12 May 1937. NRL Report No. B-1363.

NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report of Test

on

Wind Intensity and Direction Indicating Equipment.
Manufactured and Submitted
by
Chas. J. Henschel and Co.,
Amesbury, Mass.

FR-1363

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 8 Plates - 17

Authorization: BuEng. ltr. S65-5/L5(1-26-Ds) of 28 Jan. 1937.

Date of Test: February, March and April, 1937.

Tested by:

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Distribution:
BuEng.(5)

epc

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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 (f) inclusive.

Reference: (a) BuEng. ltr. S65-5/L5(1-26-Ds) of 28 January 1937.
(b) Specifications SGS(65)-130 of 2 January 1936.
(c) Specifications SGS(65)-130a of 1 April 1937.
(d) Manufacturer's drawing of transmitter, No. 10-888.
(e) Manufacturer's drawing of master indicator transmitter, No. 10-886.
(f) Manufacturer's drawings of combined wind velocity and wind direction indicator, numbers 10-847-1 and 10-847-2.

OBJECT OF TEST.

2. The object of this test was to determine how closely the subject system complied with the specifications for type approval, references (b) and (c), and its suitability for Naval use.

ABSTRACT OF TEST.

3. Upon completion of tests for wind velocity versus anemometer speed, conducted by the Bureau of Standards, Washington, D.C., the system, shown by Plates 4 to 15 respectively, was set up at this Laboratory and checked for conformance with the specifications, references (b) and (c). The order in which the tests were made is outlined therein under paragraph F-2.

CONCLUSIONS.

(a) The subject system failed to meet the following requirements of the specifications:

(1) The system complied with the 500 hour endurance test but for an occasional error due to the failure of the monel rollers in the follow-up systems of the master indicator-transmitter to function properly. An inspection disclosed lack of free movement of the roller arm assembly, thereby preventing the roller from properly contacting the segments in the follow-up motor circuits.

(2) Under test for accuracy of the system, the only excessive errors observed (at an equivalent cup speed of 5 knots) were +0.5 in the master indicator-transmitter and +0.25 in the repeater indicator. See curves, Plate 3.

(3) Under test for shock integrity, trouble developed in the repeater indicator due to the whipping and shorting of the type M motor brush springs at the time of impact. Trouble also developed in the recording instrument due to the threaded lever, which normally engages the lead screw, disengaging and then engaging at a different position.

(4) Under the vibration test, an occasional error occurred in the master indicator-transmitter, due to the lack of free movement of the roller arm assembly, thereby preventing the roller from properly contacting the follow-up motor contact segments.

(5) Under the dielectric test, one of the dial lighting transformers in the repeater indicator broke down, the breakdown occurring between primary and ground.

(6) Under test for watertight integrity, the master indicator-transmitter leaked 150 cc. of water due to a sand hole in the case.

(7) The transmitter unit, when splashed with water under the conditions specified in D-10b of reference (c), leaked 35 cc. of water. This leak occurred at the skirts on the anemometer and vane shafts.

(8) The weight of the master indicator-transmitter is 114 lbs., while that allowed is 70 lbs.

(b) Under inspection of the master instrument at the close of the tests, the following defects were noted:

(1) One side of each of the low voltage windings of the follow-up motors is purposely grounded. Insulated circuits should be substituted.

(2) The type M motor shaft on the wind direction unit was bent, undoubtedly due to the heavy gear it supports.

(3) The friction disc shaft was bent causing uneven contact between the disc and the friction roller. A steel shaft should eliminate this condition.

(4) Provisions should be made for a more positive contact between the roller and follow-up motor contact segments.

(5) The lugs, securing the types A, B, and M motors, were bent. However, cast lugs furnished later by the manufacturer proved satisfactory.

(6) The terminal blocks should have an additional support in the middle to insure a more rigid mounting.

(7) Better means should be provided to prevent the zero cut-off switch screws from loosening under shock.

(8) The friction disc and roller showed excessive wear. See Plate 11.

(c) Provisions should be made to prevent the shorting of the brush springs in the self-synchronous motors, resulting from shock.

(d) No multi-pronged jacks or blocks are furnished on the instruments as required under par. E-7c(4).

(e) Although the mounting lugs on the master instrument case did not fracture under the shock test, they should be ribbed to give additional strength.

(f) The priming coat of zinc chromate paint has been omitted on the aluminum alloy cases and wind vane.

(g) Tests conducted as specified under par. F-2d(2)e, showed no increase in power consumption of the driving motor when the 19 type M motors were locked at zero and the anemometer driven at various speeds.

RECOMMENDATIONS.

(a) In view of the subject wind system having completed the 500 hour endurance test (when operating under adverse conditions, resulting from damage attributed to the shock and vibration tests) and of its compliance with the accuracy test with the exception of a 0.5 plus error at 5 knots, it is recommended that it be approved for Naval use subject to the following conditions:

(1) The correction of the deficiencies noted herein under "Conclusions."

(2) Test on a modified system for contract suitability.

DESCRIPTION OF MATERIAL UNDER TEST.

4. The subject system was manufactured by Chas. J. Henschel and Company, Inc., Amesbury, Mass., its purpose being to measure wind velocity and wind direction.

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

6. The equipment submitted consists of the following units:

1 - Transmitter.
1 - Master indicator-transmitter.
1 - Combined wind velocity and wind direction indicator.
1 - Combined wind velocity and wind direction recorder.
19 - Type M Self-synchronous motors to simulate load of repeater indicators.

Transmitting Head - Henschel Drawing No. 10-888.

7. The transmitting head consists of a three cup anemometer, having copper cups mounted on corrosion resisting steel cup arms, fastened to a vertical shaft. This 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 vane arm.

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

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

10. The case, housing the two type "A" motors, together with a terminal bar, is made of Composition BE and has a Composition BE cover. The joint between the case and cover is made watertight by means of a moulded rubber gasket.

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

12. The transmitting head is designed for mounting on the end of a 2"0 vertical pipe.

13. A 1-1/4" pipe tap is provided in the case for a Navy standard terminal tube.

Master Indicator and Transmitter - Henschel Drawing No. 10-886.

14. This instrument is, in reality, two separate instruments mounted in the same case.

15. The wind velocity section is designed to convert the output of the anemometer into wind velocity in knots and to indicate these values on a dial which is part of the instrument as well as to transmit these values to repeater indicators.

16. The mechanism in this section consists of one type "A" transmitting motor, one type "B" transmitting motor, one synchronous motor with a built-in worm gear speed reducer, one reversing motor, a friction disc and roller assembly, and a follow-up mechanism.

17. The type "A" transmitting motor is connected electrically to the type "A" motor in the transmitting head which is geared to the anemometer cup shaft. This motor is geared to a threaded shaft on which the friction disc roller is free to thread itself back and forth.

18. The friction disc is geared to the synchronous motor so its speed is always constant.

19. As the threaded shaft is connected to the anemometer cups through a pair of self-synchronous motors, it will revolve at a reduced speed proportional to that of the cups, due to the gear reduction between the anemometer shaft and motor.

20. The friction roller will then thread itself along this shaft until it reaches a point on the friction disc which has the same perephial velocity as the roller.

21. 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 velocity, 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 rack pinion is connected to a type "B" transmitting motor through a follow-up mechanism, and it is also connected directly to the dial pointer which gives the indication in this instrument.

22. The follow-up mechanism incorporates a large gear mounted on the type "B" motor shaft. On this gear slip rings and a segment assembly are mounted. The segment assembly consists of two brass segments separated by a narrow insulating segment, and 180° opposite this insulating segment is a very small air gap. A small monel metal roller, mounted on an arm which is coupled to the rack pinion, rolls around the segment assembly. A small reversing motor is geared to the gear on the type "B" motor shaft and so operates that when the roller is on the insulating segment the motor is at rest. When the roller moves onto one or the other of the brass segments, due to turning of the rack pinion, the reversing motor starts to operate and drives the segment assembly around until the insulating segment comes under the roller, which causes the motor to stop.

23. Thus, the type "B" transmitting motor is being driven into position with a power motor and with no mechanical connection between the type "B" motor and the rack pinion.

24. Therefore, the only load on the friction disc and roller assembly is that required to operate the pointer and small contact roller. This load will always be constant, regardless of the number of repeaters connected to the type "B" motor.

25. The wind direction section consists of one type "M" indicating motor, one type "B" transmitting motor, one reversing motor, and a follow-up mechanism.

26. The type "M" motor is connected electrically to the type "A" transmitting motor in the transmitting head which is geared to the wind vane shaft. This type "M" motor is geared to the contact roller arm of the follow-up mechanism, which is identical with the follow-up mechanism in the wind velocity section. The type "B" motor is driven at a constant rate of three degrees per second.

27. A dial and pointer are also provided for indicating wind direction.

28. The complete mechanism is mounted on a cast Composition "M" base-plate, which is in turn mounted in a cast aluminum alloy case and cover.

29. Terminal bars are also mounted on the base-plate and are accessible through a terminal opening located on top of the case.

30. All cover joints are made watertight by means of moulded rubber gaskets.

31. Bosses are provided in the case for I.P.S. taps for Navy standard terminal tubes. There are two bosses in the bottom of the case and two on each side.

Repeater Indicator - Henschel Drawing No. 10-847-1.

32. The repeater indicator consists of two type "M" indicating motors, two instrument lamp transformers, two lamp dimming rheostats, two dial and pointer assemblies, four dial lamps, type TS-53 (two lamps for each dial) and a terminal bar, all mounted on a cast Composition M base-plate which is in turn mounted in a cast aluminum case and cover. A separate cover is provided for access to the terminal bar and is located at the bottom of the case. The rheostats are operated by knobs mounted on the front cover and connected to the rheostats through slip couplings. Cover joints are made watertight by means of moulded rubber gaskets. Bosses are provided in the bottom of the case as well as the sides for I.P.S. taps to accommodate Navy standard terminal tubes.

33. The dials in both the master indicator-transmitter and the repeater indicator are identical. They are brass dials with a dull black background and depressed dull white markings.

34. The wind velocity dial is graduated from 5 to 80 knots in increments of one knot with markings every ten knots and distinctive lines every five knots.

35. The wind direction dial is graduated from 0 to 360° in increments of 5° with markings every 10° and distinctive markings every 30°.

Combined Wind Velocity and Wind Direction Recorder.

36. The recorder was submitted as a bench model and not as a finished product. It graphically records the wind velocity and wind direction on 24 hour paper charts.

37. Two type M motors are driven by the type "B" motors located in the master indicator-transmitter and each positions an aluminum drum on which a chart is located.

38. The recording of the wind velocity and wind direction is accomplished by an oscillating arm having two adjustable pointers which make markings on the charts by making impressions through fixed strips of typewriter ribbons. This arm oscillates at the rate of 60 times per minute and travels the length of the charts in 24 hours.

39. A Holtzer-Cabot 60 r.p.m. constant speed motor drives a lead screw which positions the oscillating pointer assembly and is deenergized by a "Burgess" micro-switch at the time the oscillating arm reaches the end of the charts. For further identification, see Plates 14 and 15.

METHOD OF TEST.

40. The system was first 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.

41. During the 500 hour test, the wind vane was rotated at approximately 1/3 r.p.m., and its direction of rotation was reversed each 24 hours.

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

43. 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.

44. Following are the results of the tests:

Requirements.	Test Values.
Voltage of system: 115.	115 volts.
Current consumption: Not specified.	13 amperes, including 19 additional type "M" motors for load.
Frequency: 60 cycles.	60 cycles.
Endurance: Par. F-2d(1).	*See remarks under "Conclusions."
Accuracy: Par. F-2d(2).	*See curves, Plate 3, and remarks under "Conclusions."
Shock integrity: F-2d(3).	*See remarks under "Conclusions."

Requirements	Test Values
Vibration integrity: Par. F-2d(3)c.	*See remarks under "Conclusions."
Accuracy following shock: Par. F-2d(2).	*See curves, Plate 3, and remarks under "Conclusions."
Damping tests: Par. F-2d(4).	Satisfactory, an average pointer displacement of 3 degrees per second.
Damping tests: Par. F-2d(4)c of ref.(c).	Satisfactory, 0.2 oz. to move vane.
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(2)f.	Satisfactory, causing no additional errors in the system. Note: Not applicable to disc motor in master instrument and timing motor in recorder.
Inclination tests: Par. F-2d(1)c.	Satisfactory operation under the specified conditions.
Dielectric tests: Par. F-2d(5)d.	*Satisfactory except for breakdown occurring on one of the lighting transformers of the repeater indicator.
Insulation tests: Par. 5-2d(5)e.	Satisfactory, 200 megohms by 500 volt megger.
Watertight tests: Par. 5-2d(5)f.	*Master indicator-transmitter leaked 150 cc. of water. Transmitter leaked 35 cc. of water when splashed.
Dial illumination: Par. E-5h.	The distance from which the repeater dials could be read in a dark room was approximately 2 feet.
Dimensions: Par. E-4a(4).	
Master-indicator 21" x 14" x 12"	19" x 17" x 12".5
Repeater-indicator 21" x 12" x 10"	18" x 11" x 9".25
Transmitter: Not specified	32".5 in height and 38".0 in diameter.
Recorder: Not specified	24".0 x 10".0 x 9".5
Weights: Par. E-4a(5)	
Master-indicator 70 lbs.	*114 lbs. 9 oz.
Repeater-indicator 60 lbs.	45 lbs. 8 oz.
Transmitter - 90 lbs. ref. (b)	
45 lbs. ref. (c)	49 lbs. 6 oz.
Recorder: Not specified	46 lbs. 4 oz.

*Denotes failure to comply with specifications.

CONCLUSIONS.

45. The subject system failed to meet the following requirements of the specifications:

(1) The system complied with the 500 hour endurance test but for an occasional error due to the failure of the monel rollers in the follow-up systems of the master indicator-transmitter to function properly. An inspection disclosed lack of free movement of the roller arm assembly, thereby preventing the roller from properly contacting the segments in the follow-up motor circuits.

(2) Under test for accuracy of the system, the only excessive errors observed (at an equivalent cup speed of 5 knots) were +0.5 in the master indicator-transmitter and +0.25 in the repeater indicator. See curves, Plate 3.

(3) Under test for shock integrity, trouble developed in the repeater indicator due to the whipping and shorting of the type M motor brush springs at the time of impact. Trouble also developed in the recording instrument due to the threaded lever, which normally engages the lead screw, disengaging and then engaging at a different position.

(4) Under the vibration test, an occasional error occurred in the master indicator-transmitter, due to the lack of free movement of the roller arm assembly, thereby preventing the roller from properly contacting the follow-up motor contact segments.

(5) Under the dielectric test, one of the dial lighting transformers in the repeater indicator broke down, the breakdown occurring between primary and ground.

(6) Under test for watertight integrity, the master indicator-transmitter leaked 150 cc. of water due to a sand hole in the case.

(7) The transmitter unit, when splashed with water under the conditions specified in D-10b of reference (c), leaked 35 cc. of water. This leak occurred at the skirts on the anemometer and vane shafts.

(8) The weight of the master indicator-transmitter is 114 lbs., while that allowed is 70 lbs.

46. Under inspection of the master instrument at the close of the tests, the following defects were noted:

(1) One side of each of the low voltage windings of the follow-up motors is purposely grounded. Insulated circuits should be substituted.

(2) The type M motor shaft on the wind direction unit was bent, undoubtedly due to the heavy gear it supports.

(3) The friction disc shaft was bent causing uneven contact between the disc and the friction roller. A steel shaft should eliminate this condition.

(4) Provisions should be made for a more positive contact between the roller and follow-up motor contact segments.

(5) The lugs, securing the types A, B, and M motors, were bent. However, cast lugs furnished later by the manufacturer proved satisfactory.

(6) The terminal blocks should have an additional support in the middle to insure a more rigid mounting.

(7) Better means should be provided to prevent the zero cut-off switch screws from loosening under shock.

(8) The friction disc and roller showed excessive wear. See Plate 11.

47. Provisions should be made to prevent the shorting of the brush springs in the self-synchronous motors, resulting from shock.

48. No multi-pronged jacks or blocks are furnished on the instruments as required under par. E-7c(4).

49. Although the mounting lugs on the master instrument case did not fracture under the shock test, they should be ribbed to give additional strength.

50. The priming coat of zinc chromate paint has been omitted on the aluminum alloy cases and wind vane.

51. Tests conducted as specified under par. F-2d(2)e, showed no increase in power consumption of the driving motor when the 19 type M motors were locked at zero and the anemometer driven at various speeds.

PLATE 1.

National Bureau of Standards — 4-1/2 Foot Wind Tunnel. January 26, 1937.

Test of Wind Intensity System
Type A DR 10-886

True Wind Speed Knots	Indicated Wind Speed Knots
5.2	5.3
5.5	5.7
9.9	10.7
15.0	15.4
19.9	20.5
24.9	25.2
29.9	30.2
34.8	34.6
39.9	39.7
44.7	44.2
49.9	49.2
59.1	58.4
70.2	68.8

Starting speed . . . 5.5 knots
Stopping speed . . . 2.4 knots
Air Temperature. . . 22° C.
Pressure . . . . . 758 mm Hg.
Turbulence 0.7%

PLATE 2.

National Bureau of Standards — 4-1/2 Foot Wind Tunnel. January 26, 1937.

Test of Wind Direction System
Type A DR 10-886

Performance in 5 knot wind.

Vane deflected 5° down scale. Returned past zero position by 3°.
Vane deflected 5° up scale. Returned 3°, failing to reach zero position by 2°.
Vane deflected 15° down scale. Returned past zero position by 3°.
Vane deflected 15° up scale. Returned to zero position.

Performance in 10 knot wind.

Vane deflected 5° down scale. Returned to zero position.
Vane deflected 5° up scale. Returned to zero position.
Vane deflected 15° down scale. Returned to zero position.
Vane deflected 15° up scale. Returned to zero position.

U. S. NAVAL RESEARCH LABORATORY
BELLEVUE, D. C.

DATE

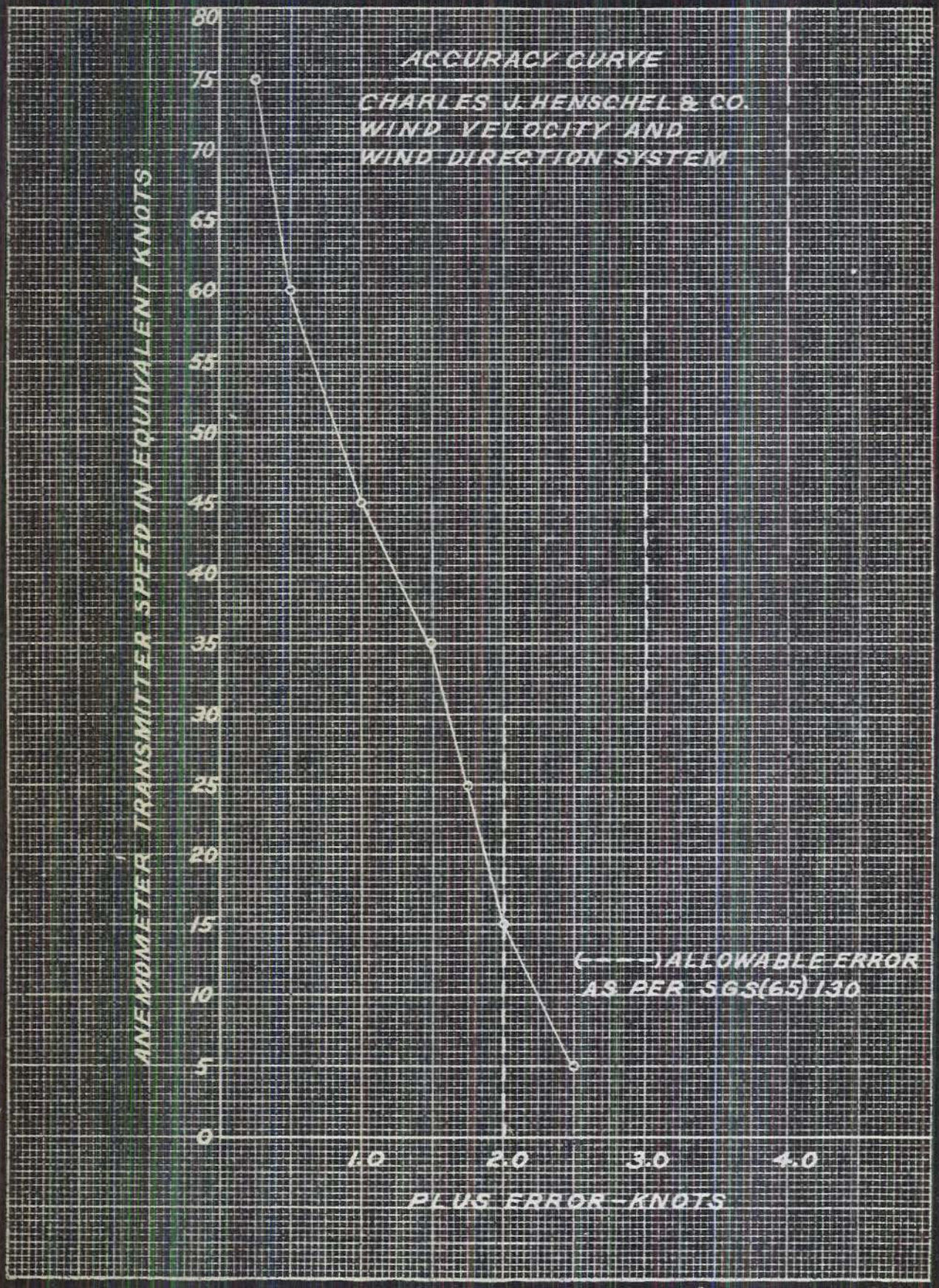
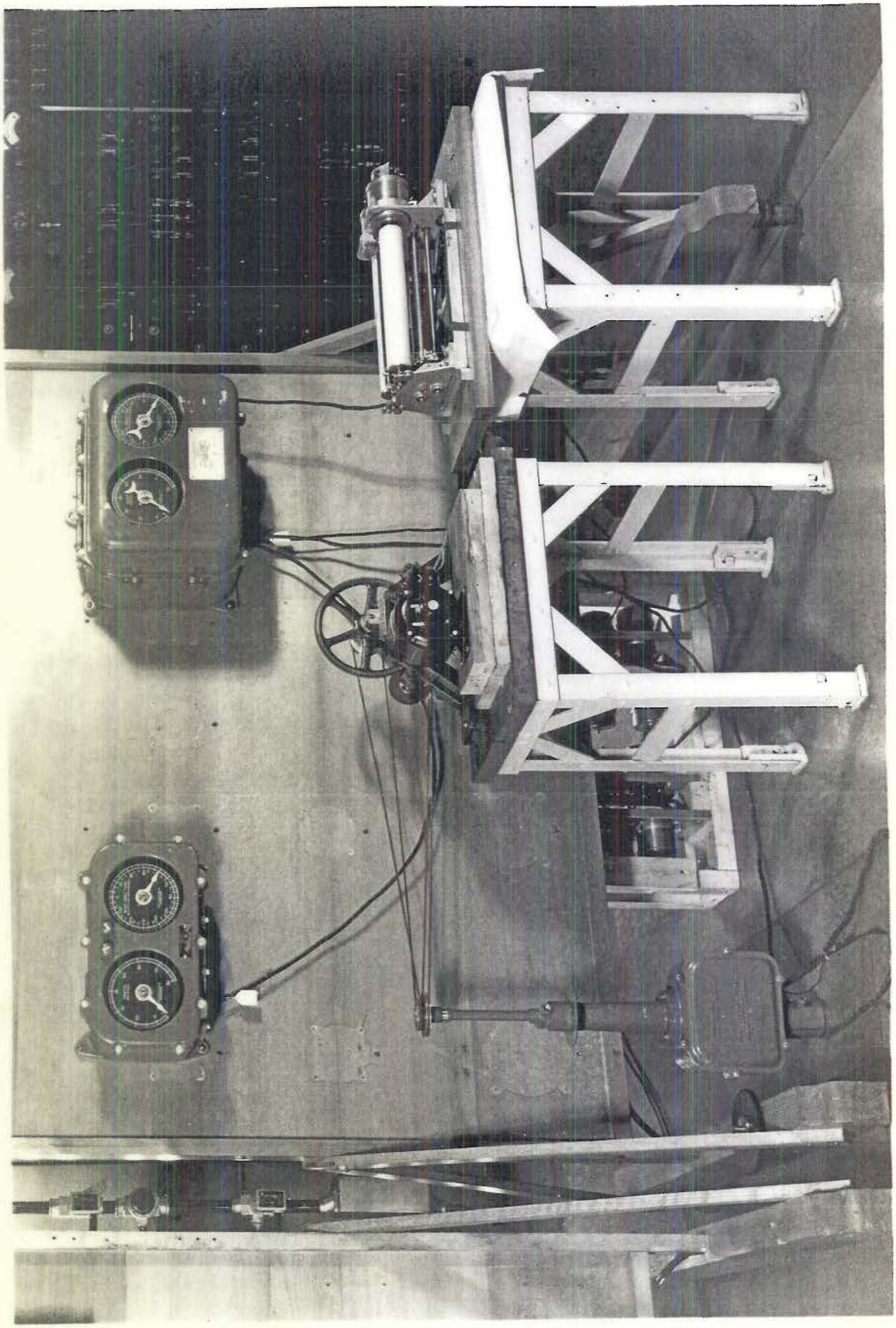


PLATE 3

N. R. L. 8A



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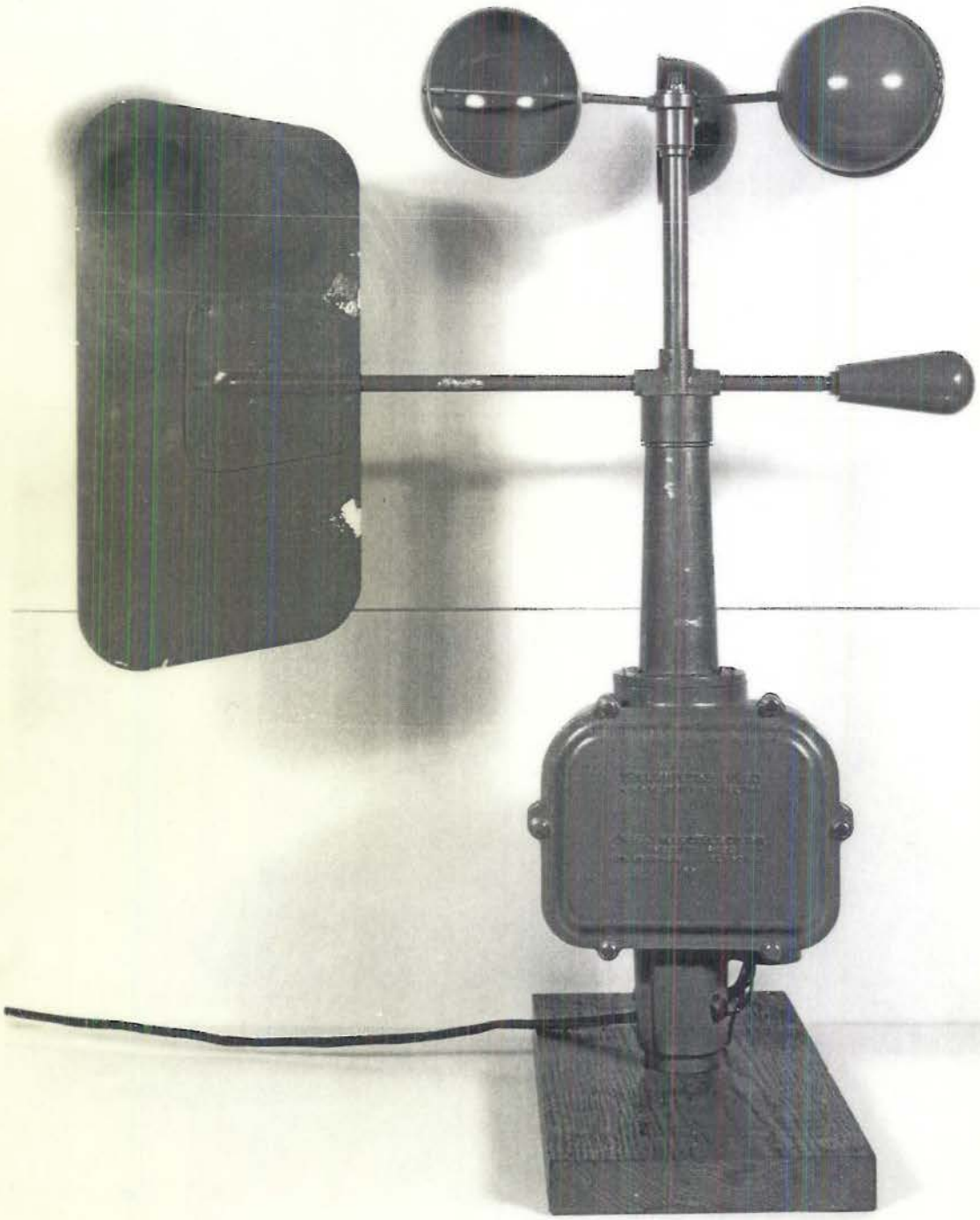

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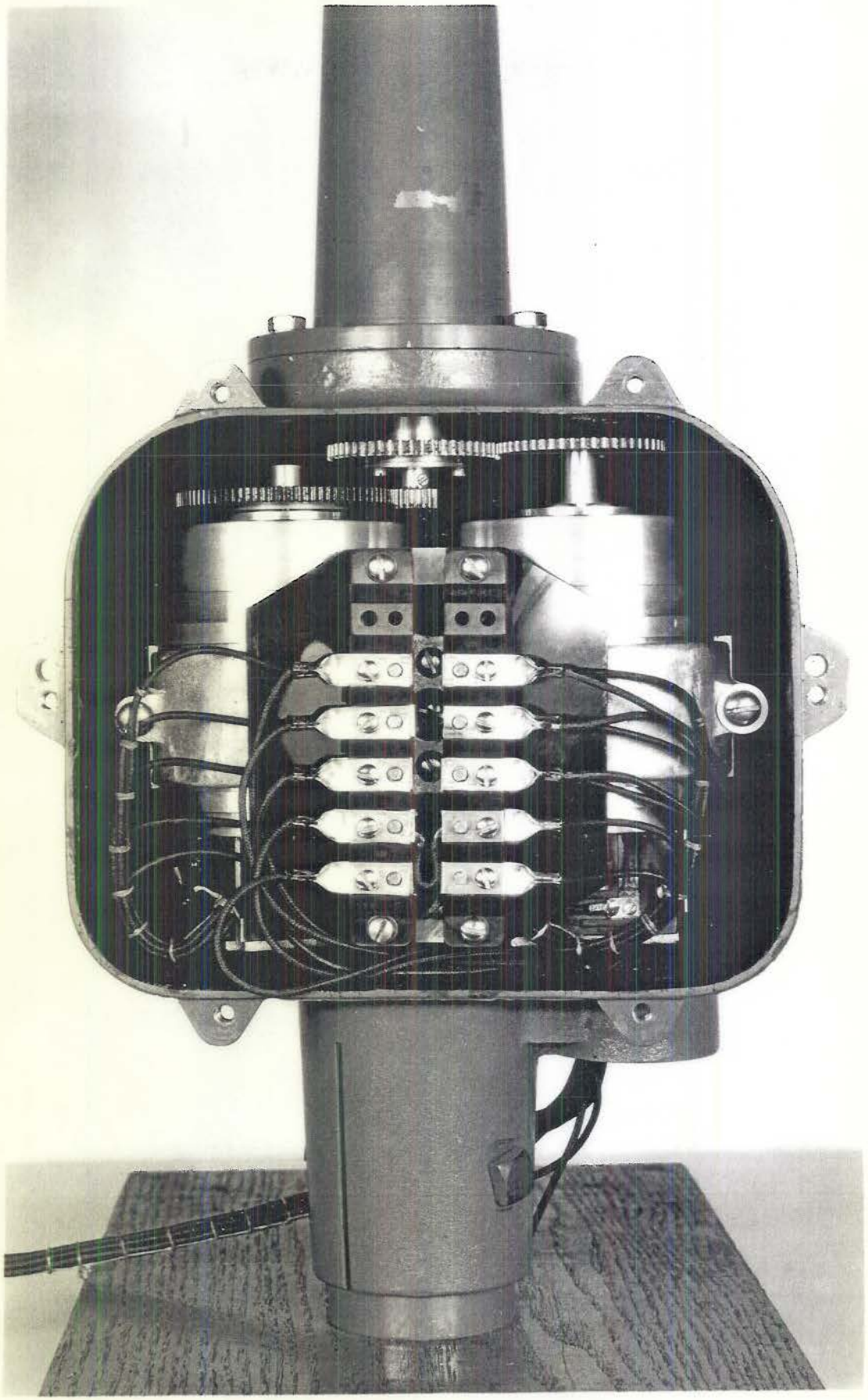
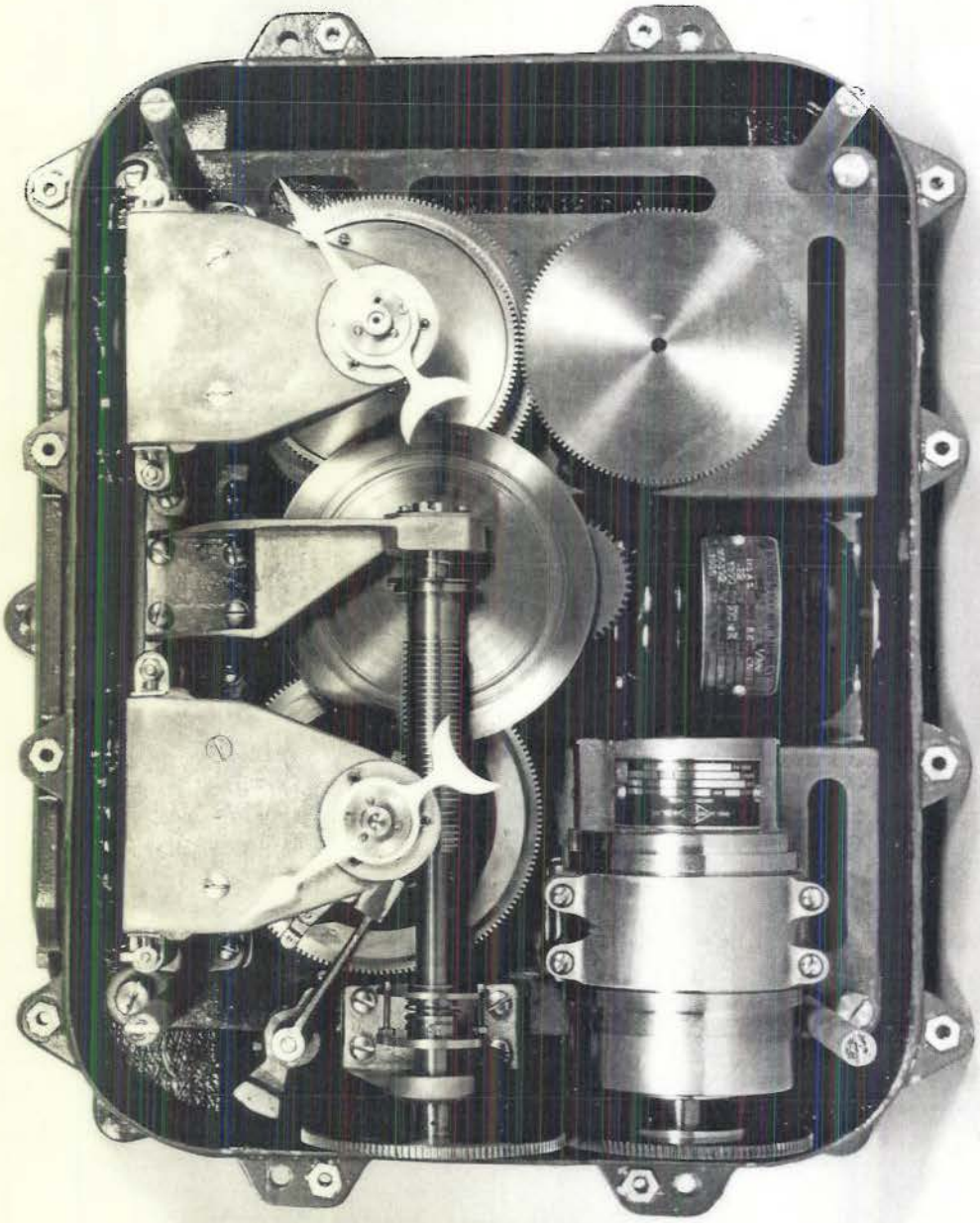


Plate 6


KNOTS
WIND DIRECTION
RELATIVE TO SHIPS BOW IN DEGREES
MASTER INDICATOR
TYPE A
WIND VELOCITY & DIRECTION
INDICATING SYSTEMS
CHAS. J. HENSCHEL & CO. INC.
AMESBURY, MASS.

Plate 7



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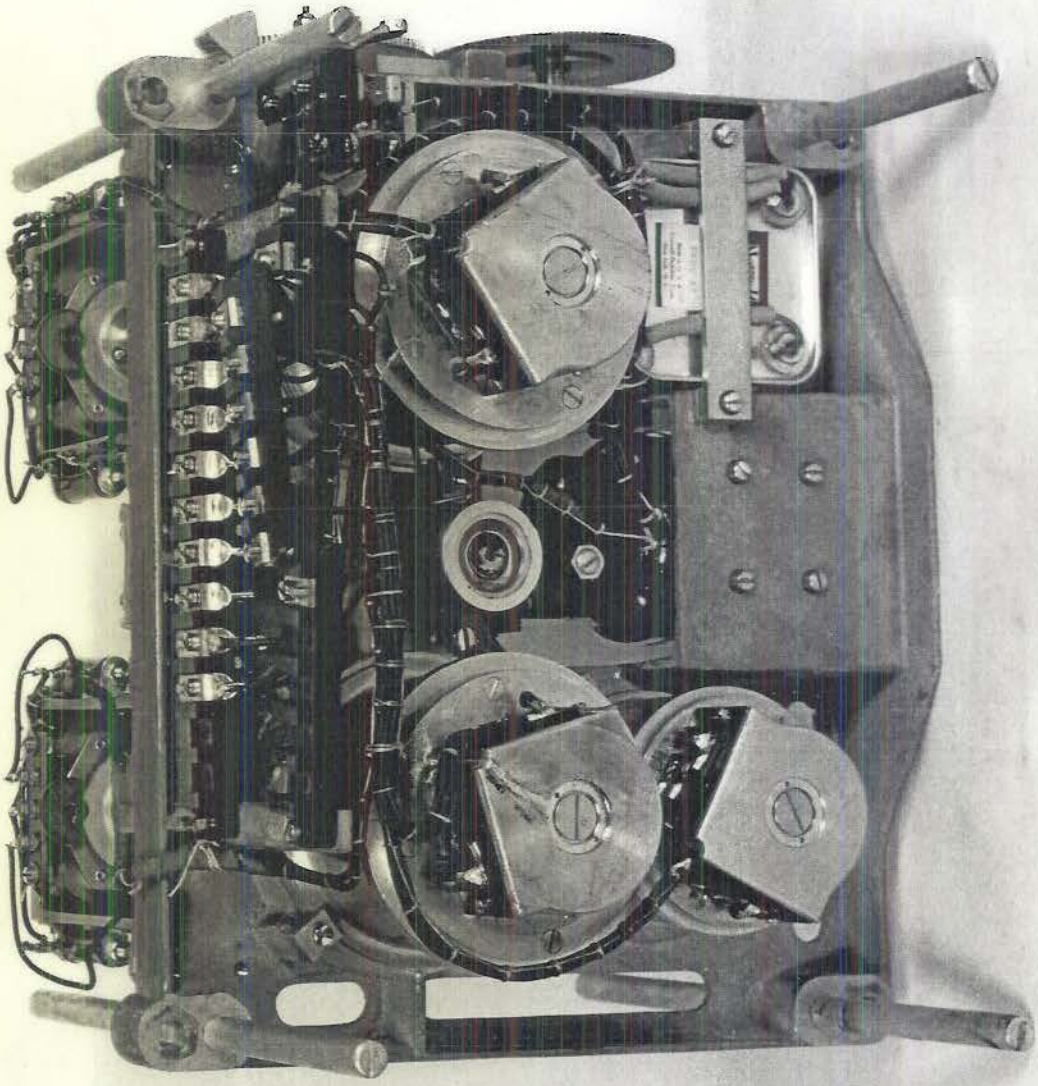

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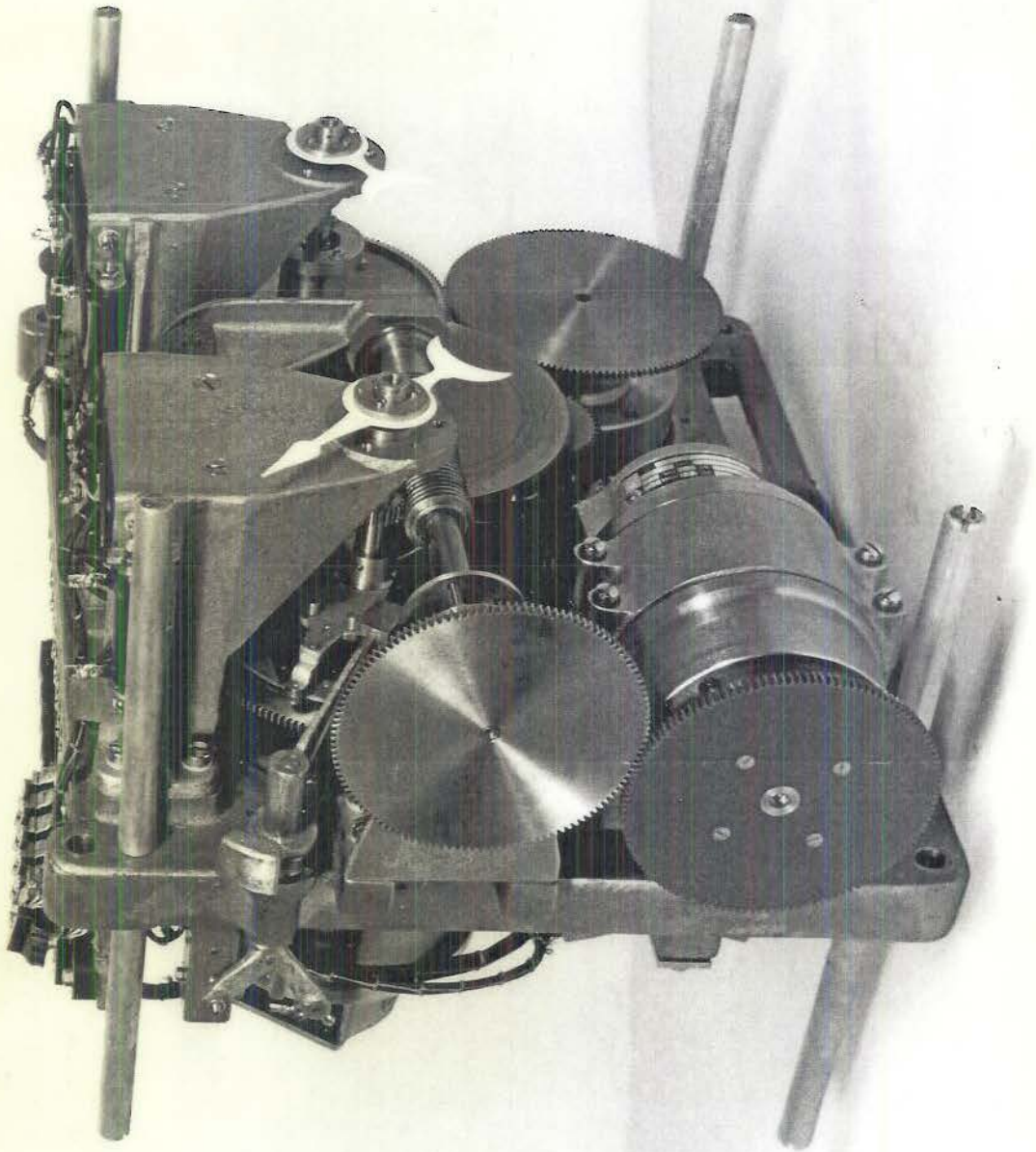


Plate 10

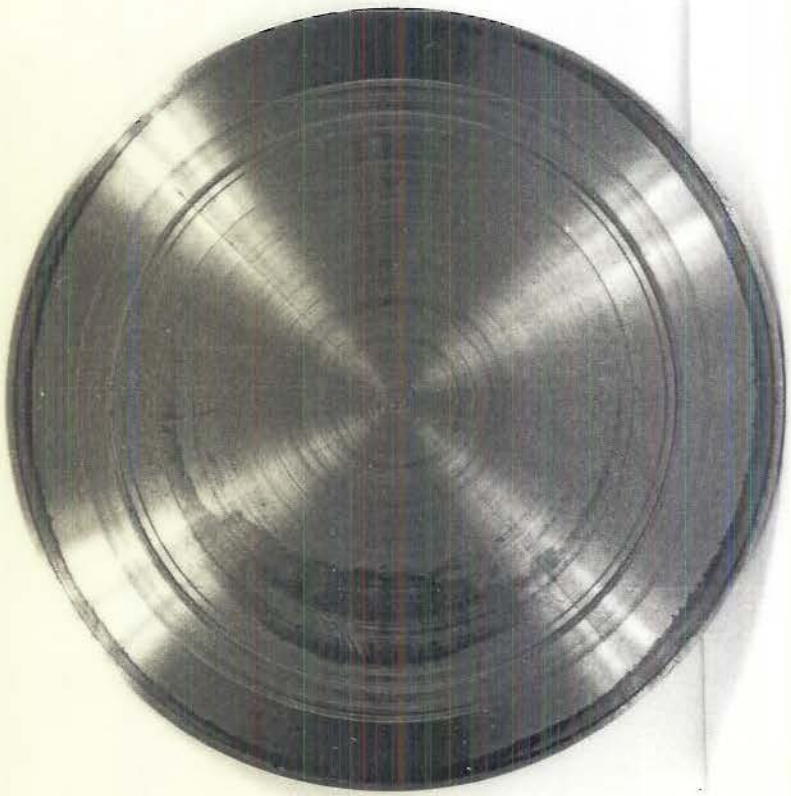


Plate 11

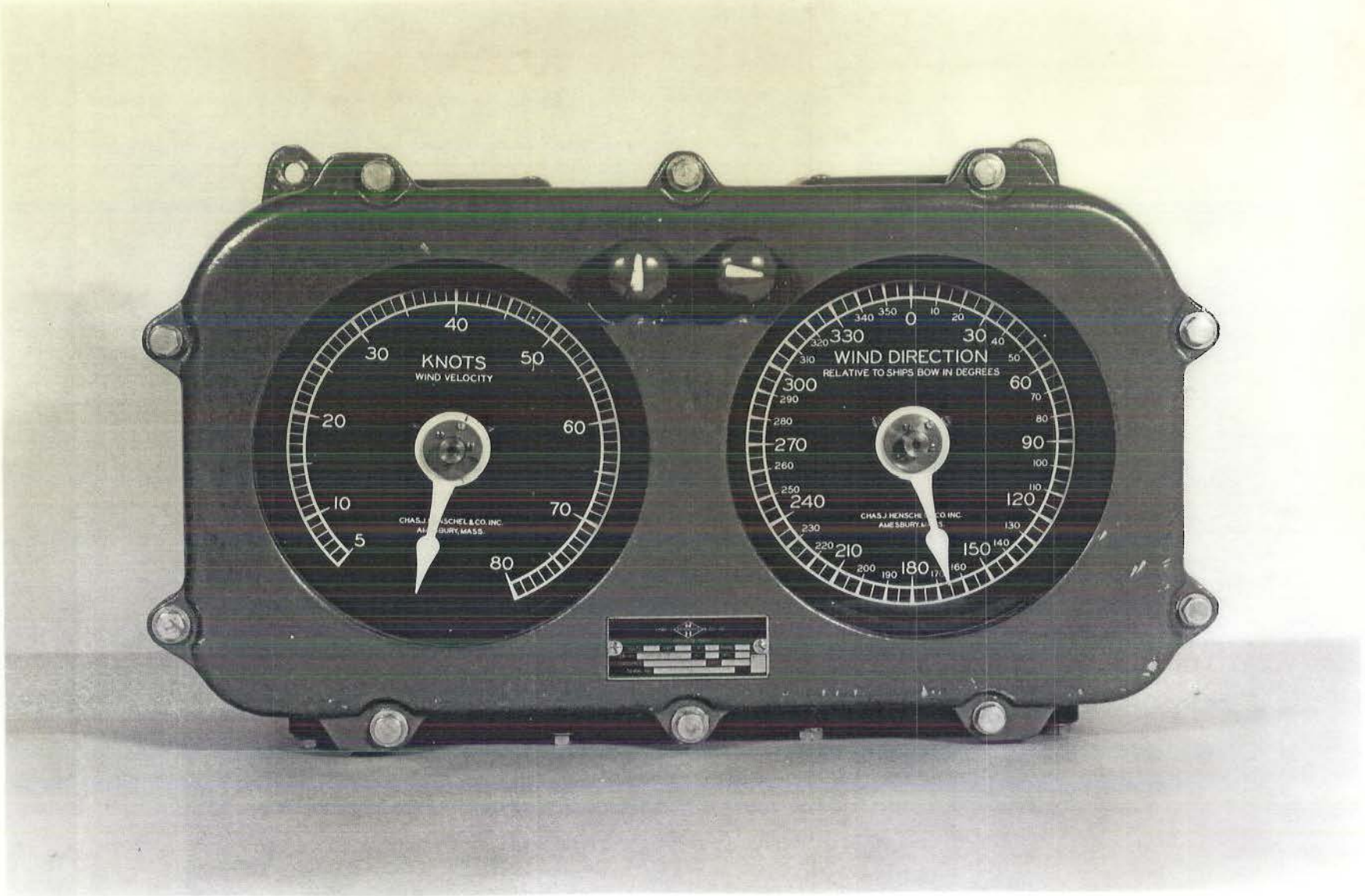
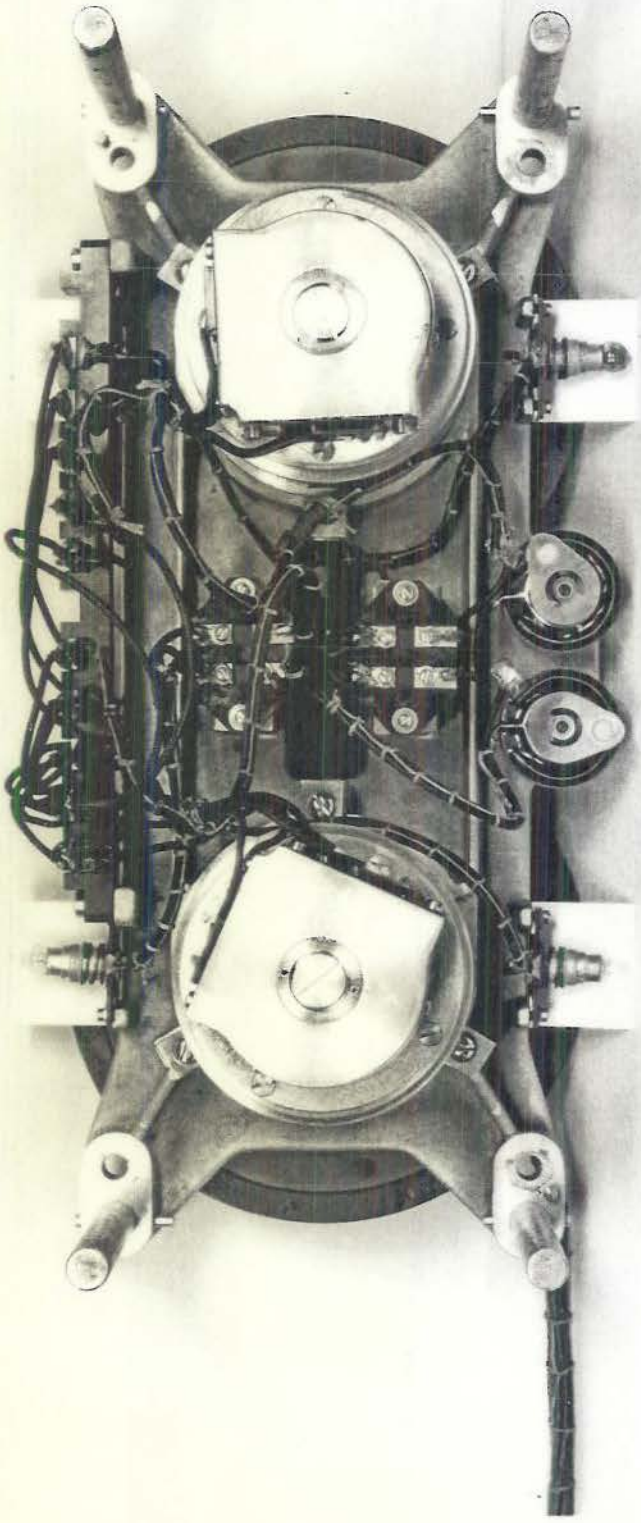

KNOTS
WIND VELOCITY
40
30
50
20
60
10
70
5
80
WIND DIRECTION
RELATIVE TO SHIPS BOW IN DEGREES
0
330
30
300
60
270
90
240
120
210
150
180

Plate 12



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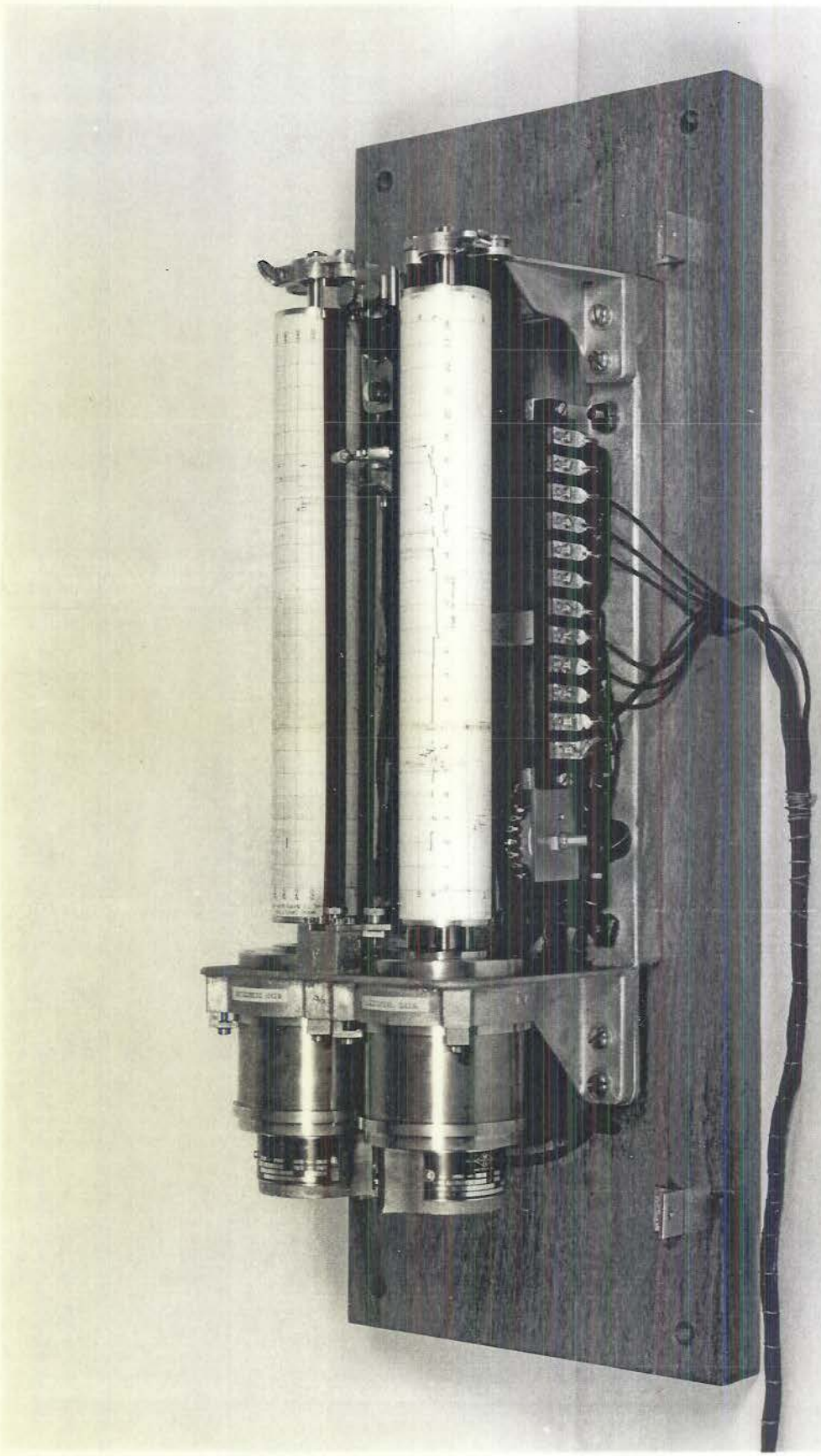

Plate 14

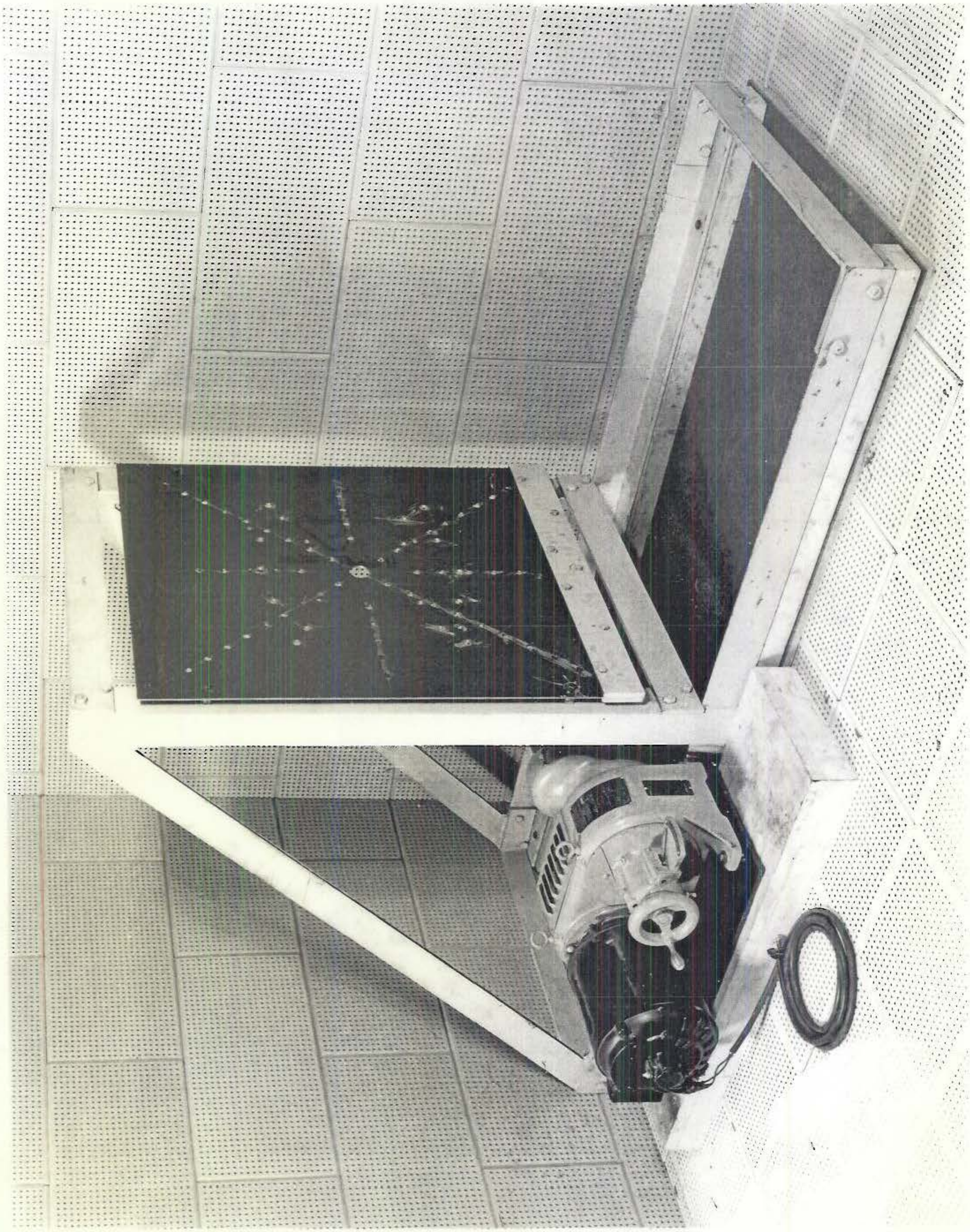

Plate 16

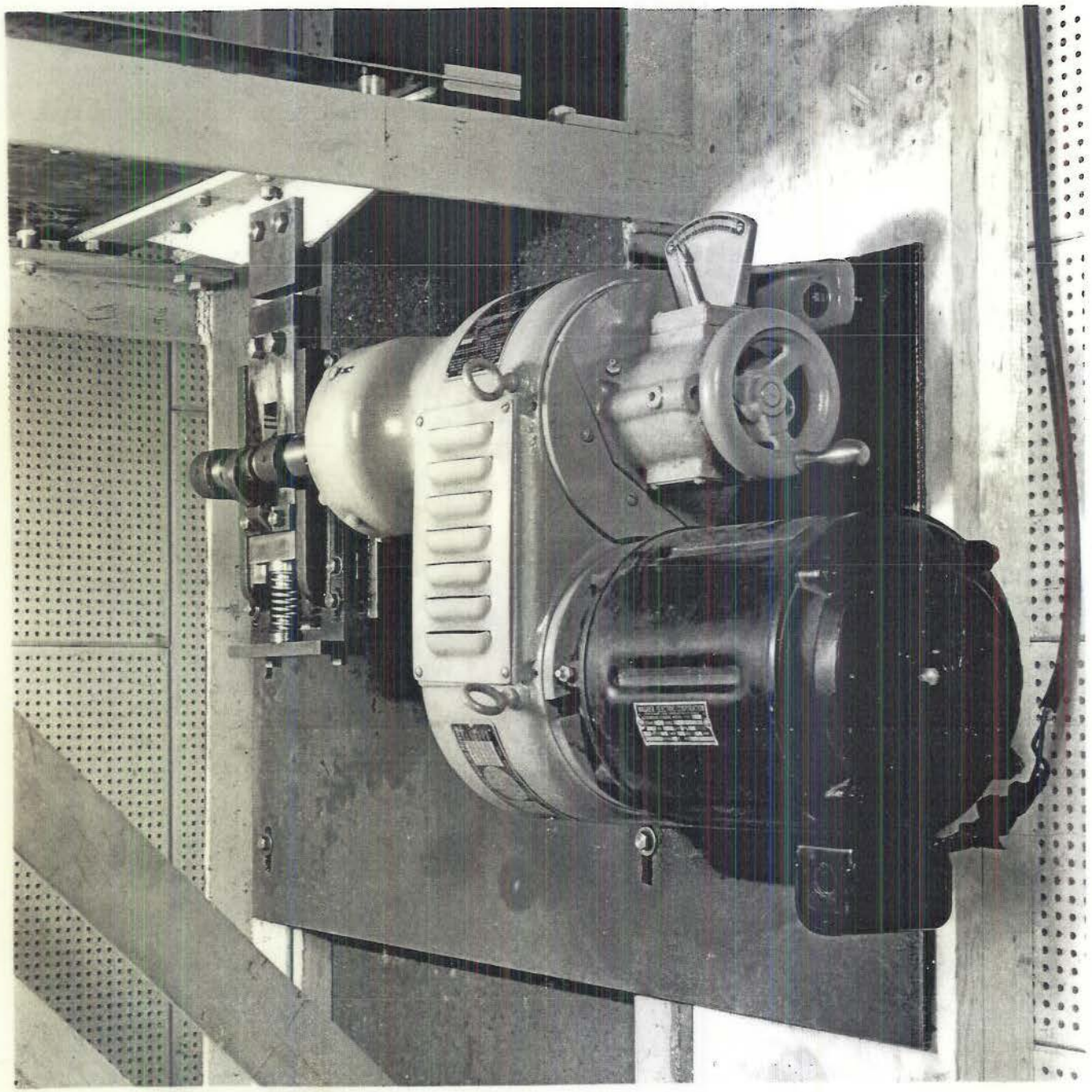

Plate 17