FR-1226

REPORT NO. B-1226

DATE 16 December 1935

SUBJECT

Report of Test

on

Wind Velocity and Wind Direction System

Submitted by Chas. J. Henschel and Co., Inc., Amesbury, Mass. - Contract NOs-37954.

by

J. R. Coomes
J. S. Bryant
W. B. Roberts

Naval Research Laboratory
Office of Naval Research
Navy Department
Washington 25, D. C.

16 December 1935 NRL Report No. B-1226

NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report of Test

on

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NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON DC

Number of Pages: Text - 8 Plates - 11

Authorization: Bu.Eng.let. S65-5/L5(5-3-Ds) of 6 May 1935.

Date of Test: November-December, 1935.

Tested by: J.F. Coomes, Sr.Eng. Aide J.L. Bryant, Sr. Eng. Aide

Prepared by: R.B. Roberts, Pr.Eng. Aide, Chief of Section.

Reviewed by: W.M. Haynsworth,Jr., Lieut., USN.

Approved by: H.M. Cooley, Captain, USN, Director.

Distribution:
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TABLE OF CONTENTS

Appendices

AUTHORIZATION

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

Reference: (a) Bu.Eng.let.S65-5/L5(5-3-Ds) of 6 May 1935.
(b) Navy Department Specifications SGS(65)-10a of 1 March 1935.
(c) Navy Department Specifications SGS(65)-42 of 1 May 1934.
(d) Contract NOs-37954.
(e) NRL Report No. B-1203 of 14 October 1935.

OBJECT OF TEST

2. The object of this test was to determine the suitability of the wind velocity and wind direction system for the Naval service and its conformance with specifications, references (b) and (c), in so far as they were applicable.

ABSTRACT OF TEST

3. Upon receipt of the system, after completion of the wind tunnel tests by the Bureau of Standards, it was connected in accordance with the schematic wiring diagram shown on Plate 11. It was then tested as a propeller shaft revolution indicator system in so far as the specifications were applicable.

(a) CONCLUSIONS

(a) This system complies with the specifications, references (b) and (c), with the exceptions noted under COMMENTS, paragraphs 28, 33, 34, 40 and 42. If corrections were made accordingly, it should prove to be a simple and reliable system for indicating wind velocity and wind direction.

(b) The Bureau's attention is invited to paragraph 25(b) of this report showing that the master indicator, when converted to a master indicator transmitter and tested for accuracy while a repeater was rotated out of phase, did not meet the requirements for propeller shaft revolution indicator systems. If the Bureau desires to waive this requirement for wind velocity and wind direction systems, the subject system could be considered acceptable for the Naval service.

(b) RECOMMENDATIONS

(a) It is recommended that this system be approved for use on this contract, reference (d), subject to correction of defects noted under COMMENTS of this report, provided the Bureau does not desire to incorporate a "Master Indicator Transmitter" in this system.

(b) It is further recommended that the Bureau consider the advisability of making the master transmitter into a "Master Indicator Transmitter" in future models. This will serve as a check on all repeaters in case of casualty to any of the repeater circuits. In case the master transmitter motor failed or were it necessary to cut out all repeaters, there would still be one instrument from which the wind velocity could be obtained.

(c) It is also desired to repeat the recommendations covered by recommendations (d) and (e) of reference (e). The results of tests, described in paragraph 25 of this report, appear to demonstrate that a follow-up mechanism in the master instruments of systems of this type, whether they be used as wind velocity or shaft revolution indicator systems, is unnecessary. It is believed that a perfected propeller shaft indicator system of this type would be superior in simplicity, ruggedness and dependability to any system tested to date. An overload relay may be incorporated in the master indicator transmitters so that faulty repeaters may be cut out of the circuit when a trouble alarm signal operates. However, a locked out of phase repeater will cause an excessive hum and noticeable vibration of the pointer at the master instrument. It is suggested that a master cut-out switch be provided on the master instrument so that the repeater circuit may be immediately cut out when trouble develops.

DESCRIPTION OF MATERIAL UNDER TEST

4. This system was manufactured by Charles J. Henschel and Company, Inc., Amesbury, Massachusetts, and submitted for test under Contract NOs-37954.

5. The system is designed to measure wind velocity and wind direction and to give a continuous indication of the same at any designated station or stations aboard ship.

6. The wind direction is indicated in degrees relative to the ship's bow and the wind velocity in knots ranging from five to ninety knots.

7. The material submitted for test consists of one transmitter, one master transmitter and one indicator.

Transmitter - Henschel Dr. No. 10-845.

8. The wind velocity transmitter is designed for location on the trident truck or yard arm and is made in combination with the wind direction transmitter. It is of the 3 cup anemometer type, having aluminum cups mounted on aluminum rods, fastened to a vertical shaft. The shaft is mounted in ball bearings and is concentric with the hollow wind direction shaft. A type "A" transmitting motor is driven by bevel gears from the inboard end of the shaft. The gear ratio between the cups and the transmitting motor is 5:1. The transmitting motor is connected electrically to a type "A" motor in the master transmitter.

9. The wind direction part of the transmitter consists of a wind vane, secured to a hollow shaft, mounted on ball bearings. This shaft is connected to a Telindicator generator and a magnetic dampening device to prevent the vane from being affected by sudden gusts of wind. This generator is electrically connected to all of the wind direction indicators in the system.

10. The transmitter is mounted in an aluminum alloy case having four (4) mounting lugs. This case is of the usual watertight construction, having one (1) boss, tapped for a 1-1/4" standard Navy terminal tube and embodying a 1/4" square rubber gasket but, due to the anemometer and wind vane shafts entering the case, can only be considered splashproof. All of the mechanism is mounted on a cast brass plate secured to the case cover which is hinged to permit free access to the instruments. A hand hole cover is also provided so that all terminals may be reached. The transmitter unit is shown by photographs, Plates 2 and 3.

11. The master transmitter consists of one (1) type "A" motor, one (1) type "M" motor, a synchronous motor and a friction disc positioning mechanism. The type "A" motor is driven electrically from the anemometer transmitter motor. This motor drives a threaded steel, ball-bearing mounted, shaft through bevel gears, ratio 1:1. The threaded shaft carries a bronze nut mounted in such a manner that, when the nut and shaft revolve at the same speed, there is no travel of the nut relative to the shaft. When the shaft revolves at a different speed than the nut, the latter is threaded along the shaft. A hardened steel roller is secured to the nut and is in contact with a polished and ground, hardened steel

the latter is threaded along the shaft. A hardened steel roller is secured to the nut and is in contact with a polished and ground, hardened steel disc. This disc is driven at a constant speed of 60 r.p.m. by the synchronous motor which is supplied from a controlled frequency source. Sufficient pressure to prevent slippage is maintained by an adjustable spring on the shaft of the disc and, since the disc and the roller are in rolling contact, the peripheral speed of the roller is the same as the surface speed of the disc at the point of contact. This gives a certain angular velocity to the roller which, if different from the angular velocity of the threaded shaft which supports the roller, will cause the roller and nut to thread along the shaft until they reach a point where the angular velocities of nut and shaft are equal. Thus, for any speed of the anemometer and consequently of the threaded shaft, the roller assumes a definite position on the disc. The outside of the threaded nut, attached to the roller, is in the form of a circular rack which engages a steel pinion on the type "M" transmitting motor. The transmitting motor is electrically connected to the type "M" indicating motors in all the wind velocity repeaters in the system. A protective device, located on the threaded shaft, stops the nut from traveling too far and jamming when the wind velocity exceeds ninety (90) knots and allows the nut to return to its proper position as the wind velocity decreases. The entire mechanism is mounted on a cast brass plate, secured to steel inserts in bosses in the aluminum alloy case with four (4) 5/16" steel cadmium plated cap screws. The case is provided with one (1) tapped boss for 1-1/2" terminal tube and four (4) mounting lugs.

Indicator - Henschel Dr. No. 10-846.

12. The wind velocity and wind direction indicator consists of two (2) indicating motors mounted in a watertight aluminum alloy case with two (2) dials, one for each motor. The wind velocity dial is graduated in knots, over a range of from five to ninety, in increments of one knot. The wind direction dial is graduated from 0 to 360° in steps of 5. Both dials have black backgrounds, but the graduations are not treated with radium luminous material. Instead, the pointers and dial graduations are painted white. Six (6) sockets for type VG-2A lamps are provided for each dial, but no lamps were furnished. The case embodies four (4) mounting lugs, two (2) tapped bosses for 1-inch standard Navy terminal tubes and a hand hole to provide free access to the terminal block. Imbedded in the case cover is a 1/4" square rubber gasket to insure watertightness. All instruments are provided with steel inserts for the case and hand hole cover securing screws.

METHOD OF TEST

13. The system as submitted was first interconnected electrically and operated for the required 500 continuous hours by driving the cups with a blower at a speed which produced an indication of approximately 35 knots.

14. It was then tested for accuracy by removing the anemometer cups and substituting a gear drive. The transmitter was then driven at speeds corresponding to wind velocities of 14.93, 24.88, 37.32, 49.76, 62.21 and 74.65 knots.

disc. This disc is driven at a constant speed of 60 r.p.m. by the synchronous motor which is supplied from a controlled frequency source. Sufficient pressure to prevent slippage is maintained by an adjustable spring on the shaft of the disc and, since the disc and the roller are in rolling contact, the peripheral speed of the roller is the same as the surface speed of the disc at the point of contact. This gives a certain angular velocity to the roller which, if different from the angular velocity of the threaded shaft which supports the roller, will cause the roller and nut to thread along the shaft until they reach a point where the angular velocities of nut and shaft are equal. Thus, for any speed of the anemometer and consequently of the threaded shaft, the roller assumes a definite position on the disc. The outside of the threaded nut, attached to the roller, is in the form of a circular rack which engages a steel pinion on the type "M" transmitting motor. The transmitting motor is electrically connected to the type "M" indicating motors in all the wind velocity repeaters in the system. A protective device, located on the threaded shaft, stops the nut from traveling too far and jamming when the wind velocity exceeds ninety (90) knots and allows the nut to return to its proper position as the wind velocity decreases. The entire mechanism is mounted on a cast brass plate, secured to steel inserts in bosses in the aluminum alloy case with four (4) 5/16" steel cadmium plated cap screws. The case is provided with one (1) tapped boss for 1-1/2" terminal tube and four (4) mounting lugs.

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METHOD OF TEST

13. The system as submitted was first interconnected electrically and operated for the required 500 continuous hours by driving the cups with a blower at a speed which produced an indication of approximately 35 knots.

14. It was then tested for accuracy by removing the anemometer cups and substituting a gear drive. The transmitter was then driven at speeds corresponding to wind velocities of 14.93, 24.88. 37.32, 49.76, 62.21 and 74.65 knots.

15. Next, each of the units was tested separately for shock integrity by placing it on a Bureau of Engineering shock stand and subjecting it to 20 blows of 250 foot pounds. During this test, each instrument was

mounted in its normal position and operated in the system while the transmitter was being driven at an approximate speed of 26 knots (indicated velocity).

16. Following this, the system was again checked for accuracy, as described in paragraph 14.

17. To determine the effect of high temperatures, the master transmitter was placed in a compartment having a controlled temperature of 135° for a period of four hours and then rechecked for accuracy at a speed equivalent to 62.21 knots.

18. The system was then checked to note the effect of variations in voltage and frequency as required by the specifications, reference (b), paragraph F-2c(4)d.

19. Each instrument was then tested for its dielectric strength and insulation resistance.

20. The instruments, transmitter excepted, were next tested for their watertight integrity by submerging them in 3 feet of water for one hour.

21. The transmitter was given a splashproof test in view of the shaft housing being of non-watertight construction.

22. The required tests were concluded with an inspection of the design, material and workmanship.

RESULTS OF TEST

23. The tests results given below were obtained when the system was tested for conformance with the specifications, references (b) and (c), in so far as they were applicable.

Requirements	Test Values
Endurance: System shall be operated continuously for 500 hours, at approximately maximum speed.	System operated satisfactorily for 500 continuous hours, at a speed equivalent to 35 knots.
Accuracy test: Error shall not exceed 1 knot ±, when tested as a propeller shaft indicator system. Note: Results computed from ratio furnished by manufacturer, 1085 r.p.m. of cup shaft = 90 knots.	Cup shaft speed in knots / Error in knots 14.93 / +0.82 24.88 / +0.37 37.32 / -0.07 49.76 / -0.51 62.21 / -0.71 74.65 / -0.90
Shock test: Shall withstand 20 blows of 250 ft.lbs. each, without damage, while separately mounted on a Bu. Eng. shock stand and operating in the system.	Tested as required, with system operating at 26 knots. Transmitter satisfactory. Master transmitter and indicator units unsatisfactory. See COMMENTS, par. 28.

Requirements	Test Values
Accuracy test after application of shock: Error shall not exceed 1 knot ±, when tested as a propeller shaft indicator system. Note: Results computed from ratio furnished by manufacturer, 1085 r.p.m. of cup shaft = 90 knots.	Cup shaft speed in knots: 14.93, 24.88, 37.32, 49.76, 62.21, 74.65 — Error in knots: +0.60, +0.31, -0.06, -0.47, -0.71, -0.90
Temperature compensation: System shall not have an error greater than 1 knot ±, when tested at an ambient temperature of 135°F.	Master transmitter operated for 4 hrs., at ambient temperature of 135°F, at a speed equivalent to 62.21 knots. The error during this test was -0.71 knots.
Voltage and frequency compensation: Shall not have an error greater than 1 knot ±, when tested at ±10% in voltage or ±5 cycles in frequency.	Entire system, except constant speed motor, tested as required. There was no apparent change in the indication when operated at a speed equivalent to 40 knots.
Dielectric test: Each instrument shall withstand 1500 V. a.c., 60 cycles, applied between each terminal and ground, for a period of 1 minute, without breakdown.	Each instrument withstood the specified test.
Insulation resistance following the dielectric test: Shall not be less than 10 megohms when measured with 500 volt megger.	The minimum resistance of any instrument was 100 megohms when measured with 500 volt megger.
Watertight integrity: Shall not leak when submerged in water to a depth of 3 feet for a period of 1 hour.	Master transmitter and the indicator units were tested as required. Both cases leaked under this test. Note: The cup transmitter was splashed with a 1" stream of water, under a head of 35 feet, from a distance of 10 feet for a period of 5 minutes. The case leaked 5 cc of water. See COMMENTS, paragraph 33.
Dial illumination: Shall be legible from a distance of 6 feet when viewed in a dark room.	Not painted with radium luminous material nor equipped with lamps. See COMMENTS, paragraph 34.
Current consumption: (not specified)	5.48 amperes, at 115 V. a.c., 60 cycles, including constant speed motor.

24. Weights and Dimensions.

	Weight	Case Dimensions
Anemometer transmitter	61.0 lbs.	7"375 x 12"50 x 15"75
Master transmitter	51.5 lbs.	6"75 x 15"00 x 15"625
Indicator	48.5 lbs.	8"50 x 11"00 x 17"875

Overall height of anemometer transmitter - 25"75.

25. In addition, the following tests were made:

(a) With five (5) additional type "M" motors connected in parallel with the repeater motor, it was desired to determine the effect of this additional load on the operation of the system. This test was believed necessary, as the whole load of the repeaters is carried directly by the friction roller. For this test, the cups were driven by a blower to simulate service conditions. The blower speed was kept constant and the system operated with and without the load of the additional repeaters. The results of this test showed that there was no apparent difference in the indications. However, a slight increase in the time lag occurred at low velocities when the additional repeaters were used. In addition to starting the system with the additional five (5) repeaters cut in, the repeaters were energized when they were out of phase and the system was operating. Except for an initial jolt as the repeaters assumed their correct positions, there was no visible effect on the reading of the original repeater. It is believed that the number of repeaters that may be used on this system is limited only by the rating of the transmitter motor.

(b) The system was also tested for the advisability of connecting a mechanically geared pointer directly to the friction disc positioning rack to make the instrument a "Master Indicator Transmitter". The instrument as at present designed gives all wind velocity readings by repeaters. If one of these repeaters becomes jammed, all repeaters are affected and the indications are erroneous. If there were a mechanically geared pointer on the instrument itself, it was thought possible it would not be affected by a casualty to the repeater system, and, in such a case, would give correct indications at this station. Accordingly, such a pointer was temporarily installed, as shown on Plate 8, and, for test purposes, provided with a dial graduated in degrees. The five (5) additional repeaters were then cut in with the repeater indicator motor and rotated out of phase through various angles, singly and in combination, to determine the effect on the friction roller and its mechanically geared pointer. It was found that the amount of deflection of this pointer depended on the tension of the spring forcing the constant speed disc against the friction roller. With the spring tension adjusted as received, it was possible to deflect the pointer approximately 20°. With the tension increased, the deflection was reduced to about 5°. It should be possible to eliminate it entirely, but it is not considered desirable, as it is believed that the increased tension will cause excessive wear of the disc and roller.

COMMENTS ON RESULTS OF TEST

26. The system operated satisfactorily during the required endurance test of 500 continuous hours at a speed equivalent to 35 knots.

27. The maximum error of the system, when tested for accuracy as a propeller shaft revolution indicator system, was +0.82 knots and the minimum error was -0.90 knots.

28. Under shock, the "Bodine" constant speed motor in the master transmitter became loose in its mounting cradle due to the securing screws backing out. This defect can be remedied by providing lockwashers. A small crack also occurred in the case casting near one of the tapped bosses. Except for the bending of the dial pointers, the indicator unit withstood the required shock.

29. When checked for accuracy after the application of shock, there was no appreciable change in the error of indications.

30. The system showed practically no change in error when the master transmitter was subjected to a temperature of 135°F and operated for four (4) hours.

31. No additional error was noted when the supply to the entire system, except the constant speed motor, was varied ±10% in voltage or ±5 cycles in frequency.

32. The results of the dielectric and insulation resistance tests were satisfactory.

33. Under test for watertight integrity, the master transmitter unit leaked 5 cc of water through a small crack in the bottom of the case near one of the tapped bosses. This crack was the result of the shock test. The indicator unit leaked approximately 10 cc of water at the gasket of the hand hole cover. The anemometer transmitter, when given a splash test, leaked 5 cc of water at one of the aprons located on the shaft housing.

34. The dials furnished with the twin indicator unit are not painted with radium luminous material and are of such a size that they extend over the sockets, preventing the installation of the lamps.

35. The noise produced by this system when operating at maximum speed is negligible.

36. In order to test the master transmitter for conformance with paragraph F-2c(4)e of reference (b), it was provided with a dial and pointer, shown on Plate 8, thus converting it to a "Master Indicator Transmitter". When the repeater was rotated out of phase, as described in paragraph 25(b) of this report, the master instrument was affected considerably. However, the error decreased as increased spring tension was applied to the constant speed disc. It is believed possible to use enough tension to prevent an out of phase repeater from affecting the master instrument, but it is not known whether or not the wear of the mechanical parts would be increased to such a point as to affect accuracy.

37. Under test, with five (5) repeaters added to the system, as described in paragraph 25(a) of this report, it appeared that additional repeaters did not introduce any error and only slightly increased the time lag. The increased time lag occurred at the low velocities.

38. The time lag measurements, made at various velocities, confirm the results of the Bureau of Standards' letter, Plate 10.

39. An inspection of the equipment showed the material and workmanship to be in accordance with the specifications.

40. There is considerable lost motion between the steel pinion gear on the transmitter motor in the master transmitter and the circular brass rack. Possibly a closer fitting gear could be designed for this purpose; increasing the accuracy of the system.

41. A careful inspection of the friction disc and roller after test showed no evidence of wear. These parts are normally kept covered with a film of oil. The oil does not appear to cause any slippage or inaccuracy.

42. Steel washers, cadmium plated, should be substituted for the brass washers used under the heads of the case cover securing screws on the anemometer transmitter.

CONCLUSIONS

43. This system complies with the specifications, references (b) and (c), with the exceptions noted under COMMENTS, paragraphs 28, 33, 34, 40 and 42. If corrections were made accordingly, it should prove to be a simple and reliable system for indicating wind velocity and wind direction.

44. The Bureau's attention is invited to paragraph 25(b) of this report showing that the master indicator, when converted to a master indicator transmitter and tested for accuracy while a repeater was rotated out of phase, did not meet the requirements for propeller shaft revolution indicator systems. If the Bureau desires to waive this requirement for wind velocity and wind direction systems, the subject system could be considered acceptable for the Naval service.

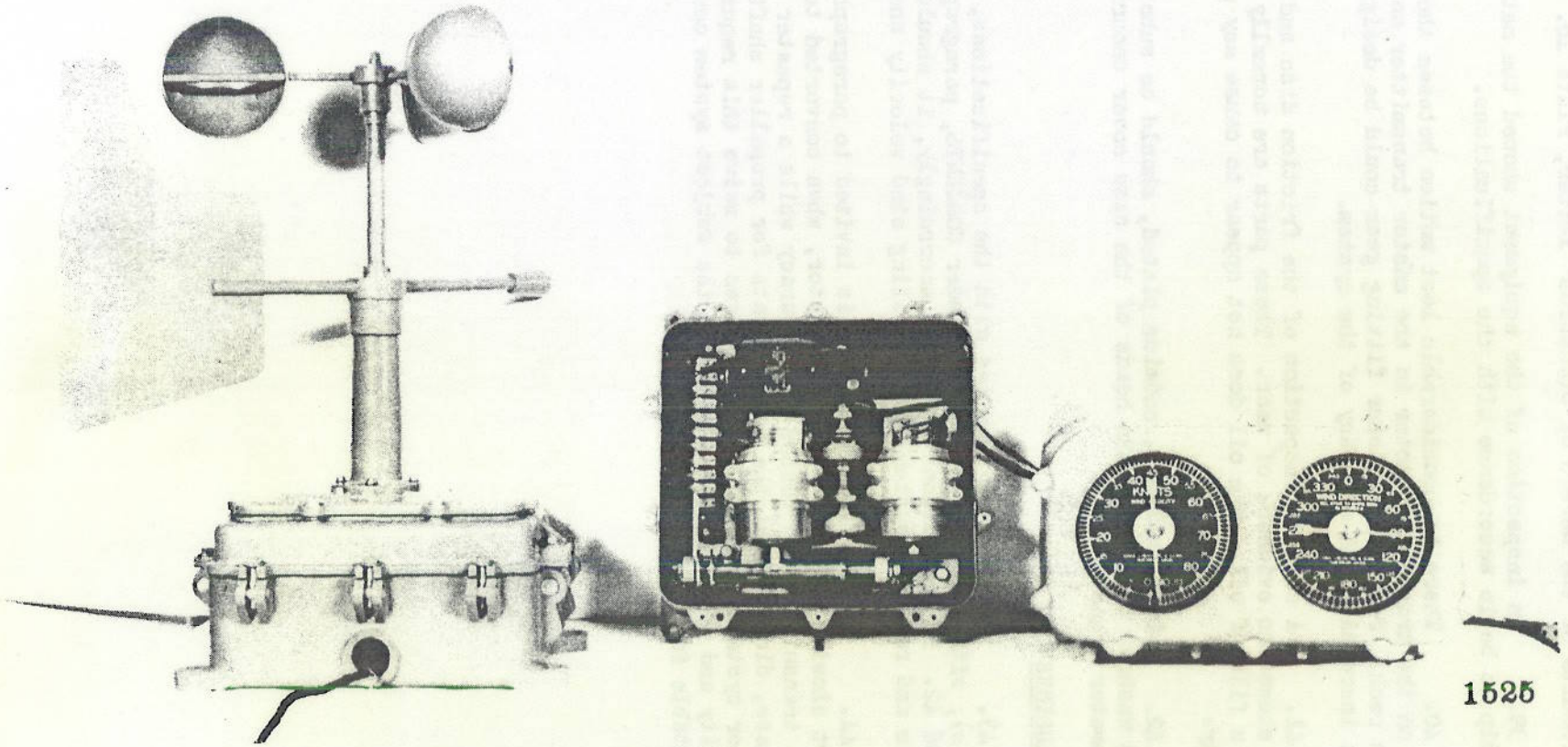

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Plate 1

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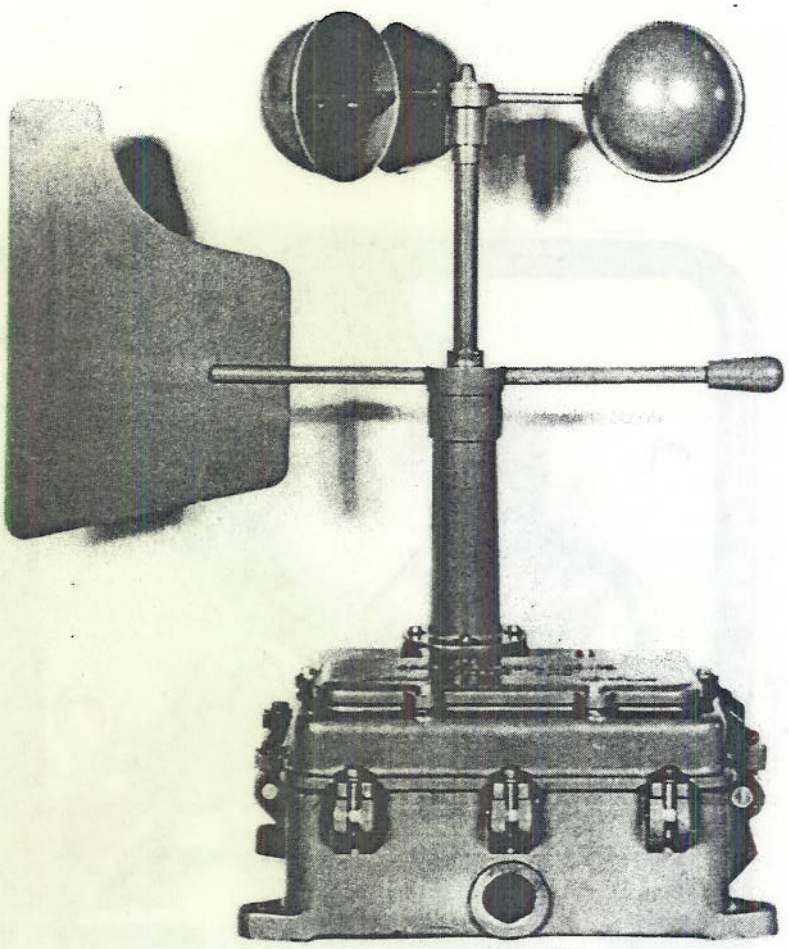

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Plate I

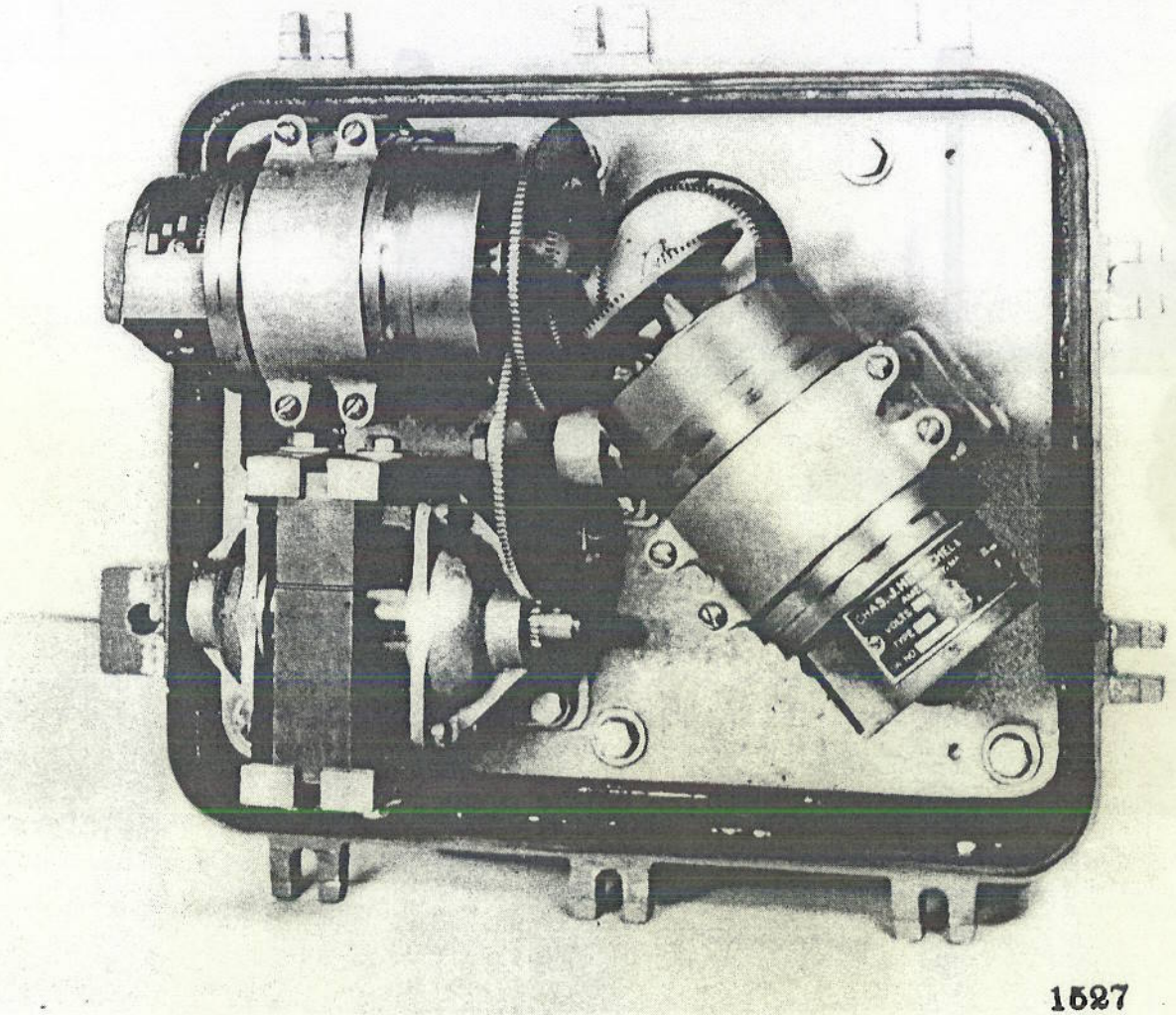

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Plate 2

1530

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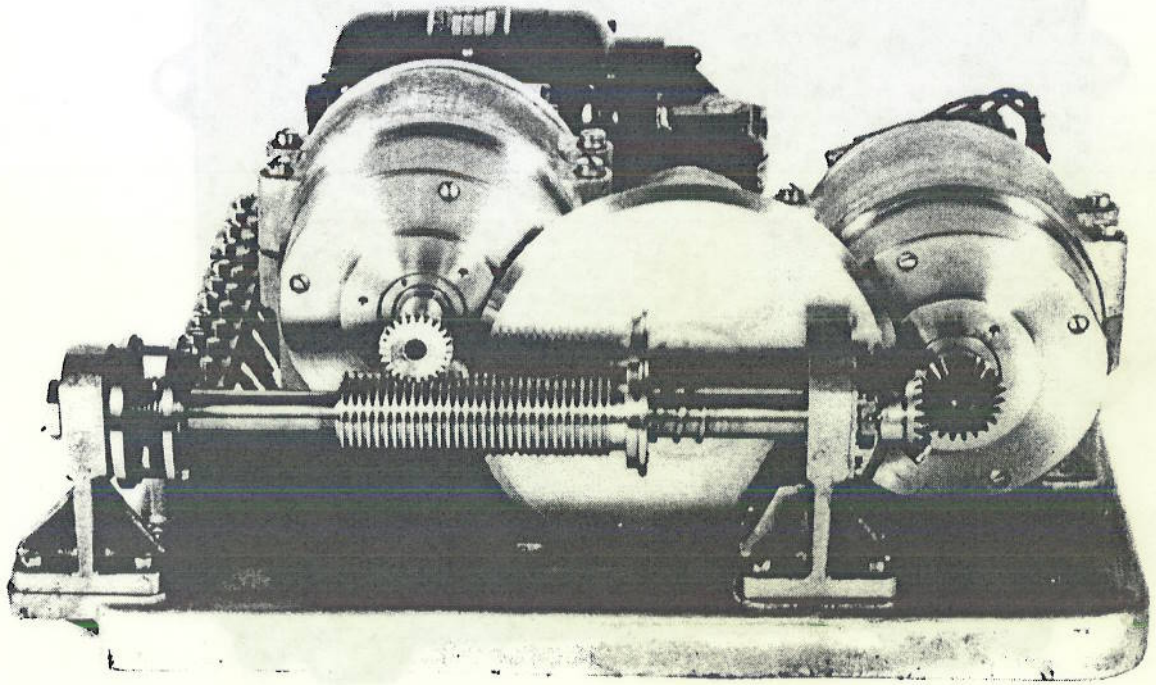

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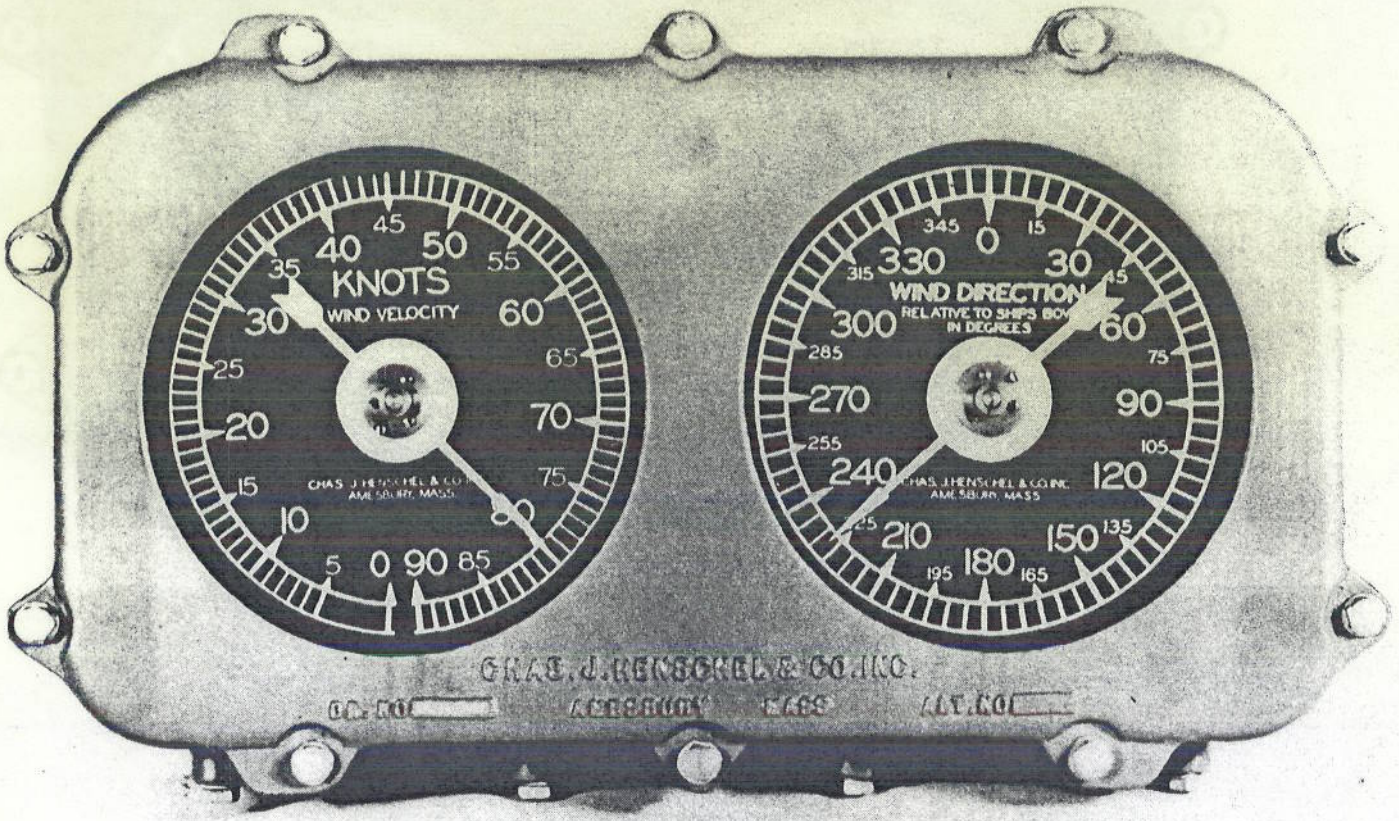

1528

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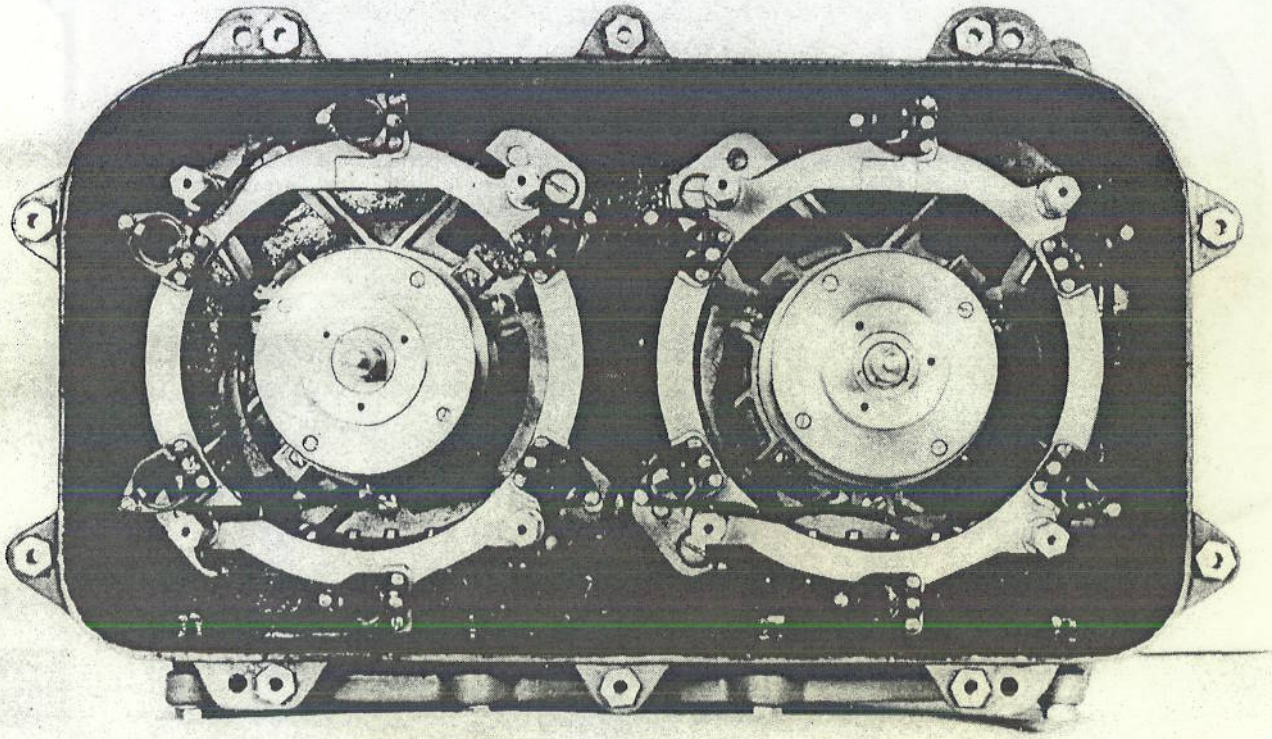

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Plate 7

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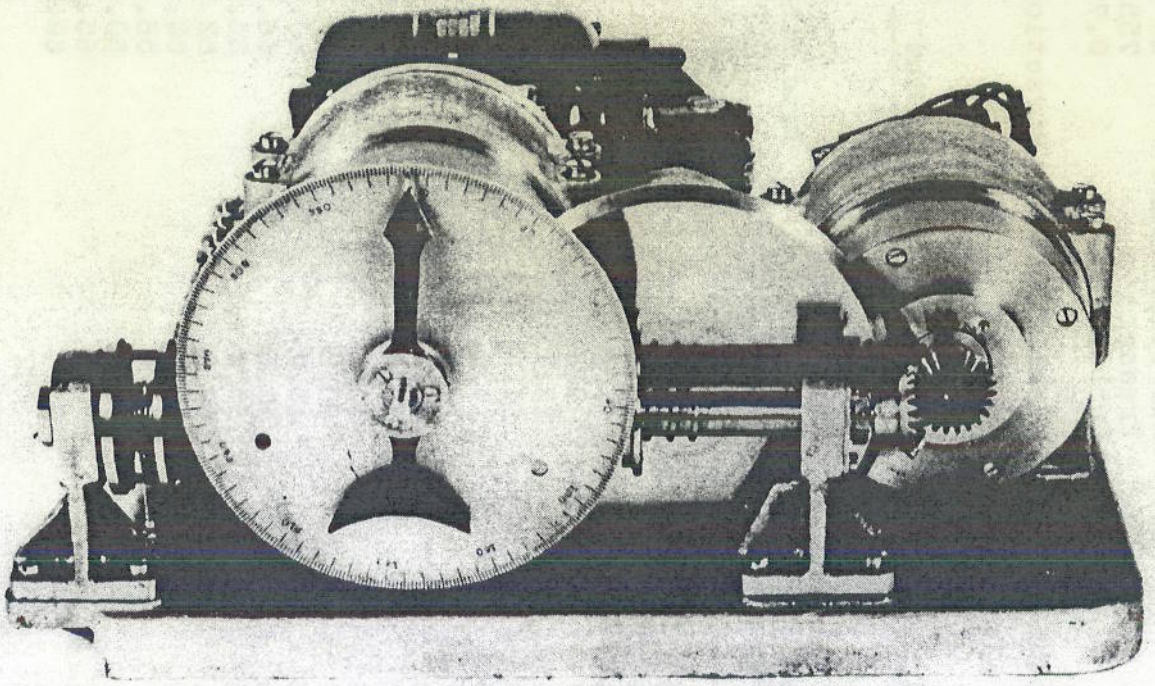

1532

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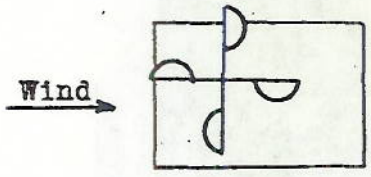
National Bureau of Standards 4 1/2 Foot Wind Tunnel

September 13, 1935.

Calibration of Wind Velocity System
For Chas. J. Henschel & Company, Inc.

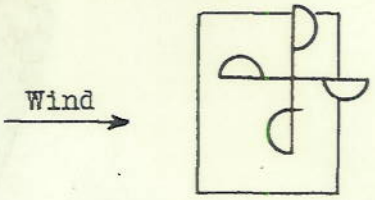
Air Temperature	24°C
Pressure	755 mm Hg
Turbulence	0.7%

Direction Indicator Reading 90°



True Wind Speed Knots	Indicated Wind Speed Knots
0	between 0 and 5
3.9	5.2
6.4	7.2
8.7	9.8
11.4	12.1
13.6	14.2
14.5	14.8
18.9	19.2
23.0	23.0
25.7	26.0
35.9	35.7
40.7	40.5
46.2	45.7
50.8	50.5
55.5	55.2
60.1	59.9
66.4	66.3

Direction Indicator Reading Zero



True Wind Speed Knots	Indicated Wind Speed Knots
0	between 0 and 5
4.7	6.1
6.3	7.3
8.6	9.9
11.2	12.2
11.3	12.3
13.5	14.3
14.5	15.3
19.1	19.8
26.0	26.4
30.1	30.1
35.6	35.6
40.6	41.1
46.7	47.0
26.1	26.5
52.3	53.0
52.7	53.2
56.5	57.3
60.8	61.5
65.2	66.0
69.8	70.4

DEPARTMENT OF COMMERCE

BUREAU OF STANDARDS

WASHINGTON

ADDRESS REPLY TO
BUREAU OF STANDARDS
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September 13, 1935

IN YOUR REPLY
REFER TO FILE NO.
VI-4/TN-75299

Charles J. Henschel & Co., Inc.,

Amesbury, Mass.

Subject: Test of Wind Velocity System

Gentlemen:

We wish to report herewith the calibration of the Wind Velocity System consisting of Transmitter No. 10-845, Master Transmitter No. 10-847, and Indicator No. 10-846. In the attached table two sets of results are given, corresponding to two orientations of the transmitter relative to the wind direction, as shown by the diagram above the table. This directional effect is probably due to the interference effect of the transmitter housing.

It was found during the calibration that considerable time was required for the pointer to reach its new position after a speed change. For example, if the true speed were changed from 6 knots to 9 knots, about 2 minutes were necessary for the pointer to finally reach the higher reading, the movement of the pointer being rapid at first and then slowing down to a scarcely perceptible creep over the last half knot distance on the scale. At a true speed of 14 knots a corresponding change required only 45 seconds; and while the time decreased progressively as the speed became higher, even at 70 knots it was necessary to allow at least 10 seconds before taking the reading. The instrument readings given in the attached table were taken only after the pointer had reached its final position. Using this procedure no difference was observed in the reading whether arriving at a given speed by increasing or decreasing.

Respectfully,

Lyman J. Briggs, Director.

Inclosure

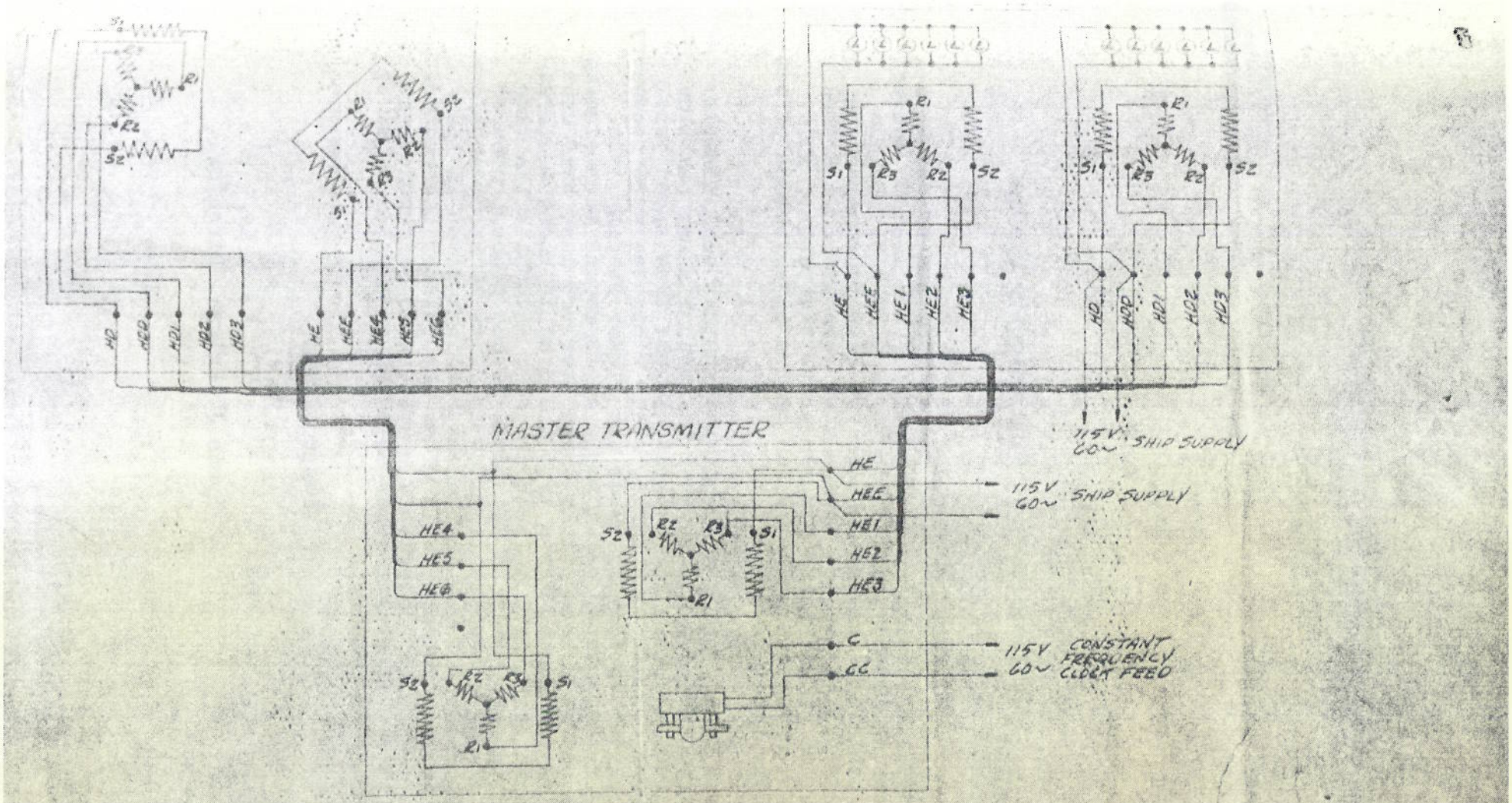

Plate 11

WIRING DIAGRAM

WIND VELOCITY & WIND DIRECTION SYSTEM
(FRICTION DISC TYPE)

JUNE 9, 1935

CHAS. J. HENSCHEL & CO. INC.
AMESBURY, MASS.

DR. NO. EXR 24