12 February 1936 NRL Report No. B-1237

NAVY DEPARTMENT
BUREAU OF ENGINEERING

FR-1237

Report on

Test of Propeller Shaft Revolution Indicator System, Instantaneous Type, Manufactured and Submitted by the Electric Tachometer Corporation, Philadelphia, Pa.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
Washington, D.C.

Number of Pages: Text - 11 Plates - 17

Authorization: BuEngr.let.S65-5/L5(12-4-Ds) of 5 December 1935.

Tested by:

J.R. Coomes, Senior Engr. Aide.

J.S. Bryant, Senior Engr. Aide.

Prepared by:

W.B. Roberts, Pr.Engr. Aide,
Chief of Section

Reviewed by:

W.M. Haynsworth,Jr. Lieutenant, USN

Approved by:

H.M. Cooley, Captain, USN,
Director.

Distribution:
Eng. (5)

vhw

TABLE OF CONTENTS

APPENDICES

AUTHORIZATION

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

Reference: (a) BuEng.let. S65-5/L5(12-4-Ds) of 5 Dec. 1935.
(b) Navy Dept.specifications SGS(65)-10a of 1 Mar.1935.
(c) Navy Dept.specifications SGS(65)-42 of 1 May 1934.
(d) NRL Report B-1203 of 14 Oct. 1935.
(e) Eng.let.DD384/S65(1-20-Df) of 4 Feb.1936 to INM, New York.

OBJECT OF TEST

2. The object of this test was to determine whether the subject shaft revolution indicator system complied with the specifications, references (b) and (c), for type approval.

ABSTRACT OF TEST

3. The submitted system, shown by Plate 1, was interconnected electrically and tested for conformance with specifications, references (b) and (c). Due to development of trouble in No. 1 master instrument, the endurance test was extended from 500 hours to 864 hours. The shaft transmitters were driven ahead at a speed corresponding to shaft speeds of 400 r.p.m. One hour in every 24 hours, the direction of rotation of both shafts was reversed. Particular attention was given the master indicator transmitters and repeater indicators to note whether the error was within the accuracy requirements. Over the entire period of the test, the synchronous motors of the master transmitter indicators were supplied with current from the frequency control unit (Drawing #2109F). The usual inspection of the equipment for conformance with the specifications, relative to design and materials, was made.

CONCLUSION

(a) This "Propeller Shaft Revolution Indicator System", manufactured by the Electric Tachometer Corporation, Phila., Pa. was generally satisfactory under test except for the inaccuracy of one master instrument. If modified to correct this and other defects noted under "Comments" of this report, it should prove satisfactory for Naval use.

RECOMMENDATIONS

(a) It is desired to repeat recommendations (c) and (d) as covered in NRL Report B-1203, reference (d).

(b) It is also recommended that the manufacturer substitute a suitable ball bearing mounting for the present sleeve bearing for the shaft of the field rheostat of the frequency control unit, to correct the defect noted in paragraph 44.

(c) In conclusion, considering the generally satisfactory test results, it is recommended that this system be given type approval subject to "Comments" of this report and a satisfactory inspection in accordance with the provision of Bureau letter to Inspector of Machinery, New York, reference (e).

DESCRIPTION OF MATERIAL UNDER TEST

4. This instantaneous type propeller shaft revolution indicator system is designed to indicate the speeds of twin shafts and to operate from the ship's supply of 115 volts, a.c., 60 cycles. The synchronous motors located in the master indicator transmitters are energized from the frequency control unit (Drawing 2109-F), which is energized from a 115 volt d.c. and a 115 volt a.c., 60 cycle supply.

5. The system submitted consists of the following units:

	Mfgr's Drawing No.
2 Shaft transmitters	2100
2 Master indicator transmitters	2102
2 Two shaft repeater indicators	2103
1 Tell-tale indicator	2104
1 Master counter transmitter	2105
1 Double intermittent counter	2106
1 Frequency control unit	2109-F

Shaft Transmitters

6. Each shaft transmitter consists of one type "A" motor, one six digit mechanical counter, one uni-directional gear assembly and a six line terminal block, enclosed in a composition BE watertight case. It is driven by means of bronze and phenolite spur gears from the propeller shaft through a ratio of 3:1, so that a speed of 400 r.p.m. of the propeller shaft produces a speed of 1200 r.p.m. at the main transmitter shaft.

7. The main transmitter shaft is housed in heavy ball-bearings, provided with a watertight stuffing gland and drives a type "A" motor through a gear ratio of 15:1. In addition to the worm gear it incorporates a uni-directional gear, so that regardless of the direction of rotation of the propeller shaft, the type "A" motor rotates in the same direction (counter-clockwise when viewed from the shaft end).

8. The six digit counter, counting unit revolutions of the propeller shaft, is driven independently through sprockets and a chain from the main transmitter shaft. It is so mounted that the type "A" motor can be removed without disturbing the functioning of the revolution counter. The counter is visible through a watertight glass window located in the top of the cover.

9. The uni-directional gear train embodies a contact switch to operate the direction of rotation signals located in the various indicators.

10. The purpose of the type "A" motor in the shaft transmitter is to transmit rotations of the propeller shaft to the motors located in the

master indicator transmitters, tell-tale indicator, and port and starboard average master counter transmitter. The speed of the transmitter motor is 80 r.p.m. when the propeller shaft speed is 400 r.p.m.

Master Indicator Transmitter (Dwg.#2102)

11. Located in the master transmitter indicator is a type "M" motor connected to the type "A" motor in the propeller shaft transmitter. This motor runs continuously in synchronism with the transmitter motor and is connected through a 1:1 spiral gear to a right-hand lead screw, supported by double ball-bearings, on which moves a rack containing a cylindrical nut secured to a hardened steel friction wheel approximately 2-3/8 inches in diameter.

12. The friction wheel is in contact with a friction disc, driven at a constant speed of 60 r.p.m. by a Holtzer Cabot synchronous motor. A reduction drive between the 1800 r.p.m. synchronous motor and the friction disc is accomplished through a 30:1 worm gear. The friction disc is pressed against the friction wheel on the screw shaft by a steel spring located in its housing. When the propeller shaft is in motion, the friction wheel will assume a position on the friction disc where the surface speeds of the disc and wheel are equal. For any speed of the propeller shaft, there is a definite location for the friction wheel along the axis of the screw shaft. The displacement of the friction wheel along the screw shaft causes the rack to rotate a steel pinion located on a vertical ball-bearing mounted shaft. Located on the rack is a lever arm which cuts off the synchronous motor driving the friction disc at approximately zero shaft speed by means of a "Burgess" normally closed "micro-switch". To prevent the rack from jamming against the screw shaft housing when the shaft speed exceeds 450 r.p.m. (approximately), or the synchronous motor fails, a pin inserted in the shaft engages a pin projecting from the friction wheel. This causes the wheel to rotate with the shaft and slip where it contacts the friction disc.

13. The vertical shaft engages a contact making device and a follow-up device described in paragraph 15.

14. From the screw shaft, which is running at a speed proportional to the speed of the propeller shaft, a six digit counter is driven by a chain and sprockets. Located in this instrument is a red and black signal target to show "Back" or "Ahead" rotation of the propeller shaft through the operation of the contact switch located in the propeller shaft transmitter. The object of the follow-up contact device is to actuate a reversible type follow-up motor in order to set the pointers to a position corresponding to true r.p.m. of the propeller shaft. At the same time, the follow-up motor, through suitable gearing, positions a type "A" motor, which positions the type "M" motors located in the twin repeater indicators.

15. The action of the follow-up mechanism is as follows: Located on the end of the pinion shaft, actuated by the rack on the screw shaft nut, is a steel disc, approximately 1-3/4 inches in diameter, having a notch in its periphery. A follow-up switch or contactor is mounted on a second (insulating) disc, parallel to and co-axial with the notched operating disc. It normally shorts both forward and reverse shading coil circuits of the follow-up motor, but may open one or the other to give the desired direction of rotation. The

contactor is operated by a small crank having a roller which normally engages the notch on the first disc. Displacement of the notch to a higher speed position turns the small crank out of its normal radial position and lifts the reverse contact arm from its contact. The other contact arm remains closed and allows the follow-up motor to operate and turn the hands (and the second disc carrying the contactor) up to a new position, the roller drops into the slot, the crank assuming its normal radial position, and the raised contact arm makes contact renewing the short circuit on the reverse shading coils. This normal short on both forward and reverse shading coil circuits results in a strong inductive breaking effect on the rotor, which stops the follow-up system at a point corresponding to the new readings. Change to a lower speed indication is effected in the same way, the displacement opening the forward circuit until the new indication is duplicated by the follow-up system.

16. The case and cover of the master indicator are aluminum castings and square cross section rubber gaskets are provided. An aluminum mounting plate is bolted in the case and is provided with legs and lifting handles so that the complete unit may be removed from the case and placed on a flat surface for inspection. The case is designed for panel mounting.

17. The dial is approximately 8 inches in diameter and has white markings on a dull black background. It is illuminated with five (5) VG2-N lamps and is divided into two concentric scales, the inner scale reading from 0 to 4 and denoting hundreds of r.p.m., the outer scale reading from 0 to 100 and denoting units of r.p.m. Located behind a slot in the dial is a six digit mechanical counter.

Repeater Indicator (Drawing #2103)

18. This two shaft indicator contains two type "M" motors and two direction targets. It has a 7 inch dial graduated from 0 to 400 in divisions of 2 r.p.m. and is numbered every 20 r.p.m. Every fifth division and the pointers and direction target are painted with radium luminous material. The pointers are identified by the numerals "1" and "2" on green and red backgrounds respectively. The dial is illuminated with six (6) type VG2-A lamps from two circuits. The watertight cast aluminum case is provided with two (2) bosses tapped for 1-1/4 inch terminal tubes, a hand hole cover, and four (4) lugs for bulkhead mounting.

Tell-tale Indicator (Drawing #2104)

19. This instrument embodies two (2) type "M" motors which run continuously at the same speed as the type "A" motors of the propeller shaft transmitters. Both motors are geared to a mechanical differential in such a way that a pointer secured to the spindle rotates one complete revolution for a difference of twenty (20) revolutions between the two shafts. When the leading shaft, No. 1, turns faster than the following shaft, the pointer rotates in a counter-clockwise direction and when the following shaft is faster, the pointer rotates in a clockwise direction. When the shaft speeds are equal, the pointer remains stationary. A direction target is provided to show the direction of rotation of the leading shaft. The dial is 8 inches in diameter, having a black background with white markings and white pointer. It is graduated from 0 to 20 in steps of 1, every second division being

numbered. Six (6) type VG2-N lamps are provided for dial illumination. The watertight aluminum case is provided with two bosses tapped for 1-1/4 inch terminal tubes, a hand hole cover, and is designed for panel mounting.

Master Counter Transmitter (Drawing #2105)

20. This instrument contains two type "M" motors, one type "A" motor, three "Veeder" six digit mechanical counters and a mechanical differential. The rotation of the propeller shafts is transmitted to the type "M" motors which are connected to two sides of the differential as well as to their respective counters. The driven shaft of the differential is connected to a third counter and a type "A" motor, which transmits the average revolutions to the double intermittent counter. The counters are visible through windows located in the case and are illuminated with four (4) type VG2-N lamps. The case is of watertight construction having two (2) bosses tapped for 1-1/4 inch terminal tubes and four (4) lugs for bulkhead mounting.

Double Intermittent Counter

21. This watertight unit is portable and is designed for use where jacks are located. It contains a type "M" motor and two (2) six digit Veeder counters connected through a gear shifting device. This enables the operator to connect the motor to either of the counters and obtain average r.p.m. by clocking. The instrument is built into an aluminum case and is equipped with 30 feet of portable cord and a watertight plug. A watertight jack box, having an aluminum case and a BE cover is also provided.

Frequency Control Unit (Drawing #2109-F)

22. This unit is designed to regulate the frequency output of a 60 cycle, a.c. motor-generator which supplies power for the synchronous motors of the master indicator transmitters, and comprises a 60 cycle tuning fork operating in conjunction with a vacuum tube amplifier to drive a small Holtzer-Cabot synchronous motor, geared to one side of a mechanical differential. A similar synchronous motor, geared to the other side of the differential is connected to the output of a DC-AC 250 watt motor-generator set. This machine has an auxiliary regulating field winding in the d.c. motor side, connected in series with a field control rheostat operated by the mechanical differential. Thus, one differential motor runs at a speed of 1800 r.p.m. (proportional to the tuning fork frequency) and the other runs in synchronism with the motor-generator set. Any variation of speed of the motor-generator set will result in a change of the rheostat resistance. The frequency output of the motor-generator set is therefore equal to the tuning fork frequency. The fork is said to have a temperature coefficient so low that the frequency will not vary more than 0.05 of 1% over a temperature range of 40° to 140°F.

23. The three (3) stage a.c. operated vacuum tube amplifier has two (2) channels so designed that failure of any one tube, or all four (4) tubes in one (1) channel or a maximum of four (4) tubes alternately staggered in both channels, does not affect either the operation or the accuracy of the unit. Each of the type 83 mercury-vapor hot-cathode rectifiers and each bank of amplifying tubes has a separate filament supply winding in the power transformer.

24. A self-starting clock motor, with a one-minute sweep hand, a stroboscope with a glow lamp, and a relay connected to the a.c. output of the motor-generator set, operate as follows:

(a) The sweep hand of the clock motor provides a check of the motor generator output frequency when clocked.

(b) The glow lamp and stroboscope disc driven by the tuning fork motor, provide an instantaneous check for the motor-generator frequency against the fork frequency.

(c) The two (2) pole D.T. relay instantaneously connects the synchronous motors of the master instruments to the ship's 60 cycle supply in case of failure of the motor-generator set.

Operation of Frequency Unit

25. The toggle switch "T" is thrown to the "ON" position, supplying ship's 60 cycle power to the tuning fork amplifier through two-ampere fuses. Unless started with a light tap, 1-1/2 to 2 minutes are required for the tuning fork to build up to a normal amplitude of vibration and cause the top motor of the differential to revolve the stroboscope disc. When this time has elapsed, the motor-generator should be started by connecting to the ship's 115 d.c. supply.

26. The output of the motor-generator operates the clock motor and the lower motor of the differential and lights the neon glow lamp behind the stroboscope disc. The rheostat, operated by the differential, is thereby moved to a position where the speed of the motor-generator is such that its frequency output is equal to the frequency of the fork. When the radiating lines of the stroboscope do not appear to rotate either to the right or left, the frequency output of the motor-generator and the vacuum tube amplifier are equal. The winding of a D.P.D.T. relay, located in the center connection box of the motor-generator is energized by the a.c. output and is so connected that the synchronous motors in the master indicator transmitters are energized from the motor-generator when it is running and from the ship's a.c. supply when it is not.

Motor-Generator

27. This set is manufactured by the Electric Specialty Company and the following nameplate data are given:

Motor	Generator
115 V. d.c.	115 V. a.c.
4.5 amps.	2.8 amps.
1/2 H.P.	250 V.A.
1800 r.p.m.	85% P.F.

Compound wound	Compound wound
Continuous duty	
Ball-bearing	Ball-bearing

METHOD OF TEST

28. The system was first tested for endurance while the two (2) synchronous motors in the master instruments were energized from the output of the frequency controlled equipment furnished with the system. During this test the two (2) shaft transmitters were driven by synchronous motors, through suitable gears, at a speed corresponding to a propeller shaft speed of 400 r.p.m. The direction of rotation of the driving motors was reversed for one hour in each twenty-four hours of operation.

29. Following the endurance test, the accuracy of the system was checked at shaft speeds of 60, 100, 150, 200, 250, 300 and 400 r.p.m. for periods of three hours clockwise and three hours counter-clockwise.

30. The temperature compensation tests were next conducted by successively placing one master indicator transmitter and the frequency control unit in a compartment having an ambient temperature of 135°F for a period of twenty-four hours. For the last two hours of this period, the system was energized and operating at the maximum speed of 400 r.p.m. In addition, tests were made to note any change in the 60 cycle output of the motor-generator by removing the vacuum tubes in one channel and also removing alternate tubes in both channels.

31. Following this, the system, less the synchronous motors of the master indicator transmitters, was tested for voltage and frequency compensation under power supply variations of ± 10 per cent in voltage or ± 5 cycles in frequency. The accuracy of the system was closely observed during the period of this test.

32. It was then tested to determine whether the accuracy of the master instruments would be affected by derangement of the repeater circuit. Tests were also made to note the operating characteristics of the system when the master instruments and frequency unit were inclined 30° from the vertical in all planes.

33. A shock test on one instrument of each type then followed by subjecting it to 20 blows of 250 foot pounds each. The shock was applied while the instrument was mounted in its normal position on a Bureau of Engineering shock machine and electrically connected and operating in the system at the maximum speed of 400 r.p.m.

34. Upon completion of the shock test, the test for accuracy was repeated, as outlined in paragraph 29.

35. The test was concluded with the usual insulation resistance, dielectric strength, dial illumination and watertight integrity tests and an inspection of materials.

RESULTS OF TESTS

Endurance

36. The entire system was operated at the maximum designed speed of 400 r.p.m. and the direction of rotation was reversed one hour in every twenty-four hours of operation. At the start of this test an error of plus 0.5 r.p.m. was observed on No. 1 master instrument while an error of plus 1.25 r.p.m. was observed on No. 2 master instrument. After the 96th hour, No. 1 master became erratic, indicating 12 to 18 r.p.m. high, but the test was continued and, after 240 hours, a representative of the manufacturer adjusted the instrument. This instrument then operated satisfactorily for twenty-four hours, after which the same erratic operation occurred. The instrument was again adjusted by a representative of the company after 312 hours of operation. Shortly afterwards, the same trouble occurred and, after 720 hours, the defective instrument was replaced. The test was then continued until the remainder of the system had operated 864 hours, at which time it was discontinued by direction of the Bureau. The substituted instrument operated only 144 hours of the required 500 hours. The maximum error observed during this test was approximately plus 1.75 r.p.m. on No. 2 master instrument and plus 0.5 r.p.m. on the substituted No. 1 instrument.

37. After 96 hours of operation, trouble developed in the master counter transmitter due to a pressed fit gear becoming loose on its hub. This was corrected by the representative by pinning the gear to the hub, after which it operated satisfactorily for the remainder of the test -- 768 hours.

38. There was no observable difference in the indicated r.p.m. of the master instruments and the indicated r.p.m. of their respective repeaters during the 864 hour endurance test.

39.
Accuracy Tests Before Application of Shock

Driver Speed	#1 Master Instrument		#2 Master Instrumen	
r.p.m.	Indicated r.p.m.	Error r.p.m.	Indicated r.p.m.	Error r
60	59.5	-.5	60.50	+.50
100	99.75	-.25	100.75	+.75
150	150.00	0.0	151.00	+1.00
200	200.25	+.25	201.25	+1.25
250	250.50	+.50	251.50	+1.50
300	300.50	+.50	301.75	+1.75
400	400.50	+.50	401.75	+1.75

Note: The indicated r.p.m. of the repeaters was the same as the indicated r.p.m. on their respective master instruments.

Temperature Compensation and Inclination Tests

40. Under these tests, outlined in paragraph 30, there was no observable change in the indications of the instruments. There was also no change in the operation of the system when the vacuum tubes in one channel or alternate tubes in both channels were removed from the frequency control unit.

Voltage and Frequency Compensation Tests

41. There was no change in the indications of the instruments due to ±10% change in the voltage or ±5 cycles in frequency in the supply to the type "A" and "M" motors and the input to the frequency control unit. Varying the D.C. supply to the motor-generator ±10 volts also produced no change in the accuracy of the system.

Derangement of Repeater Circuit

42. With one repeater indicator connected to each of the master instruments and locked at zero, the shaft transmitters were accelerated from zero to maximum speed. The follow-up system of the master instruments had sufficient torque to position the master indicating hands without increase in error.

Accuracy Test After Application of Shock

43. All instruments except the frequency control unit and motor-generator were given 20 blows of 250 foot pounds each, after which the accuracy tests, outlined in paragraph 29, were repeated. There was no increase in error following this test.

Shock Test on Frequency Control Unit

44. With the instrument mounted horizontally and the tuning fork parallel to the vertical bulkhead near the point of impact, the unit was subjected to 20 shocks of 250 foot pounds each. It was connected in the system and the effect of each shock was shown by the indications of the master instruments. It was noted that most of the shocks caused a change in the frequency output in the motor-generator that produced an error of approximately 7 r.p.m. on the master instruments. However, the output of the tuning fork amplifier remained constant at 60 cycles. The discrepancy between the two frequencies was due to excessive friction in the motor-generation field rheostat assembly. After oiling the rheostat shaft and the differential gears, the frequency of the motor-generator became more nearly constant at 60 cycles, due to reduced friction. This allowed the system to resume its normal operation more quickly when recovering from the effect of each shock which caused a shift in frequency and a consequent temporary error of approximately minus 7 in r.p.m. indications. It was also noted that the tubes were partly out of their sockets after application of several blows and it was necessary to push them back into place before resuming the test. The shocks caused no damage to the unit.

Additional Tests

45. The time required for the master indicator transmitters to indicate 400 r.p.m., starting from zero, was 29 seconds.

46. The minimum insulation resistance between all current-carrying parts and ground was approximately 200 megohms when measured with a 1000 volt megger.

47. All instruments withstood the required dielectric test of 1500 volts, 60 cycle alternating current applied for one minute between all current-carrying parts and ground.

48. The current consumed by the synchronous motor driving the discs in the master transmitters was 1.25 amperes. The current consumed by the remainder of the system was 8.8 amperes at 115 volts, a.c., 60 cycles. The input rating of the motor-generator is 4.5 amperes at 115 volts, d.c.

49. The maximum distance from which the indications of the master indicator transmitter, master counter transmitter and tell-tale indicator could be clearly read was six feet in a dark room. The repeater indicators could not be read from a distance greater than three feet.

Watertight Integrity

50. A representative instrument of each type was submerged in 3 feet of water for a period of one hour. The double intermittent counter leaked, 15 cc of water entering through the gland of the gear shift control rod. The gland was repacked and the case was then found to be watertight. The number one master indicator transmitter leaked and 10 cc of water entered through a crack in the built-up area around the hand hole in the rear of the instrument. This flaw may have become enlarged during the shock test.

Weight and Dimensions

51.

Instrument	Weight	Height	Width	Depth
Shaft Transmitter	55 lbs.	12".75	10".9375	9".25
Master Indicator Transmitter	80 lbs.15 oz.	15".625	16".125	11".75
Repeater Indicator	40 lbs.2 oz.	12".75 Diam.		8".875
Tell-Tale Indicator	40 lbs.12 oz.	12".75 Diam.		10".50
Double Intermittent Counter	27 lbs.8 oz.	6".625	9".00	7".50
Master Counter Transmitter	48 lbs.	11".375	15".00	8".125
Motor-Generator	108 lbs.12 oz.	19".0	7".50	12".00
Frequency Control Unit	93 lbs.	21".5	18".25	11".375

COMMENT ON RESULTS OF TESTS

52. The results of the endurance and accuracy tests on the system show that No. 2 master indicator transmitter exceeded the allowable error of ±1 r.p.m. by 0.75 r.p.m. at maximum shaft speed, 400 r.p.m. The substituted No. 1 master instrument had a maximum error of 0.5 r.p.m. but operated only 144 of the required 500 hours.

53. The minor repair on the master counter transmitter, described in paragraph 37, was satisfactory and no further trouble developed during the remaining 768 hours of the test.

54. The repeaters, throughout the endurance, shock and accuracy tests, were in step with the master indicator transmitters.

55. Under the temperature compensation and inclination tests, outlined in paragraph 30, the operation of the frequency control unit and a master instrument was unaffected.

56. The duplicate channel system of the tuning fork amplifier operated satisfactorily, as all the vacuum tubes in one channel or alternate tubes in both channels could be removed without affecting the operation of the unit.

57. There was no change in the operation of the system when the a.c. and d.c. power supplies were varied in accordance with the specifications, as outlined in paragraph 41.

58. The results of the test on the master instruments were satisfactory when the repeater circuit was deranged, as outlined in paragraph 42.

59. There was no increase in the errors of the system except as noted in paragraph 44, following the application of shock, nor was there any damage to the equipment.

60. The accuracy of the 60 cycle output of the motor-generator was checked over two hour periods with the use of a standard chronometer. The average error of seven tests, at ambient of 72°F, was plus 0.035%. The average error of three tests, at ambient of 132°F, was minus 0.062%. During this test, the frequency control unit was enclosed in a compartment equipped with temperature controls.

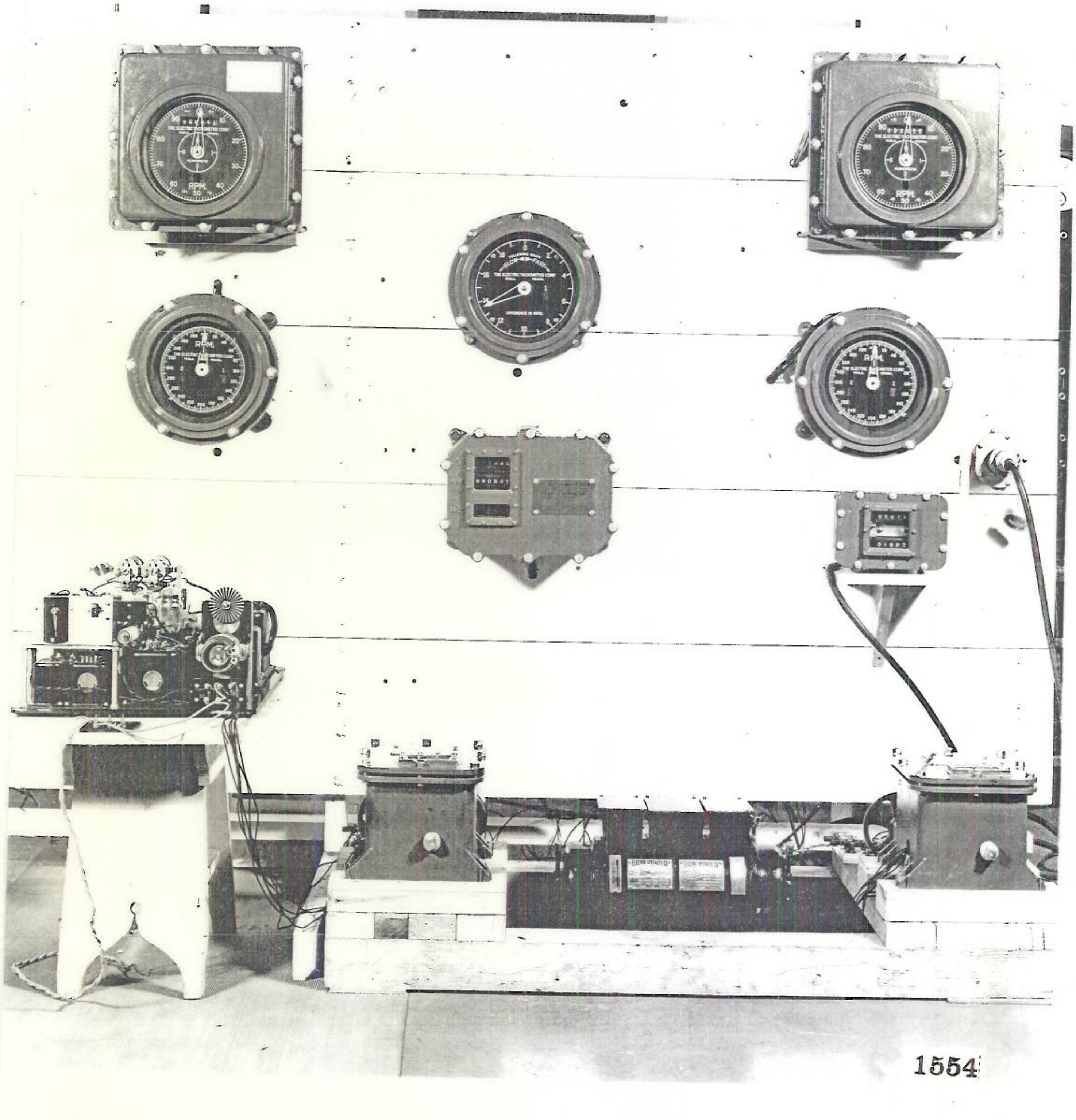
61. The follow-up system in the master instruments operated satisfactorily during a test period of 8 hours, when the speed of the motors, driving the shaft transmitters, was varied 8% plus and minus every 15 minutes.

62. The watertight integrity test on No. 1 master indicator transmitter was unsatisfactory due to a defective casting.

63. The dial illumination was in accordance with the specifications on all instruments except the repeater indicators. As noted under paragraph 49, the dials of these instruments could be read from a maximum distance of three feet.

CONCLUSION

64. This "Propeller Shaft Revolution Indicator System", manufactured by the Electric Tachometer Corporation, Phila., Pa., was generally satisfactory under test except for the inaccuracy of one master instrument. If modified to correct this and other defects noted under "Comments" of this report, it should prove satisfactory for Naval use.



NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Plate 1