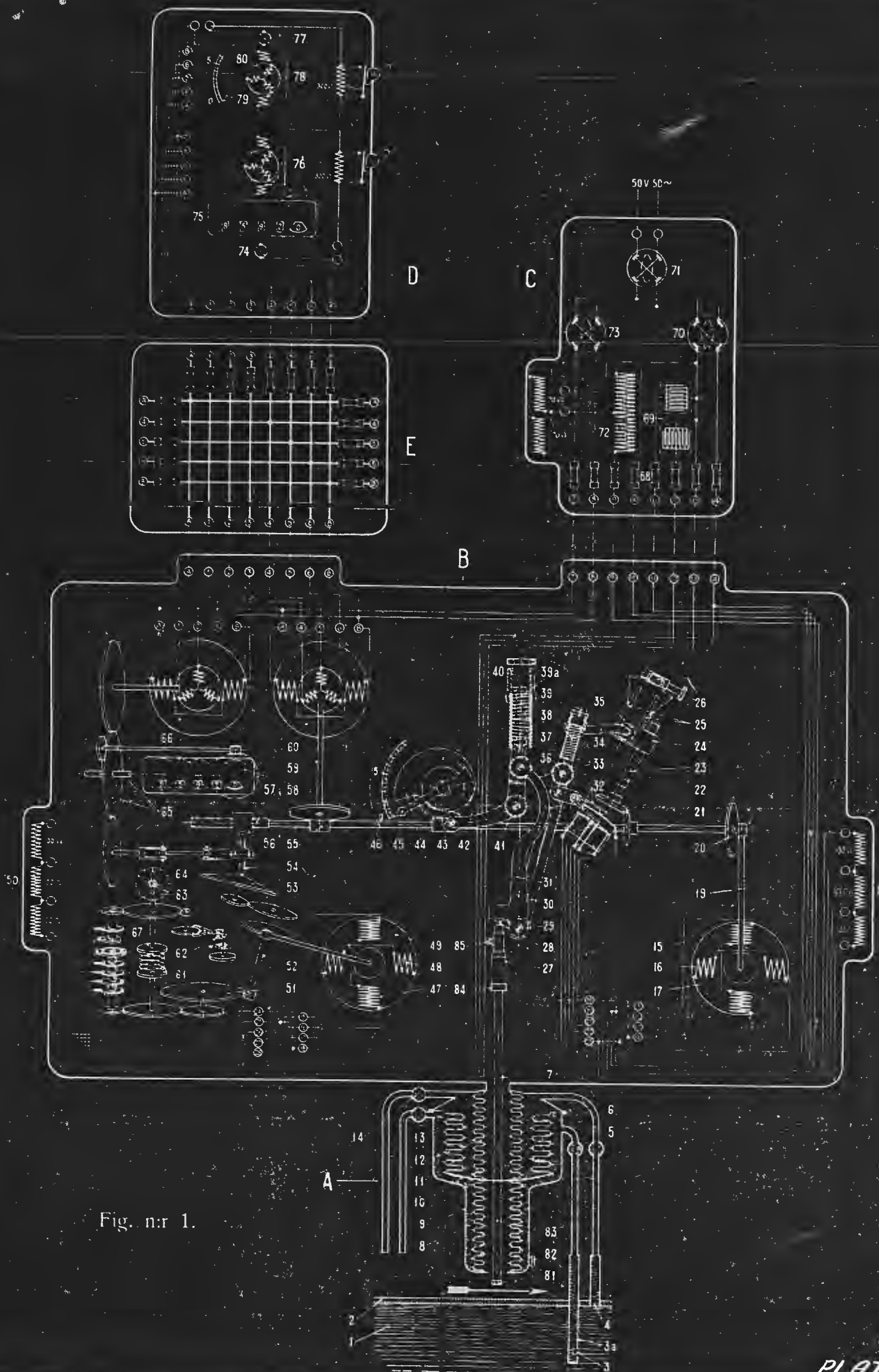


Fig. n.r. 1.

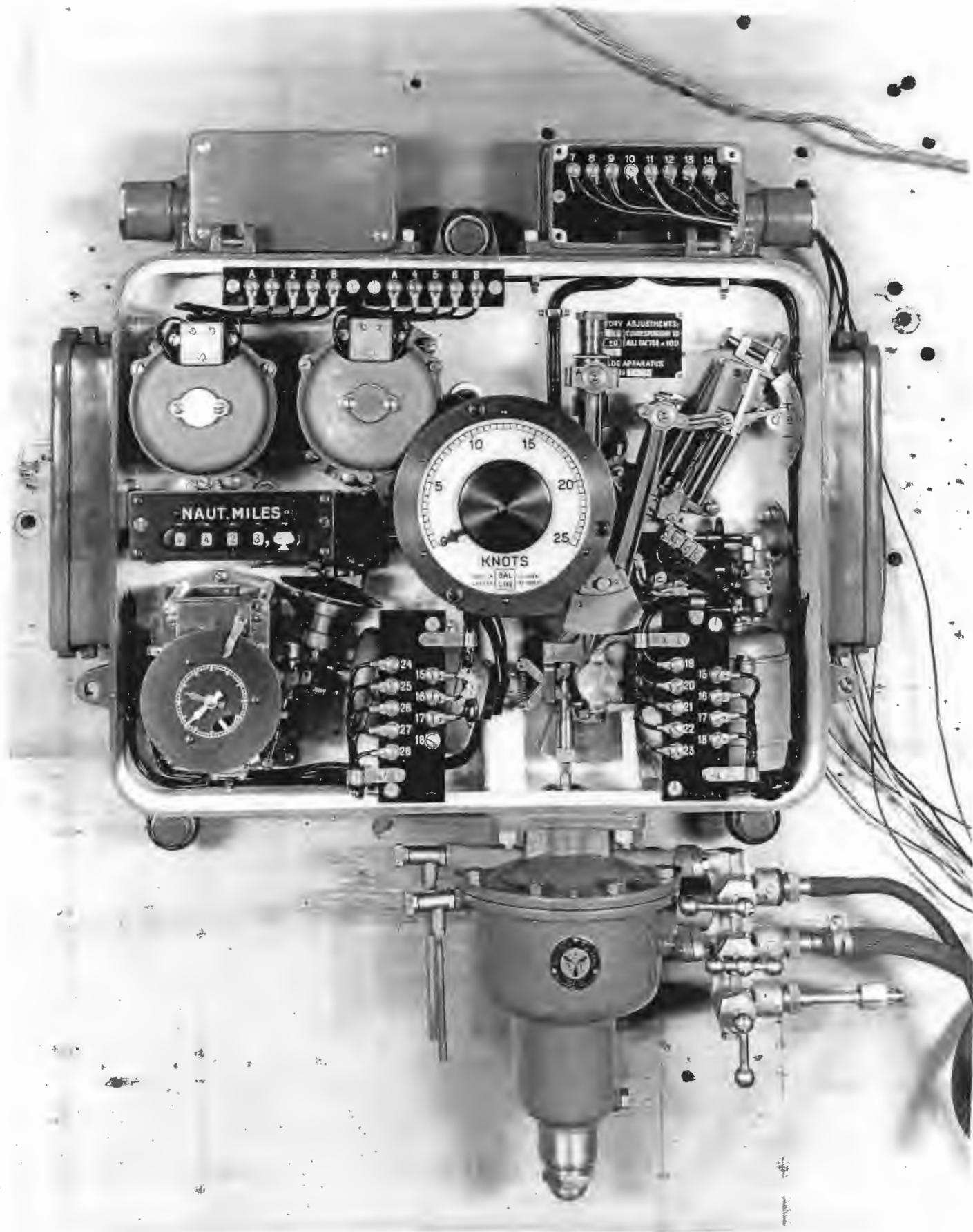


Plate 8



Plate 9