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NAVY DEPARTMENT

Report of Test on Wind Intensity and Direction Indicating Equipment Manufactured and Submitted by Henschel Corporation, Amesbury, Massachusetts

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

FR-1583

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Authorization: BuEng. ltr. S65-5/L5 (10-17-Ds) of 26 October 1939.

Date of Test: November and December 1939.

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APPENDICES

AUTHORIZATION

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

Reference: (a) BuEng. ltr. S65-5/L5 (10-17-Ds) of 26 October 1939.
(b) Specification SGS(65)-130a of 1 April 1937.
(c) Manufacturer's drawing of transmitter, No. 10-888.
(d) Manufacturer's drawing of master transmitter, No. 10-946.
(e) Manufacturer's drawings of combined wind intensity and wind direction indicator, Nos. 10-938 and 10-947.

OBJECT OF TEST

2. The object of this test was to determine how closely the subject system complied with the specification, reference (b), and its suitability for Naval use.

ABSTRACT OF TEST

3. Upon completion of tests for wind intensity, versus indicated intensity, conducted by the Bureau of Standards, Washington, D. C., the system, shown by Plates 2 to 6, inclusive, was set up at this Laboratory and checked for conformance with the specification, reference (b). The order in which the tests were made is outlined therein under paragraph F-2.

Conclusions

(a) The operation and accuracy of the wind intensity part of this system was satisfactory over the range of 5 to 80 knots during the wind tunnel and other tests. As shown by Table 1, the pointer indicated 2.5 knots when there was zero wind. This was due to the master mechanism "driving back" through the self-synchronous motors and rotating the cups, following a period during which the wind had been rotating the cups. With the cups stalled, the starting speed was 2.9 knots. Therefore, the graduations from zero to 3 knots are of no value.

(b) The operation of the wind direction master unit became unsatisfactory after approximately 250 hours of the endurance test due to pitting and poor contact between the contact roller and the contact segments. This weakness was brought out by modifying the test procedure after 125 hours so that the vane was rotated at 5 r.p.m. instead of 1/2 r.p.m. as given by the specification. This higher rate caused much more frequent operation of the contact mechanism. Since the 1/2 r.p.m. rate previously used nearly corresponded to the damping rate provided by the follow-up motor, the vane and the follow-up mechanism were almost in synchronism and but few contact operations were required.

(c) At one time during the wind tunnel test, the direction indicator pointer did not return to zero after the vane had been deflected 5° in a 5-knot wind and released.

(d) It was found that when the follow-up contact arm was deliberately placed in a position bridging the diagonal gap in the contact segments, the follow-up mechanism stopped. This caused an error of 180 degrees in the direction indicators. When the roller was oscillated across the gap, the indicators oscillated approximately 180 degrees in error.

(e) The following features are at variance with the specification:

(1) The system has a master transmitter instead of a master transmitter-indicator.

(2) The wind direction and intensity indicators have a common dial and concentric pointers instead of being separate instruments.

(3) No dial illumination is provided and, due to the use of a common dial, the distance between the 10-knot graduations is less than the 1"5 required.

(4) The pintle mounting socket of the transmitter is bored to a 2"375 diameter for a depth of 3"0 to fit on a 2" (IPS) pipe instead of 2"0 diameter as given in paragraph E-3a(8).

(5) The transmitter weight is seven pounds more than that allowed.

(f) The following mechanical features were noted as being unsatisfactory:

(1) There is considerable play in the bearings of the concentric hubs of the indicator. This is due to the use of only one single race ball bearing for each of the concentric shafts. The use of double race ball bearings is suggested.

(2) The sleeve, pc. 24, used in the concentric assembly of the indicator was found fractured. This failure was caused by the thinness of the wall between the bore and the root of the threads.

(3) The skirted guards on the transmitter spindles are not of the best design to prevent locking due to ice formation.

(4) The master case had a sand hole in the rear of the main casting which permitted water to enter the case.

Recommendations

(a) It is recommended that the subject wind system be not approved for Naval use until it has been modified to correct the deficiencies noted herein and satisfactorily completes a test for type approval.

DESCRIPTION OF MATERIAL UNDER TEST

4. The subject system was manufactured by Henschel Corporation, Amesbury, Massachusetts, its purpose being to measure wind intensity and indicate wind direction.

5. The wind direction is indicated in degrees relative to the bow of the ship and the intensity in knots ranging from 0 to 80.

6. The equipment submitted consists of the following units:

1 - Transmitter (anemometer and wind vane)
1 - Master transmitter
1 - Combined wind intensity and wind direction indicator

Transmitter (Drawing No. 10-888)

7. The transmitter consists of a three cup anemometer, having copper cups mounted on corrosion resisting steel arms fastened to a vertical shaft. The shaft is mounted in grease sealed ball bearings and is concentric with a hollow shaft which is also mounted in grease sealed ball bearings. An aluminum wind vane is fastened to the hollow shaft by means of a corrosion resisting steel arm.

8. A type "A" generator is geared to the anemometer shaft through a pair of spur gears. The speed ratio between the anemometer and the type "A" generator is 5-5/8 to 1.

9. Another type "A" generator is geared to the hollow wind vane shaft by means of a pair of spur gears. The ratio between this shaft and the type "A" generator is 1 to 1.

10. The case is of composition BE metal and is of splashproof construction. A terminal block is provided for line connections.

11. The points where the anemometer shaft and vane shaft enter the case are designed to be splashproof by means of skirts.

12. The transmitter is designed for mounting on the end of a 2"0 vertical pipe, the socket being bored 2"375 diameter for a depth of 3"0. A boss, tapped for 1-1/4 inches (IPS), is provided in the case for a Navy standard terminal tube.

Master Transmitter (Drawing No. 10-946)

13. This instrument consists of two separate units mounted in the same case.

14. The wind intensity section is designed to convert the output of the anemometer into wind intensity in knots and to transmit these values to indicators.

15. The mechanism in this section consists of two type "A" generators, one synchronous motor with a built-in speed reducer, and a

self-positioning friction disc and roller assembly.

16. One type "A" generator is connected electrically to the type "A" generator in the transmitting head. This generator is geared to a threaded shaft on which the friction roller is free to thread itself back and forth.

17. The friction disc is driven by a 60 r.p.m. "Bodine" synchronous motor.

18. As the threaded shaft is driven by the anemometer cups through a pair of type "A" generators, it will revolve at a speed proportional to that of the cups, due to the gear reduction between the anemometer shaft and generator. The friction roller will then thread itself along this shaft until it reaches a point on the friction disc which has the same peripheral velocity as the roller.

19. A circular bronze rack is attached to the roller and in this rack runs a steel pinion, so that as the roller moves back and forth over the disc, due to changes in the wind intensity, the steel pinion is made to revolve. The pinion and rack are so designed that the pinion will make less than one revolution when the rack has traveled its maximum distance. This pinion is mounted on the shaft of a type "A" generator which positions the wind intensity indicators. At zero intensity (approximately), the disc motor is cut off through the action of a limit switch operated by movement of the rack.

20. The wind direction section consists of one type "A" generator, one type "M" motor, and a follow-up mechanism incorporating a shaded-pole induction motor. The type "M" motor is positioned by the wind direction generator in the transmitter. It does no work except that required to rotate a small counter-weighted contact arm mounted on its shaft.

21. The type "A" generator is mounted in line with the type "M" motor (shaft ends facing) and has a phenolic disc on its shaft. On this disc are mounted two slip rings connected to two segments of approximately 180° each. A ball bearing contact roller, mounted on the contact arm, rests on the segments which are separated at one point by an insulating insert and at another by a gap which is cut on an angle to permit the roller to pass over without opening the circuit. Two brushes are provided for the slip rings. This entire assembly forms the equivalent to a single-pole double-throw switch to control the follow-up motor. The control circuit is grounded as the control current for the follow-up motor passes through the bearings of the type "M" motor to reach the contact arm. The contacts are shunted with 500 ohm resistors, presumably to reduce arcing.

22. The internally geared follow-up motor is geared to the type "A" wind direction generator with a worm and wheel.

23. In operation, a change of wind direction causes the type "M" motor to change position, shifting the contact arm and causing the

contact roller to move from its position on the insulating insert in the segments. This closes the control circuit and the motor drives the type "A" generator until the phenolic disc, mounted on its shaft, has rotated far enough to again place the insulating insert under the contact roller. When this operation is completed, the transmitter has duplicated the displacement of the wind vane and has positioned the indicators in the circuit without placing any load on the vane. The rate of movement of the indicator pointers is fixed by the speed of the follow-up mechanism. This provides a damping effect for the indicators without restricting the vane movement. The case is provided with multiple jacks to fit the multi-pronged plugs of the units. A removable plate on the lower part of the case covers the line connection terminals.

Combined Wind Direction and Wind Intensity Indicator

24. The combined wind direction and wind intensity indicator comprises two type "M" motors, two multi-pronged connection blocks, one dial with wind direction and wind intensity scales, and two white metal pointers geared (1:1) to their respective motors. All of the parts are mounted on a cast BE metal spider, secured to bosses on the aluminum alloy case. The bosses are equipped with steel inserts.

25. The case cover is of cast BE metal and is secured with eight 5/16-inch brass cap screws which thread into steel inserts located in bosses on the outer edge of the case.

26. The dial is of brass, having a black background with white graduations. The wind intensity scale is graduated from 0 to 80 knots in steps of 1 knot with distinctive markings every 5 knots and numerals every 10 knots. The wind direction scale is graduated from 0° to 360° in steps of 5° with numerals every 10°.

METHOD OF TEST

27. After a wind tunnel test at the Bureau of Standards, the system was subjected to an endurance test consisting of operating it for 500 hours at constantly varying cup speeds, oscillating through a range of 30 to 75 knots at a rate of change of approximately 15 knots per minute. Once each hour the cup speed was steadied at approximately 75 knots to determine indicator errors. This test was continuous except for an interruption at the end of the 50th hour to permit the accuracy, shock, and vibration tests to be conducted.

28. During the first 125 hours of the 500 hour test, the wind vane was rotated at approximately 1/2 r.p.m. and its direction of rotation was reversed each 24 hours. After 125 hours, the rate of wind vane rotation was increased to 5 r.p.m. in order to make the follow-up contacts operate more frequently.

29. The remaining tests were conducted in the order specified for type approval tests, required under reference (b).

30. The test was concluded with a general inspection of the equipment to determine the quality of workmanship and material used in its construction.

RESULTS OF TEST

31. The test results obtained were as follows:

Requirements	Test Values
Voltage of system: 115	115 volts
Current: Not specified.	Synchronous motor - 0.060 amperes. Remainder of system - 3.89 amperes.
Frequency: 60 cycles.	60 cycles
Endurance: Par. F-2d(1)	Wind intensity satisfactory. *See remarks under "Conclusions" for wind direction operation.
Accuracy: Par. F-2d(2)	Satisfactory from 5 to 80 knots. See curves, Plate 1.
Shock integrity: Par. F-2d(2)b	Satisfactory
Vibration integrity: Par. F-2d(2)c	Satisfactory
Damping tests: Par. F-2d(4)	Satisfactory, an average pointer displacement of 2.75 degrees per second.
Sensitivity test: Par. F-2d(4)c	Satisfactory, 0.2 oz. per sq. ft. caused vane tc move.
Temperature compensation: Par. F-2d(5)c	Satisfactory, causing no additional errors in the accuracy of the system.
Voltage and frequency compensation: Par. F-2d(3)f	Satisfactory, causing no additional errors in the system. Note: Not applicable to disc motor in master instrument.
Inclination tests: Par. F-2d(1)c	Satisfactory operation under the specified conditions.
Dielectric tests: Par. F-2d(5)d	Satisfactory
Insulation tests: Par. F-2d(5)e	Satisfactory, 200+ megohms by 1000 volt megger.

Requirements	Test Values
Watertight and splashproof tests: Par. F-2d(5)f and F-2d(5)g	*Satisfactory, except master case leaked 2-1/2 pts. of water due to sand hole in rear of main casting.
Dial illumination: Par. E-5a(8)	*None provided.
Dimensions: Par. E-4a(6)	
Master - 21" x 14" x 12"	15"75 x 15"875 x 9"375
Indicator - 21" x 12" x 10"	10"625 x 11"375 x 9"125
Transmitter - Not specified	Height 32"5 Vane radius 19"0
Weights: Par. E-3a(5) and E-4a(7)	
Master - 70 lbs.	55 lbs. 2 oz.
Indicator - 50 lbs.	41 lbs. 4 oz.
Transmitter - 45 lbs.	*52 lbs.

*Denotes failure to comply with the specification.

CONCLUSIONS

32. The operation and accuracy of the wind intensity part of this system was satisfactory over the range of 5 to 80 knots during the wind tunnel and other tests. As shown by Table 1, the pointer indicated 2.5 knots when there was zero wind. This was due to the master mechanism "driving back" through the self-synchronous motors and rotating the cups, following a period during which the wind had been rotating the cups. With the cups stalled, the starting speed was 2.9 knots. Therefore, the graduations from zero to 3 knots are of no value.

33. The operation of the wind direction master unit became unsatisfactory after approximately 250 hours of the endurance test due to pitting and poor contact between the contact roller and the contact segments. This weakness was brought out by modifying the test procedure after 125 hours so that the vane was rotated at 5 r.p.m. instead of 1/2 r.p.m. as given by the specification. This higher rate caused much more frequent operation of the contact mechanism. Since the 1/2 r.p.m. rate previously used nearly corresponded to the damping rate provided by the follow-up motor, the vane and the follow-up mechanism were almost in synchronism and but few contact operations were required.

34. At one time during the wind tunnel test, the direction indicator pointer did not return to zero after the vane had been deflected 5° in a 5-knot wind and released.

35. It was found that when the follow-up contact arm was deliberately placed in a position bridging the diagonal gap in the contact segments, the follow-up mechanism stopped. This caused an error of 180 degrees in the direction indicators. When the roller was oscillated across the gap, the indicators oscillated approximately 180 degrees in error.

36. The following features are at variance with the specification:

(a) The system has a master transmitter instead of a master transmitter-indicator.

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(e) The transmitter weight is seven pounds more than that allowed.

37. The following mechanical features were noted as being unsatisfactory:

(a) There is considerable play in the bearings of the concentric hubs of the indicator. This is due to the use of only one single race ball bearing for each of the concentric shafts. The use of double race ball bearings is suggested.

(b) The sleeve, pc. 24, used in the concentric assembly of the indicator was found fractured. This failure was caused by the thinness of the wall between the bore and the root of the threads.

(c) The skirted guards on the transmitter spindles are not of the best design to prevent locking due to ice formation.

(d) The master case had a sand hole in the rear of the main casting which permitted water to enter the case.

Table 1

National Bureau of Standards — 4-1/2-Foot Wind Tunnel

November 3, 1939

Test of Henschel Wind Velocity System

(Direction indicator reading 359 degrees)

True Wind Speed Knots	Indicator Reading Knots
0	2.5
5.0	6.2
9.9	11.2
15.0	16.0
20.0	20.8
24.7	25.4
29.9	30.2
34.9	35.1
40.0	40.0
44.9	45.0
49.9	49.8
59.8	59.7
69.7	69.9
79.9	80.0

Starting speed . . . . . 2.9 knots
Air temperature. . . . . 23 to 25°C.
Pressure . . . . . 753 mm Hg.

Wind Direction System

Indicator read 359 degrees when vane was parallel to wind.

Vane deflected until indicator showed the following reading	Performance of indicator when vane was released
5 knot wind	
5°	Returned to 0
355°	Did not return
10°	Returned to 357° or 358°
350°	Returned to 358° or 359°
15°	Returned to 356°
345°	Returned to 0
20°	Returned to 357°
340°	Returned to 0
10 knot wind	
5°	Returned to 359°
355°	Returned to 0
10°	Returned to 359°
350°	Returned to 358°
15°	Returned to 358°
345°	Returned to 359°
20°	Returned to 359°
340°	Returned to 359°

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DATE

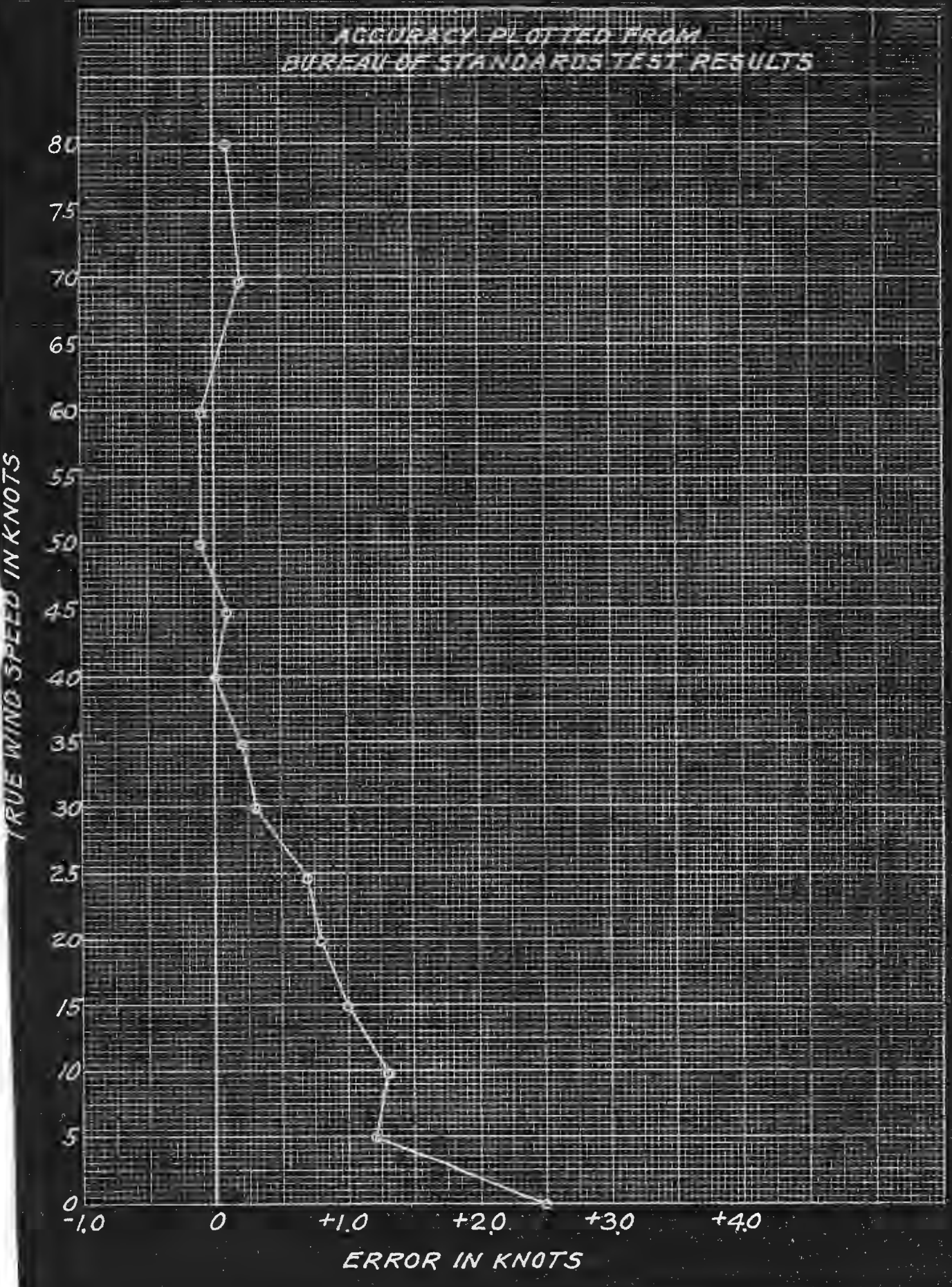
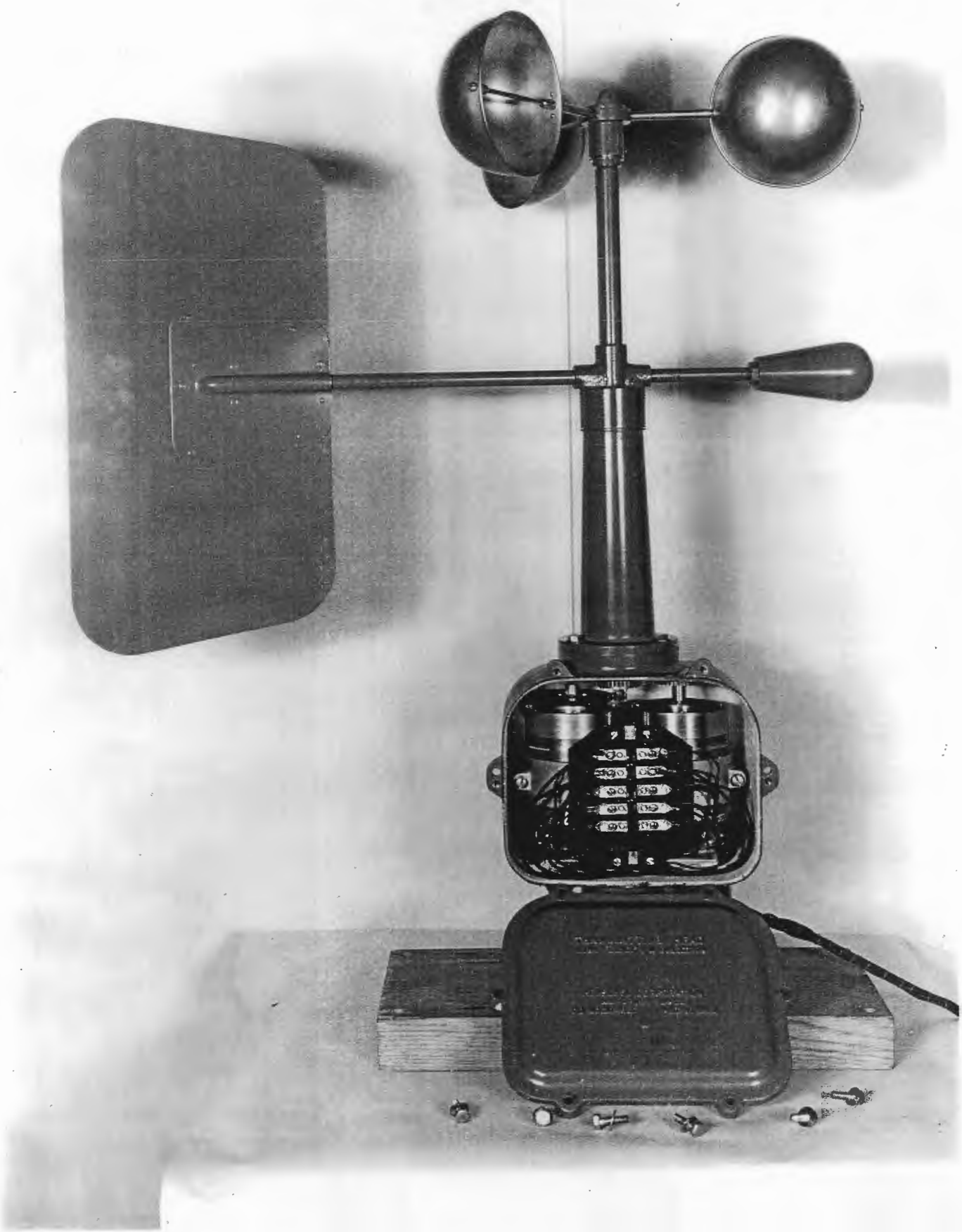


PLATE I

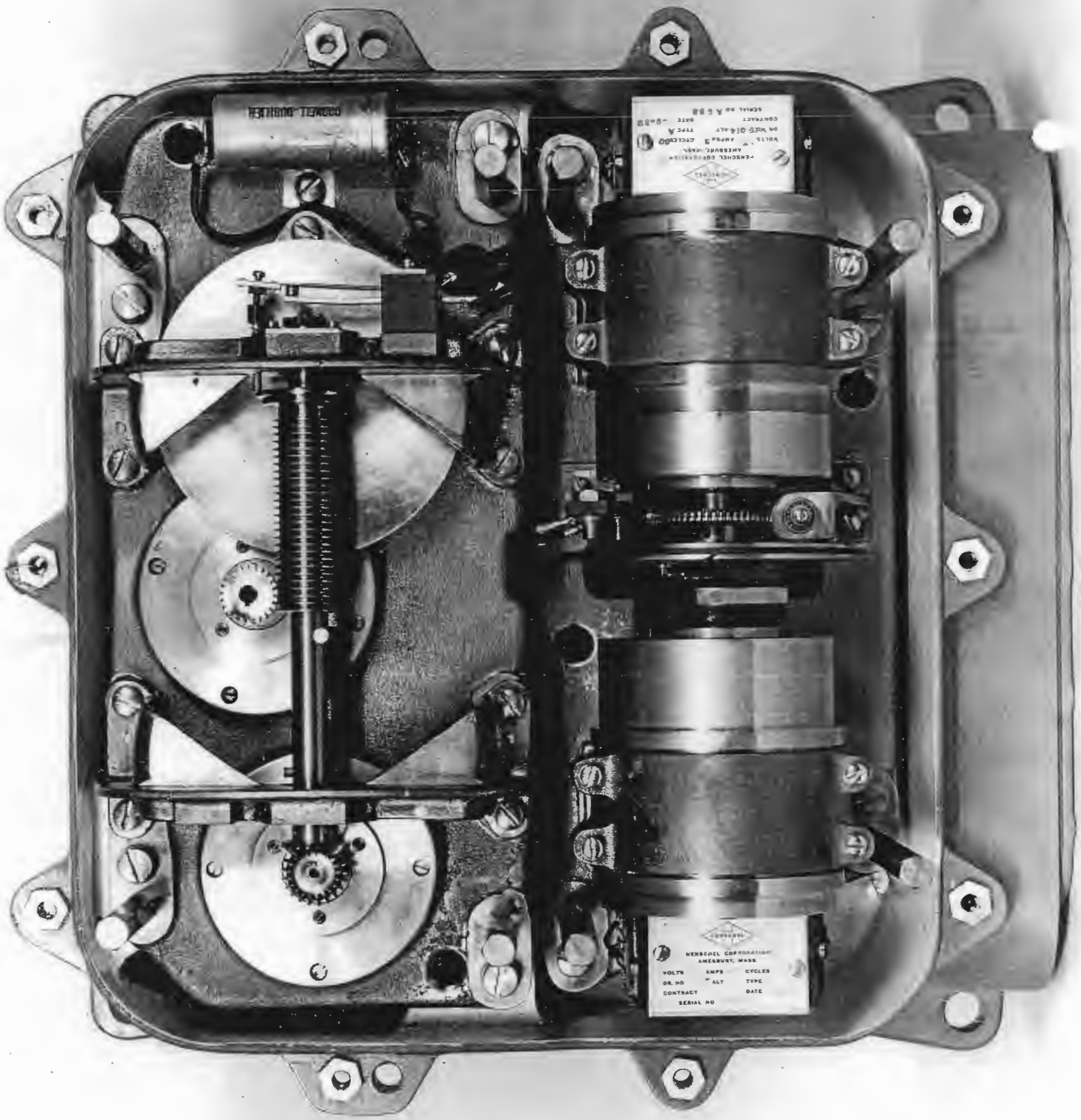


Transmitter, Case Cover Removed

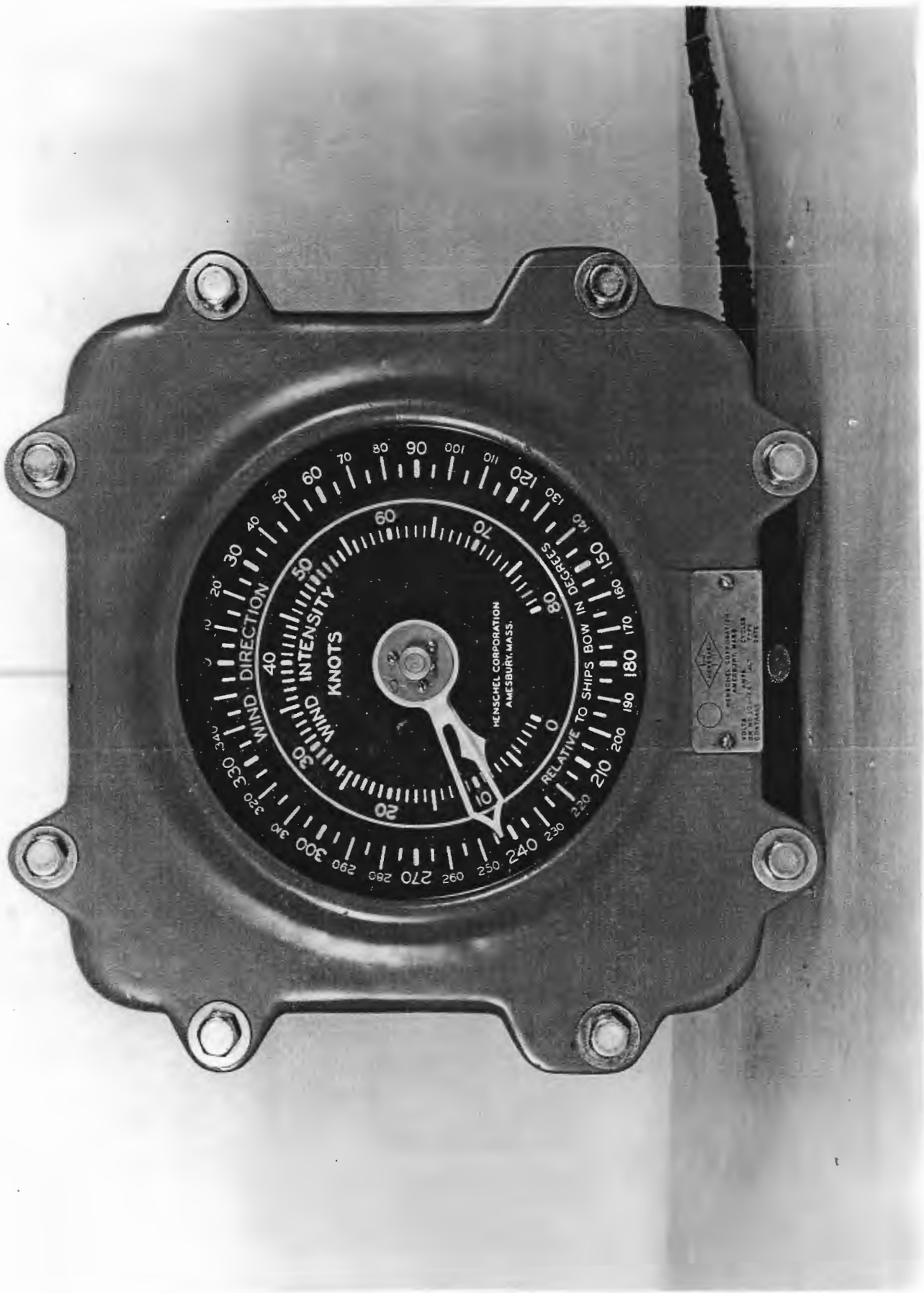
Plate 2

Master Transmitter, fully Assembled

Plate 3

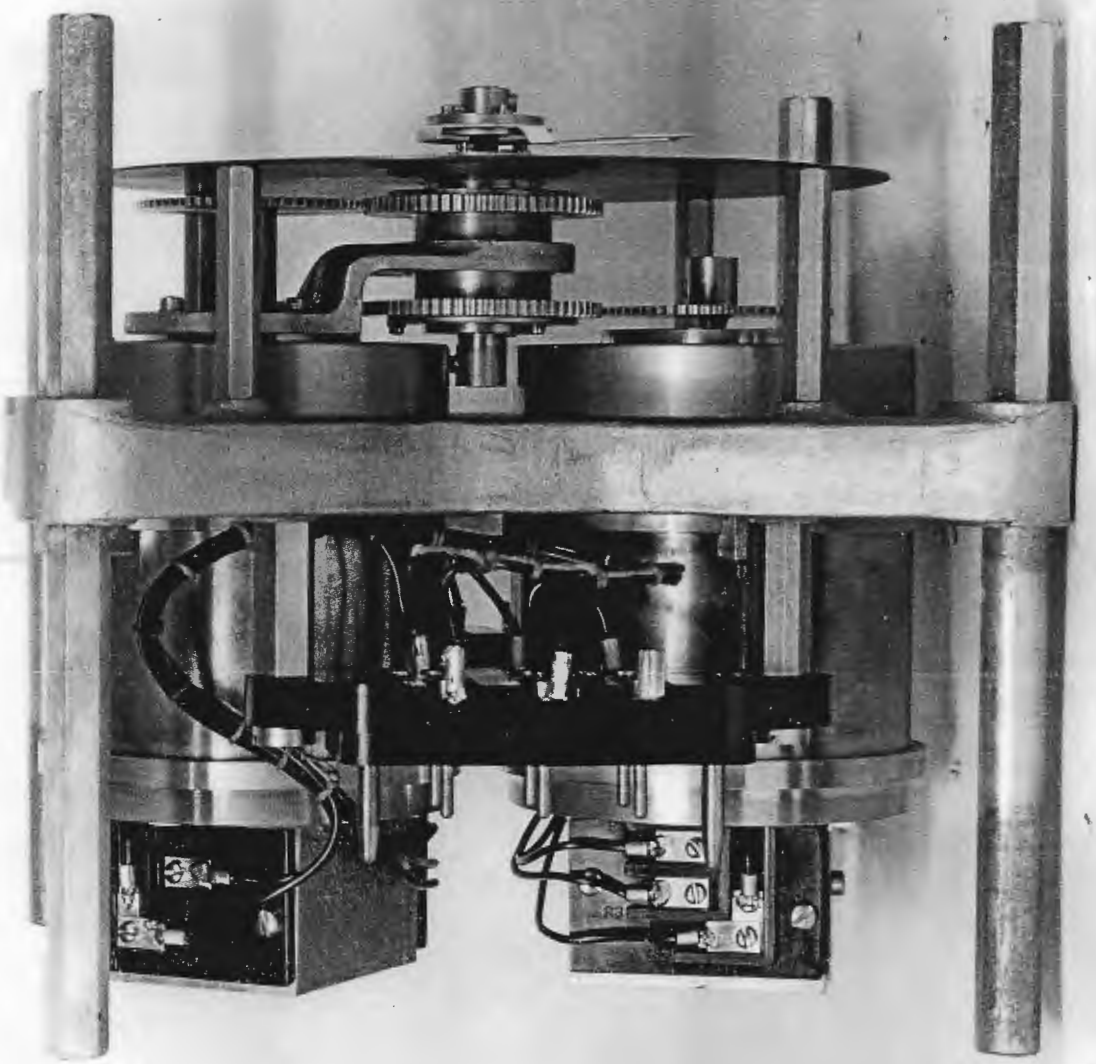


Master Transmitter, Cover Removed from Case. Plate 4



Combined Wind Direction and Wind Intensity
Indicator fully Assembled in Watertight Case.

Plate 5



Combined Wind Direction and Wind Intensity Indicator
Removed from Case.

Plate 6