NRL Report No. B-1265
Shaft Revolution Indicator of Electric Tachometer Corp.

Eng. 70-C

FR-1265

REPORT NO. B-1265

DATE 21 April 1936

SUBJECT

SHAFT REVOLUTION INDICATOR
ELECTRIC TACHOMETER CORPORATION

DEPARTMENT OF THE NAVY
BUREAU OF ENGINEERING

BY

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

DISTRIBUTION STATEMENT A APPLIES
Further distribution authorized by
UNLIMITED only.

21 April 1936 NRL Report No. B-1265

NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report of Test

on

Shaft Revolution Indicator
Manufactured and Submitted
by
Electric Tachometer Corporation
Philadelphia, Pa.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON DC

Number of Pages: Text - 5 Plates - 5

Authorization: Bu.Eng.ltr.S65-5/L5(1-21-Ds) of 22 January 1936.

Date of Test: February, March, April, 1936.

Tested by:

J.R. Coomes, Sr.Engr.Aide J.S. Bryant, Sr.Engr.Aide

Prepared by:

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

Reviewed by:

W.M. Haynsworth,Jr.,Lt., USN

Approved by:

H.M. Cooley, Capt., USN, Director.

Distribution:
BuEng (5)
ts

TABLE OF CONTENTS

Appendices

AUTHORIZATION FOR TEST

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

Reference: (a) Bu.Eng.ltr.S65-5/L5(1-21-Ds) of 22 Jan. 1936.
(b) Specifications SGS(65)10a of 1 Mar. 1935.
(c) NRL Report No. B-1203 of 14 Oct. 1935.

OBJECT OF TEST

2. The object of this test was to determine how closely the sample shaft revolution indicator complied with the specifications, reference (b), and its suitability for the Naval service.

ABSTRACT OF TEST

3. The subject indicator, shown by Plates 1, 2 and 3, was set up at this Laboratory and carefully observed while under test for conformance with the specifications, reference (b), in so far as they were applicable. The shaft transmitter, shown by Plates 4 and 5, recently tested by this Laboratory in connection with propeller shaft revolution indicators and reported under reference (c), was also used in this test. The order in which the tests were made is outlined in paragraphs 17 to 23 inclusive.

CONCLUSIONS

(a) Although not covered by the specifications, the subject indicator under test proved to be rugged in construction and accurate in operation, having an error of approximately 1 r.p.m. It is not a finished product and was submitted primarily for study of its design and its practicability for use in connection with propeller shaft revolution indicator systems. It is believed that a more carefully built instrument would give greater accuracy.

(b) There was no controlled frequency unit furnished with the equipment, therefore the maximum error of 1 r.p.m. does not include a possible error arising from this source.

(c) The faulty operation brought about by connecting an additional type M motor, with a locked rotor, in parallel with the indicator as described in paragraph 30, is a condition which will exist in any system where more than one Synchro-Motor is driven from a shaft transmitter, and a Synchro-Motor rotor becomes locked.

(d) No backing signal is provided.

(e) No switch is provided for cutting off the friction disc motor at zero shaft speed or above maximum shaft speed.

(f) In a system using equipment of this type, each instrument would be a "master indicator" and interchangeable with any other instrument. There would be no repeaters and hence no follow-up system or master indicator to drive them.

RECOMMENDATIONS

(a) In view of the satisfactory test results, it is recommended that the Bureau consider purchasing a system incorporating this type of instrument and installing it aboard ship for a service test. This type of indicator is rugged and produces as high a degree of accuracy as the larger friction disc types. In addition, due to its simplicity, it is believed to be more reliable than any such instrument tested by this Laboratory.

(b) It is further recommended that, should such a system be installed, there be provided at the gauge board a cut-out switch for each indicator circuit for use in case of such a casualty as described in paragraph 30. If one of the indicators became locked, it would affect all other indicators until it was removed from the system. No alarm for such faulty operation is necessary, since there is an oscillation of the pointers of approximately 36 degrees under this condition.

(c) It is also recommended that the indicator dial be at least 8 inches in diameter in case a single pointer is used and that if a dial of less diameter is desired that it be divided into two concentric scales, one reading from 0 to 4 and denoting hundreds of r.p.m., the other from 0 to 100 and denoting units of r.p.m. It is not believed that the load of a second pointer geared 4 to 1 would be objectionable.

DESCRIPTION OF MATERIAL UNDER TEST

4. This indicator was manufactured by the Electric Tachometer Corporation, Philadelphia, Pa., and was not submitted as a finished product, but as a bench-made model, for a study of its design and its practicability for use in connection with propeller shaft revolution systems. The unit contains the following equipment:

- 1 - Type M Synchro-Motor, Pioneer Instrument Company, Manufacturer.
- 1 - Synchronous Motor, Capacitor Type, Holtzer Cabot Company, Manufacturer.
- 1 - Mechanical six digit counter.
- 1 - Positioning roller and friction disc assembly.
- 1 - Pointer and shaft assembly.
- 1 - Dial graduated from 0 to 400 r.p.m. in steps of 2 and in numbered divisions of 20, the cipher being omitted on all figures between even hundreds.

5. All of the indicator units are mounted on a 1/4" brass circular plate.

6. In operation, the type M synchro-motor is connected to the type A synchro-motor transmitter located in the propeller shaft transmitter instrument. This motor runs continuously in phase with the transmitter motor and is connected through a 1:1 spiral gear to the right hand lead screw, supported by ball bearings, on which moves a rack embodying a hardened steel roller approximately 1"60 in diameter.

7. The roller, attached to the rack, engages a friction disc driven by a Holtzer Cabot 1800 r.p.m., 60 cycle, synchronous motor, capacitor type, at a speed of 80 r.p.m. through suitable gearing.

8. The constant speed disc, approximately 2"0 in diameter, is forced against the roller by a steel spring located in its housing. With the propeller shaft in motion, the roller will seek a position on the friction disc where the surface speeds of the disc and roller are equal. For propeller shaft speeds up to 400 r.p.m. there is a definite position for the roller along the axis of the screw shaft.

9. The pointer is positioned from the roller assembly by means of a rack engaging a pinion located on the pointer shaft.

10. The total revolutions of the propeller shaft are registered by a six digit counter driven from the screw shaft by means of a chain and sprockets. A window cut in the dial allows the counter to be read.

11. The ratio between the propeller shaft and the indicator screw shaft is 5:1, so that a propeller shaft speed of 400 r.p.m. produces a speed of 80 r.p.m. at the indicator screw shaft. Thus, with the friction disc rotating at 80 r.p.m. constant speed, the active diameter is approximately 1"6 or a roller travel of 0"002 per r.p.m. of the propeller shaft.

12. For aligning the roller rack assembly, a pin attached to a bracket located on the circular brass mounting plate slides in a groove cut into the roller rack.

13. Further description in the design and construction of the indicator is given by Plates 1, 2 and 3.

14. Plates 4 and 5 give a description of the shaft transmitter used in connection with the test, which is fully described under reference (c).

15. The approximate weight of the sample indicator is 16 pounds.

METHOD OF TEST

16. The sample indicator was first interconnected electrically to a propeller shaft transmitter and energized from a controlled frequency supply of 115 volts, a.c., 60 cycles. The constant speed motor driving the shaft transmitter and the synchronous motor driving the indicator friction disc were also energized from the same supply.

17. It was then tested for endurance by operating it at a speed of approximately 300 r.p.m. for a period of 500 continuous hours. During this test, the total revolutions of the indicator were recorded and compared with those indicated on the transmitter counter.

18. Following the endurance test, the indicator was checked for accuracy at shaft speeds of 60, 100, 150, 200, 250, 300 and 400 r.p.m. for periods of three hours each.

19. The indicator was then tested for shock integrity by placing it on a Bureau of Engineering shock stand in the normal position and applying 20 shocks equivalent to 250 foot pounds each. During this test, the indicator was energized and operating at 400 r.p.m.

20. At the conclusion of the shock test, the indicator was again checked for accuracy, as described in paragraph 18.

21. It was next placed in a compartment having an ambient temperature of 135°F and tested to note any change in its accuracy at this temperature under conditions specified by paragraph F-2c(4)c of reference (b).

22. A test was then made to determine the effect on the accuracy of the indicator of an additional type M motor connected in parallel and having its rotor locked. This test simulated a jammed indicator motor.

23. The test was concluded with an inspection of the indicator relative to design, materials and workmanship.

RESULTS OF TEST

24. The indicator under test for endurance, as outlined in paragraph 17, complied with the requirements, having operated satisfactorily for 325 hours in addition to the required 500 hours at a shaft speed of 300 r.p.m. At no instance was an error greater than 1 r.p.m. observed during the period of this test.

25. Under test for accuracy, as outlined in paragraph 18, the indicator also complied with the requirements, the maximum error being approx-

mately 1.0 r.p.m. There was no difference in the transmitted revolutions and the recorded revolutions that could not be attributed to the human error in reading the counters while under operation.

26. The accuracy test results follow:

Driven Speed R.P.M.	Indicated R.P.M.	Error R.P.M.
60	61.0	+1.0
100	101.0	+1.0
150	151.0	+1.0
200	201.0	+1.0
250	249.0	-1.0
300	299.0	-1.0
400	399.0	-1.0

27. When tested for shock integrity, as outlined in paragraph 19, there was no apparent change in the indicated r.p.m. or damage to the instrument. However, upon application of each shock, the pointer was momentarily displaced, but returned to its normal position within approximately 3 seconds.

28. Under test for temperature compensation, as outlined in paragraph 21, the 1.0 r.p.m. error remained unchanged.

29. The indicator was unaffected when the type M motor supply was varied ±10 percent in voltage and ±5 cycles in frequency.

30. With the indicator operating at 400 r.p.m. and an additional type M motor connected in parallel with its Synchro-motor and having its rotor locked, the pointer surged back and forth, the maximum surge being approximately 36°, equivalent to 40 r.p.m.

31. The time required for the indicator pointer to return from maximum speed (400 r.p.m.) to zero position was approximately 17 seconds. At a speed of 60 r.p.m., the time required was 11 seconds.

32. The insulation and dielectric tests were not made on the indicator in view of its being an unfinished product.

CONCLUSIONS

33. Although not covered by the specifications, the subject indicator under test proved to be rugged in construction and accurate in operation, having an error of approximately 1 r.p.m. It is not a finished product and was submitted primarily for study of its design and its practicability for use in connection with propeller shaft revolution indicator systems. It is believed that a more carefully built instrument would give greater accuracy.

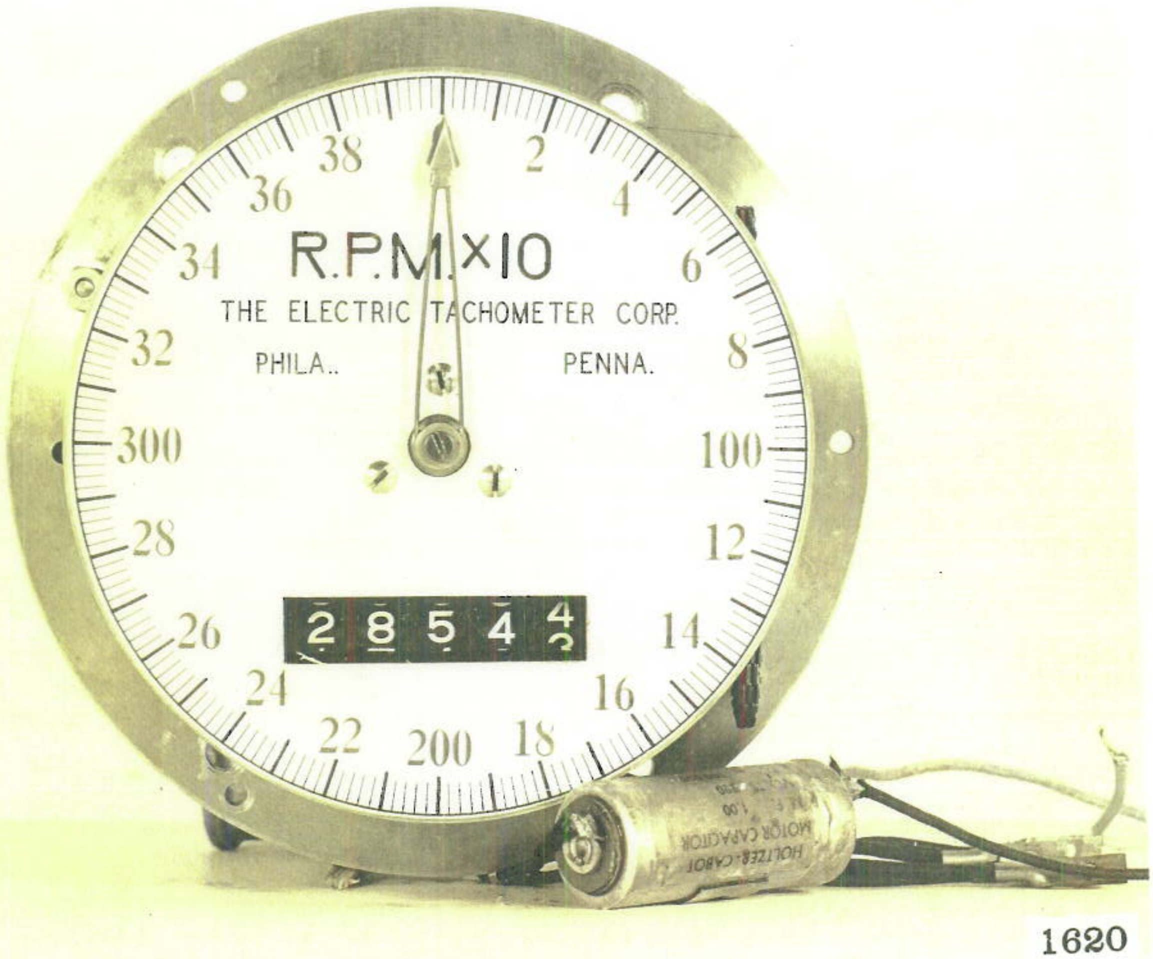
34. There was no controlled frequency unit furnished with the equipment, therefore the maximum error of 1 r.p.m. does not include a possible error arising from this source.

35. The faulty operation brought about by connecting an additional type M motor with a locked rotor in parallel with the indicator, as described in paragraph 30, is a condition which will exist in any system where more than one Synchro-Motor is driven from a shaft transmitter and a Synchro-Motor rotor becomes locked.

36. No backing signal is provided.

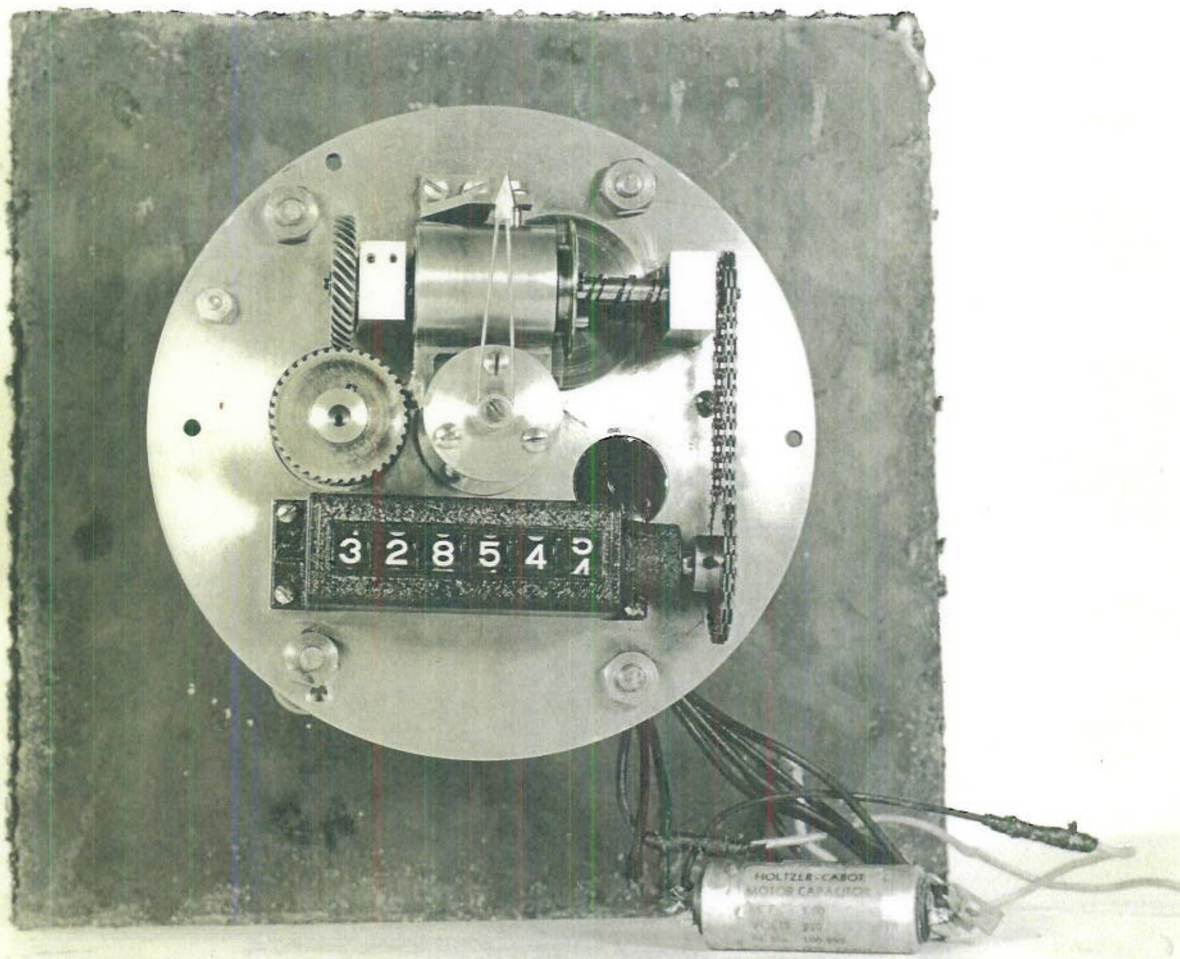
37. No switch is provided for cutting off the friction disc motor at zero shaft speed or above maximum shaft speed.

38. In a system using equipment of this type, each instrument would be a "master indicator" and interchangeable with any other instrument. There would be no repeaters and hence no follow-up system or master indicator to drive them.



NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

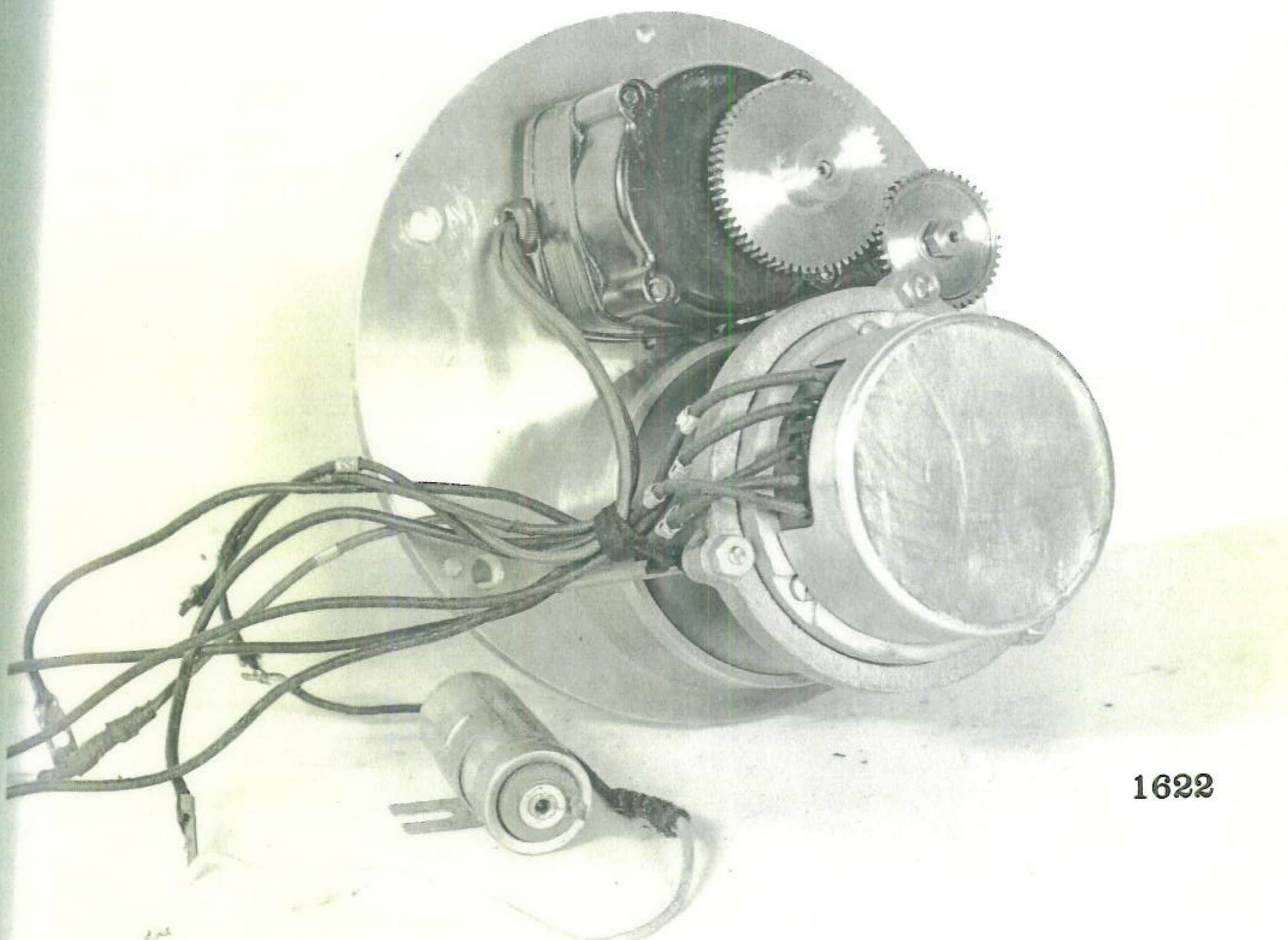
Plate 1



1621

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Plate 2



1622

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Plate 3

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

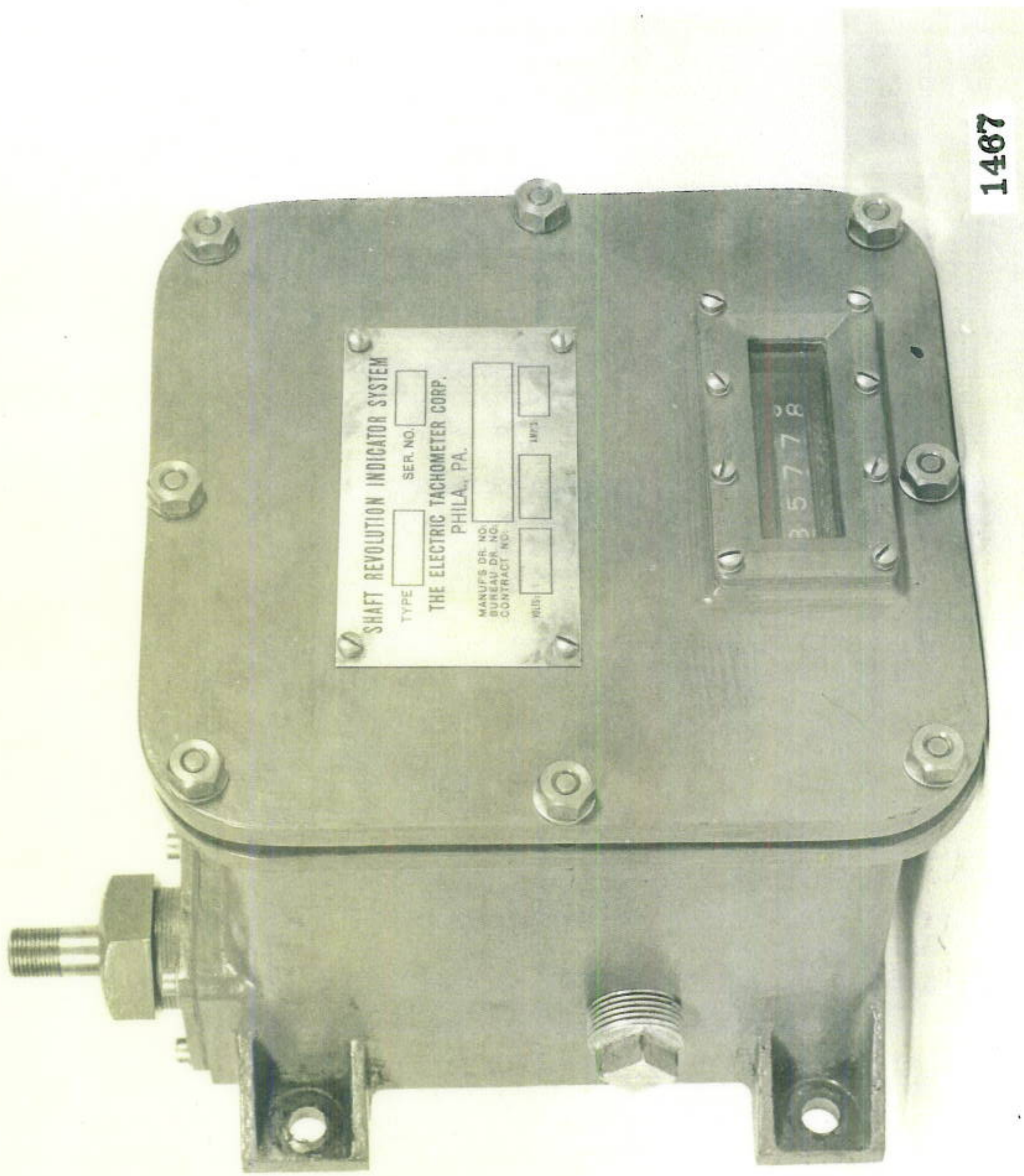


Plate 4

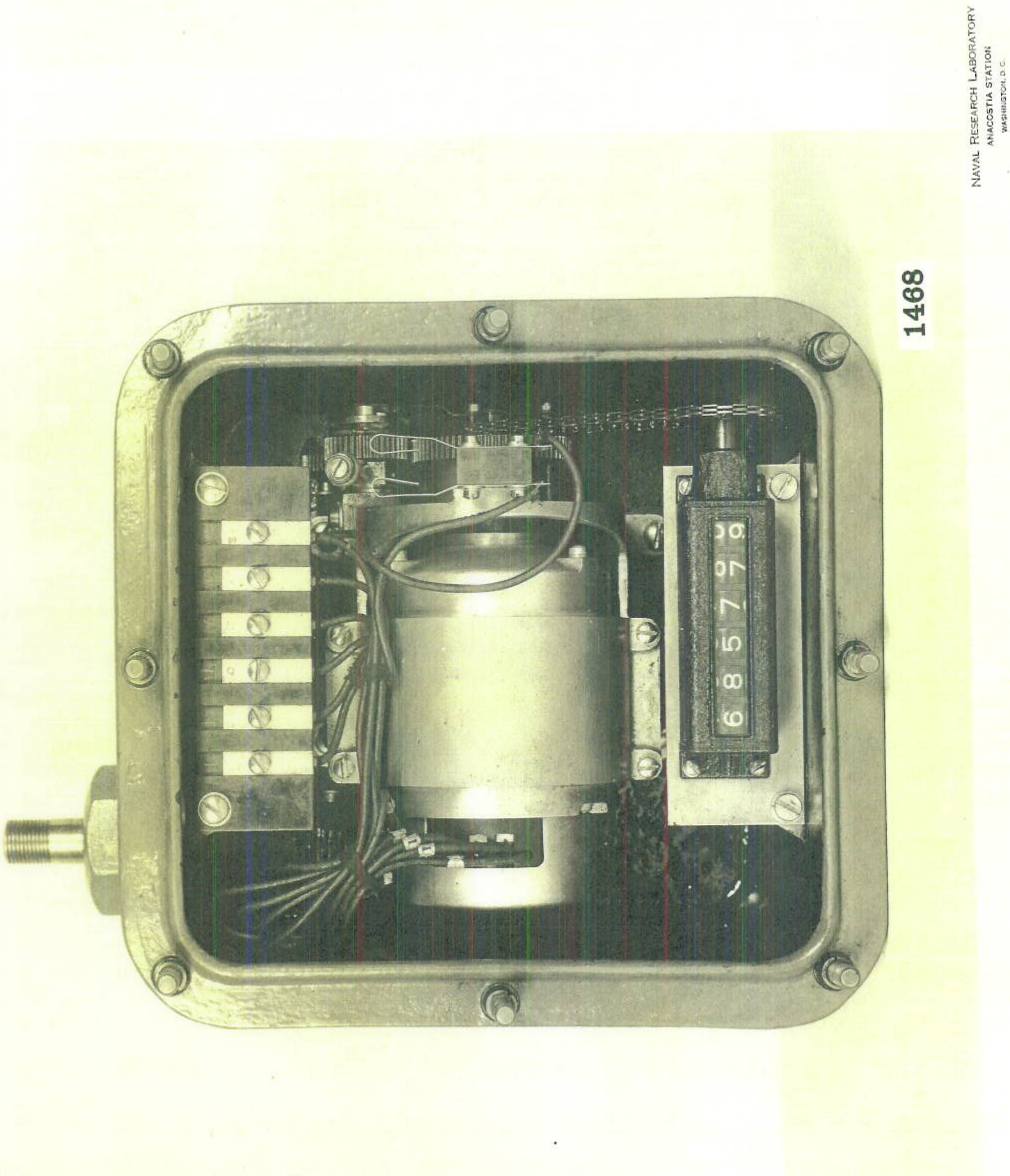

1468
NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Plate 5