

Report No. B-1242
Test of Propeller Shaft Revolution Indicator
System; Electro-Chronometric Type.

REPORT NO. B-1242

DATE 3 March 1936

SUBJECT

Test of Propeller Shaft Revolution Indicator System;
Electro-Chronometric Type.



BY

NAVAL RESEARCH LABORATORY
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AUTHORIZATION

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

Reference: (a) BuEng.ltr. SS172/S65--(10-31-Ds) of 31 Aug.1935.
(b) Navy Department Specifications SGS (65)-10
of 15 April 1935.
(c) Contract NOs-37790 - PORPOISE and PIKE.

OBJECT OF TEST

2. The object of this test was to determine whether the system, intended for submarine application, conformed with specifications, reference (b), and its suitability for Naval use, under reference (c).

ABSTRACT OF TEST

3. The equipment, shown by Plate 1, was interconnected electrically to a 115 volt direct current supply and checked for conformance with specifications, reference (b). The complete system was tested for endurance by operating it for 500 continuous hours, at a speed of 300 r.p.m., the approximate surface speed of the ships for which it is intended, reference (c). Upon completion of the endurance run, all remaining tests were made in order, as outlined under reference (b), paragraph F-2.

CONCLUSIONS

(a) This system, as manufactured and submitted by George Walker Company, for suitability test under Contract reference (c), failed to comply with the requirements of the specifications, reference (b), as noted under "Comments" of this report.

(b) The electro-chronometric control unit, which is the heart of this system, is too frail. Under shock, the reset and clutch relays shift and produce erroneous indications in the system.

RECOMMENDATION

(a) It is recommended that this system be not approved for use in the Naval service, due to non-conformance with the specifications, as noted under "Comments", paragraphs 41 to 45 inclusive.

DESCRIPTION OF MATERIAL UNDER TEST

4. The system, shown by Plate 1, is one of two intended for installation on the USS PORPOISE and USS PIKE. It is designed to measure the speed and average speed and total revolutions of the shafts.

5. The equipment submitted consists of the following:

- 2 - Shaft Transmitters
- 1 - Two Shaft Revolution Indicator
- 1 - Two Shaft Revolution Indicator
with Mechanical Counters
- 1 - Two Shaft Revolution and Average Revolution
Indicator
- 1 - Electro-Chronometric Control Unit

SHAFT TRANSMITTERS

6. These two units are identical, each being enclosed in a watertight composition BE case. The case cover is removable and embodies a watertight glass window for reading the six (6) digit mechanical "Veeder" counter and allows free access to the mechanism for adjustments or replacements. It is driven from the propeller shaft through suitable gears having a ratio of 3:1, so that a speed of 300 r.p.m. of the propeller shaft produces a speed of 900 r.p.m. at the main transmitter shaft. The motion to the contact making device is transmitted by several brass gears and two (2) shafts. The ratio of these gears is such that the cam shaft rotates 100 r.p.m. when the propeller shaft rotates 300 r.p.m. The contact making device consists of 3 pairs of flat phosphorous bronze springs provided with tungsten contacts, mounted on insulating material. Each pair of contacts, except the direction signal contacts, is shunted with a 1 MFD. 1000 V. condenser in series with a 25 ohm resistor. Three insulating cams, spaced 120°, operate the contacts. The transmitter shaft is equipped with ball bearings and a watertight stuffing gland where it extends through the case. This unit is shown by plates 2 and 3.

TWO SHAFT REVOLUTION INDICATOR

7. This instrument indicates r.p.m. of the port and starboard propeller shafts. It has 4 dials, each provided with 2 pointers. Each dial has 2 concentric scales, the outer graduated 0-100 in steps of 1 r.p.m., the other 0-600 in steps of 100 r.p.m. The dials have a black background and the graduations, numerals, and pointers are painted with radium luminous material, activated by 6-VG2-A lamps. Two direction signal targets are provided, each being operated by contacts located in its respective shaft transmitter. When the shafts rotate "Ahead", the target is white, when reversed, "B" painted with luminous material on a red background is visible. The case cover is removable and has 4 windows for reading the dials and 2 smaller ones for reading the direction targets.

8. The entire mechanism of this instrument is mounted on a hinged aluminum plate secured by machine screws. Mounted on this plate are 2 indicating units, 2 ball type clutches with electro-magnetic releases, and 2 direction targets, as well as the lamp sockets. Each unit is

operated by a step by step motor and a mechanism which functions at alternate intervals. Thus one dial indicates the revolutions of the propeller shaft during the preceding minute, while the other is counting the revolutions of the shaft during the present minute. The system is so timed that the counting period is 1 minute and the indicating period is 55 seconds, 5 seconds being allowed for resetting the pointers to 0.

9. Each unit has a dial shaft, moving magnet, armature disc, clutch disc, escapement device, return spring and stop, and the necessary gears.

10. The motor is geared to 2 large gears, each supported on a dial shaft, but free to rotate independently of the shaft. Secured to each of these gears is a drum containing an electro-magnet and provided with 2 slip rings and brushes so that the magnet may be energized. Adjacent to this magnet is a steel armature disc having a self-aligning feature and being supported on a steel clutch disc. This disc is secured to the dial shaft and is free to rotate the pointers in a clockwise direction against the tension of a return spring. A ball-type clutch is provided to prevent the return spring from resetting the pointers when the counting period is terminated and the rotating magnet is de-energized. A magnetic release is provided so that the pointers will return to 0 at the end of their indicating period of 55 seconds. To regulate the rate of return to 0, an escapement is provided and a pawl type stop engages a notch in the clutch disc. The pointers are provided with suitable gears so that one indicates units, the other hundreds of r.p.m. This instrument is shown by plates 4, 5 and 6.

TWO SHAFT REVOLUTION INDICATOR WITH MECHANICAL COUNTERS

11. This instrument is identical to that described in paragraphs 7, 8, 9 and 10, except that it incorporates 2 six digit "Veeder" mechanical counters, figures painted with radium luminous material. These counters are driven continuously from their respective step by step motors through suitable gears. The counters are visible through 2 additional windows located in the case cover. The instrument is shown by plates 7, 8 and 9.

TWO SHAFT REVOLUTION AND AVERAGE REVOLUTION INDICATOR

12. This instrument is also identical to that described in paragraphs 7, 8, 9 and 10, except that it incorporates an additional unit for indicating the average r.p.m. of the port and starboard shafts. This is accomplished by driving the unit through a mechanical differential from the 2 step by step motors. The instrument is shown by plates 10, 11 and 12.

ELECTRO-CHRONOMETRIC CONTROL UNIT

13. This instrument is housed in a cast aluminum alloy case provided with four mounting lugs and two bosses tapped for 3/4" terminal tubes. Two three-pole, double throw relays, and a double pole, double throw relay are incorporated. Two Hamilton-Sangamo seven jewel clocks

with electrically wound mechanisms are mounted on plates hinged in the cabinet. Each clock operates a pair of contacts, protected by shunting with a 0.5 MFD condenser in series with a 100 ohm resistor. These contacts operate the double-pole, double throw relay, which operates the clutch and reset relays, which serve as master switches to control the indicating units in the system. These relays have roller type coin silver contacts mounted on the armature and stationary contacts of coin silver mounted on flat phosphorous bronze springs. The contacts are protected with a 1 MFD condenser in series with a suitable resistor. An external switch may be used to transfer the timing of the system from one clock to the other. Each clock is provided with a black dial having white numerals and hands. The dials are partly cut out so that the balance wheel may be observed. The removable case cover is provided with 4 windows, 2 for the clocks and 2 for the 3 pole relays. The instrument is shown by plates 13 and 14.

METHOD OF TEST

14. The entire equipment, shown by plate 1, was interconnected electrically to a 115 volt direct current supply and the system operated for the required 500 hour endurance run. During this test, the 2 shaft transmitters were driven by synchronous motors through suitable gears, at a speed corresponding to a propeller shaft speed of 300 r.p.m. The direction of rotation of the driving motors was reversed for one hour in every twenty-four of operation. At the expiration of each 100 hour period, of the required 500 hours, the test was interrupted for a short period to allow for oiling.

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

16. It was next tested for its shock integrity, by subjecting representative instruments to 20 blows of 250 foot pounds, while mounted on a Bureau of Engineering standard shock stand and electrically connected in the system, and operating at a shaft speed of 300 r.p.m.

17. Following the shock tests, the test for accuracy was repeated, as outlined in paragraph 15.

18. The temperature compensation tests were next conducted by successively placing the electro-chronometric control unit and the two shaft revolution and average revolution indicator in a compartment for twenty-four hours. For the last two hours of this period, the system was energized from a supply of 115 volts direct current and operating at a speed of 300 r.p.m. The ambient temperature for the control unit was 115°F. and 135°F. for the indicator.

19. The system was next tested to note the effect, with respect to accuracy, while operating at a shaft speed of 300 r.p.m., when the input voltage was varied $\pm 10\%$.

20. The dielectric test was next made by subjecting each instrument to 500 volts, 60 cycle, alternating current, between each terminal and

ground for a period of one minute.

21. Succeeding the dielectric test, the insulation resistance between each terminal and ground on each instrument was measured with a 500 volt megger.

22. The efficiency of the dial illumination was determined by placing each instrument, except the shaft transmitter, in a totally dark room and observing the distance at which the dials could be read when the type VG2-A lamps were energized with 115 volts, direct current.

23. The test was concluded with the usual test for watertightness and a general inspection of the equipment to determine its conformance with the specifications relative to design and workmanship.

RESULTS OF TEST

Endurance: Specifications, Par. F-2c(2).

24. The system was operated for a period of 500 hours at a shaft speed of 300 r.p.m., the approximate maximum surface speed of the ships for which the equipment is intended. However, before this test could be made, it was necessary to reduce the spring tension on the armatures of both the reset and clutch relays of the electro-chronometric control unit, to allow them to function when energized. It was accomplished by placing washers, 0.012 thick, underneath the armature retaining springs. The maximum error observed during this test was 1 r.p.m. It was also noted that the direction signals on the two shaft revolution and average revolution indicator did not operate due to open magnet windings.

25. Over the period of the 500 hour endurance test, the indicator revolution counters checked with the propeller shaft transmitter counters.

ACCURACY AFTER ENDURANCE TEST

Specifications, Par. F-2c(7).

26. The data recorded during this test are given below:

Shaft Speed R.P.M.	Port R.P.M.		Starboard R.P.M.	
	Indicated	Error	Indicated	Error
60	59.5	0.5	59.5	0.5
100	99.5	0.5	99.5	0.5
150	149.0	1.0	149.0	1.0
200	199.0	1.0	199.0	1.0
250	249.0	1.0	249.0	1.0
300	299.0	1.0	299.0	1.0

Note: 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 they were operating.

SHOCK TEST

Specifications, Par. F-2c(5).

27. The instruments subjected to 20 shocks of 250 foot pounds, while mounted normally on a standard Bureau of Engineering stand, while electrically connected in the system and operating at a shaft speed of 300 r.p.m. were as follows:

- (a) Shaft transmitter
- (b) Two shaft revolution indicator with mechanical counters
- (c) Two shaft revolution and average revolution indicator
- (d) Electro-chronometric control unit

28. The shaft transmitter was unaffected when subjected to the shock test.

29. The two shaft revolution indicator with mechanical counters failed to withstand the test. Upon application of one 250 foot pound blow, with the past minute count of 300 r.p.m. indicating, the pointers moved counter-clockwise to 270 r.p.m. and did not return to 0 at the time of the reset period. Therefore on the next minute count, the error became additive and the dials indicated 570 r.p.m. instead of 300 r.p.m., true shaft speed. This was due to the ball-clutch device releasing for a short period at the instant the shock was applied. Although the instrument was inoperative, the remaining 19 shocks were given to determine additional defects. An inspection disclosed that the only defect arising from the shock test was a bent reset bar which prevented the reset magnet from releasing the ball clutch device. This was corrected by straightening the bar, after which the instrument could be operated.

30. The two shaft revolution and average revolution indicator also failed to meet the shock test requirements. After application of 2 blows, the instrument became erratic, failing to reset and therefore indicating erroneous r.p.m. on the next counting period. After application of the required 20 shocks, the instrument was examined and it was found that the leads to the upper reset magnet were poorly connected. When the leads were properly soldered, the instrument could be operated.

31. The electro-chronometric control unit was not satisfactory under shock as one of the clocks failed upon application of the seventh blow. After the tenth blow, the timing of the system was transferred to the starboard clock, but the indicators continued to operate erratically due to the shifting of the relays under shock. This clock operated satisfactorily following the shock test, but it was observed that the dials on both clocks were bulged.

ACCURACY AFTER SHOCK

32. There was no observable increase in the error of the system after the application of shock. In order to conduct this test it was necessary to make minor repairs, outlined in paragraphs 29 and 30.

TEMPERATURE COMPENSATION

Specifications, Par. F-2c(3)

33. This test was made as outlined in paragraph 18 and it was found that the control unit did not function at an ambient temperature of 115°F. This was attributed to the failure of the reset and clutch relays to function at the time they were energized. To verify this, the spring tension was further decreased by placing additional washers under the armature retaining springs and the relays functioned properly.

34. The specified ambient temperature of 135°F had no effect on the operation of the two shaft revolution and average revolution indicator.

VOLTAGE COMPENSATION

Specifications, Par. F-2c(4).

35. Voltage variations of +10% caused no apparent change in the operation or accuracy of the system, when the ambient temperature was approximately 72°F.

DIELECTRIC TEST

Specifications, Par. F-2c(9).

36. Under this test no breakdowns occurred on any of the instruments when 500 volts, 60 cycle, alternating current was applied between each terminal and ground for a period of one minute.

INSULATION RESISTANCE

Specifications, Par. F-2c(10)

37. The insulation resistance, succeeding the dielectric test, was 100 megohms plus on all instruments when tested with a 500 volt megger.

DIAL ILLUMINATION

Specifications, Par. E-3a(6).

38. This test was made as outlined in paragraph 22 and the maximum distance that any of the dials could be read was three feet. The maximum angle from which the entire dial could be viewed was 30°. The specifications require that dial graduations be visible at a distance of 10 feet within 45° of the normal to the instrument face during daylight, twilight, or darkness. The mounters could be read from a maximum distance of two feet.

WATERTIGHT INTEGRITY

Specifications, Par. F-2c(6).

39. Under this test, representative instruments of each type were submerged in water to a depth of 3 feet for a period of one hour and were found to be watertight.

40. The equipment submitted complies with the specifications relative to materials and workmanship.

Weights and Dimensions -

<u>Instrument</u>	<u>Weight</u>	<u>Height</u>	<u>Width</u>	<u>Depth</u>
Shaft transmitter	55 lbs. 8 oz.	14"0	13"5	9"0
Two shaft revolution indicator	71 lbs.14 oz.	19"5	18"5	10"25
Two shaft revolution indicator with counters	74 lbs.3 oz.	19"5	18"5	10"25
Two shaft revolution and average revolution indicator	87 lbs.10 oz.	19"5	23"5	10"25
Electro-chronometric control unit	42 lbs.2 oz.	15"0	19"25	6"25

COMMENTS ON RESULTS OF TEST

41. As received, the system was not operative and it was necessary to reduce the tension of the retaining springs on the reset and clutch relays of the electro-chronometric control unit, as described in par. 24. After which, the system satisfactorily completed the 500 hour endurance test.

42. The accuracy of the system before and after the shock test, was within the specification requirement of ± 1 r.p.m. However, the operation of the system was unsatisfactory during the shock test and it was necessary to make minor adjustments, outlined in paragraphs 29 and 30, before the latter accuracy test could be conducted.

43. Under the shock test, the two shaft revolution indicator with mechanical counters, two shaft revolution and average revolution indicator, and the electro-chronometric control unit failed to comply with the specifications. One of the clocks was badly damaged and the dials on both were bulged.

44. The electro-chronometric control unit failed to comply with the specifications, requiring satisfactory operation at an ambient temperature of 115°F.

45. The dial illumination is not in accordance with the specifications, although a heavy coverage of a good grade of radium luminous material is used. The results of this test are given in paragraph 38.

46. The results of the tests for voltage variations, dielectric strength, insulation resistance and watertight integrity were satisfactory.

CONCLUSIONS

47. This system, as manufactured and submitted by George Walker Company for suitability test under Contract, reference (c), failed to comply with the requirements of the specifications, reference (b), as noted under "Comments" of this report.

48. The electro-chronometric control unit, which is the heart of this system, is too frail. Under shock, the reset and clutch relays shift and produce erroneous indications in the system.

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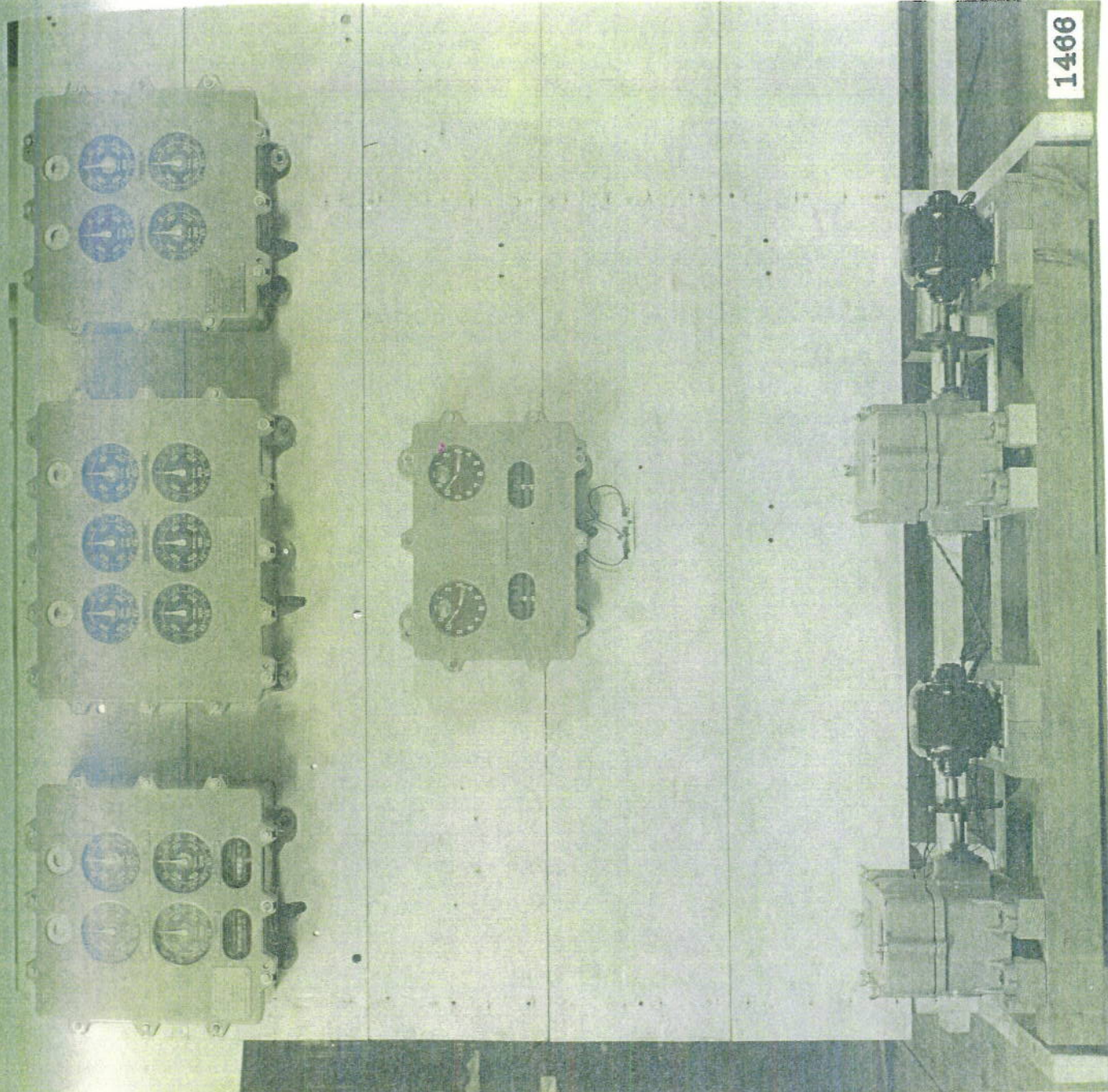
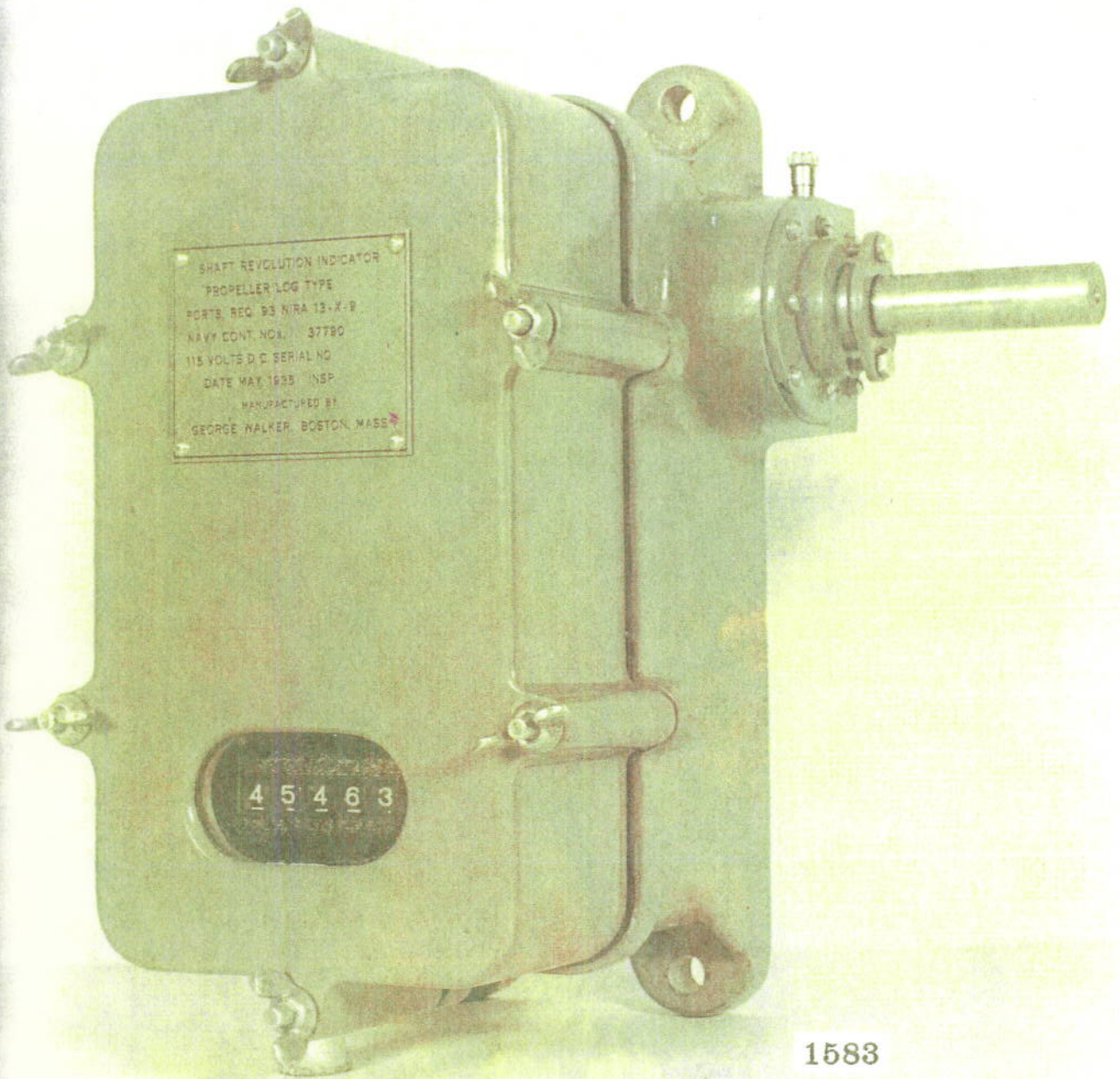


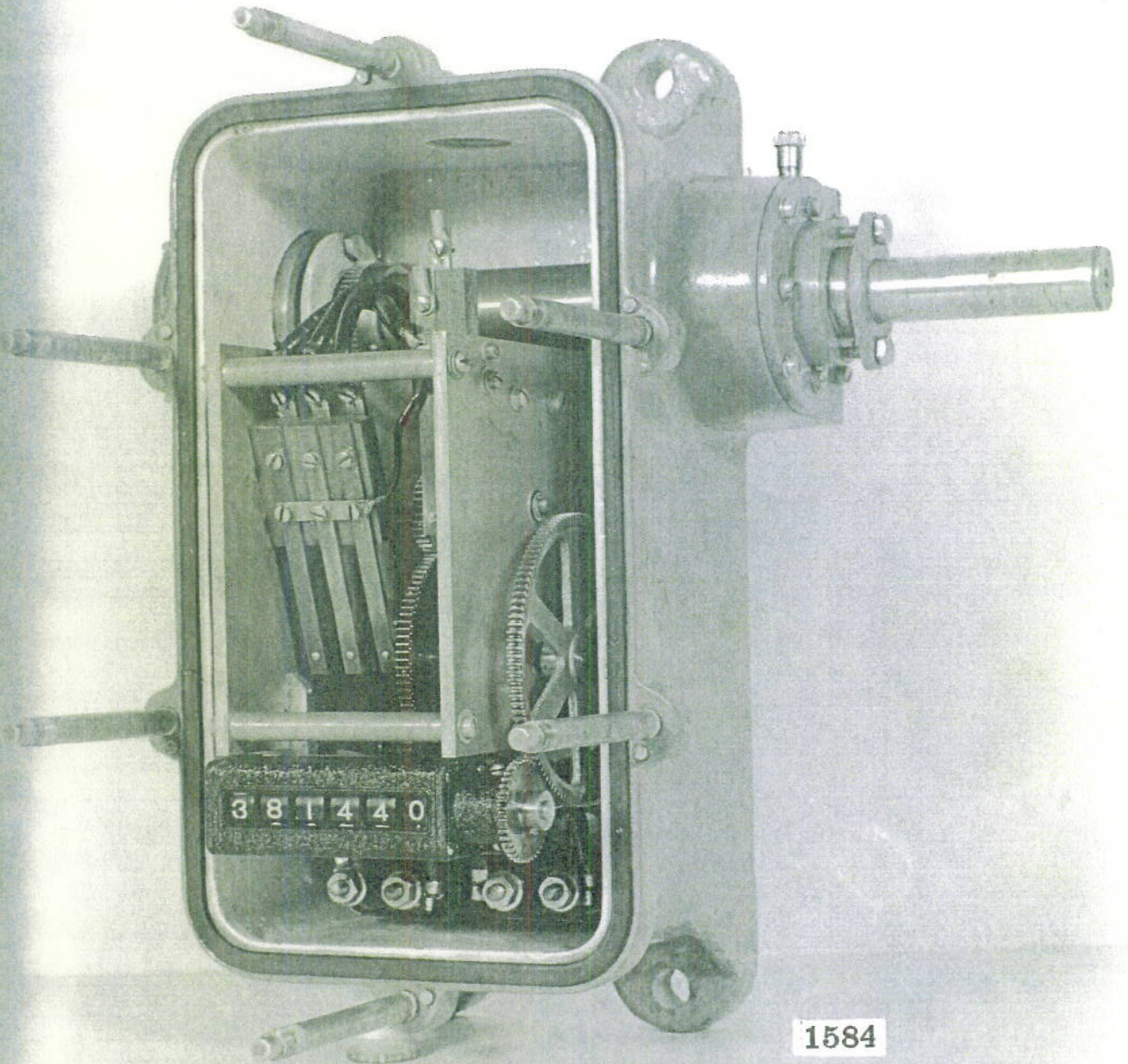
Plate 1



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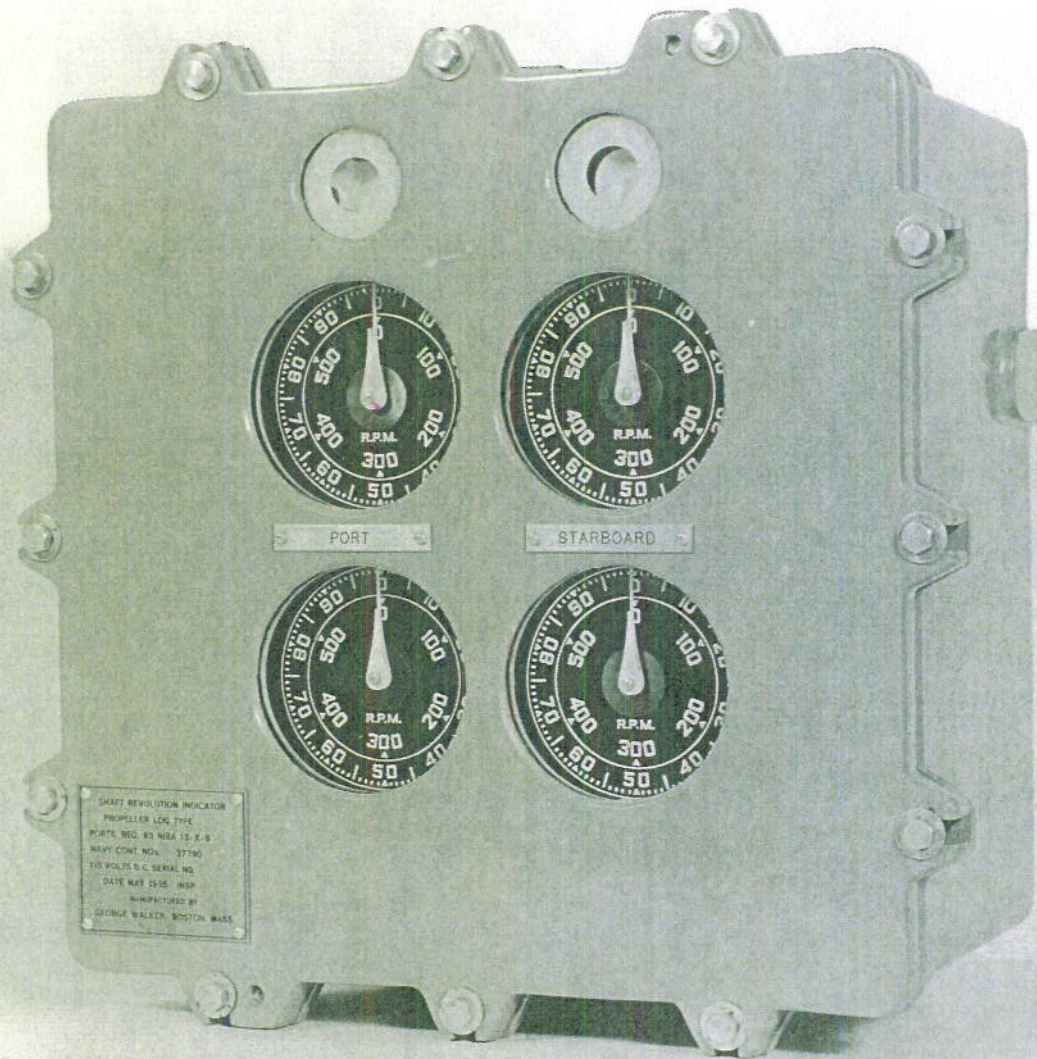
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Plate 2



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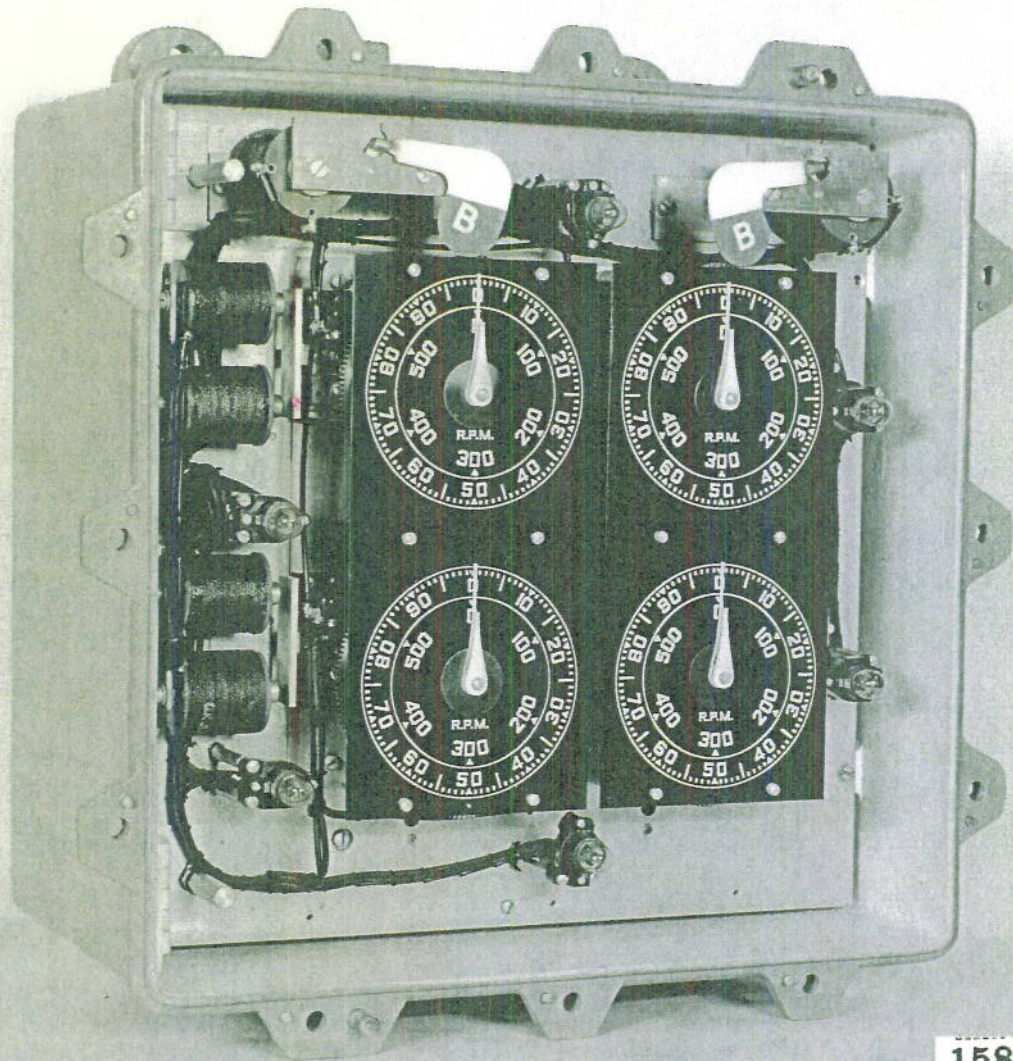
Plate 3



SHAFT REVOLUTION INDICATOR
PROPELLER LOG TYPE
PARTS REQ. 83 NBR 18 X 8
NAVY CONT. NO. 37780
115 VOLTS D.C. SERIAL NO.
DATE MAY 1935 WSP
MANUFACTURED BY
GEORGE WALKER BOSTON MASS

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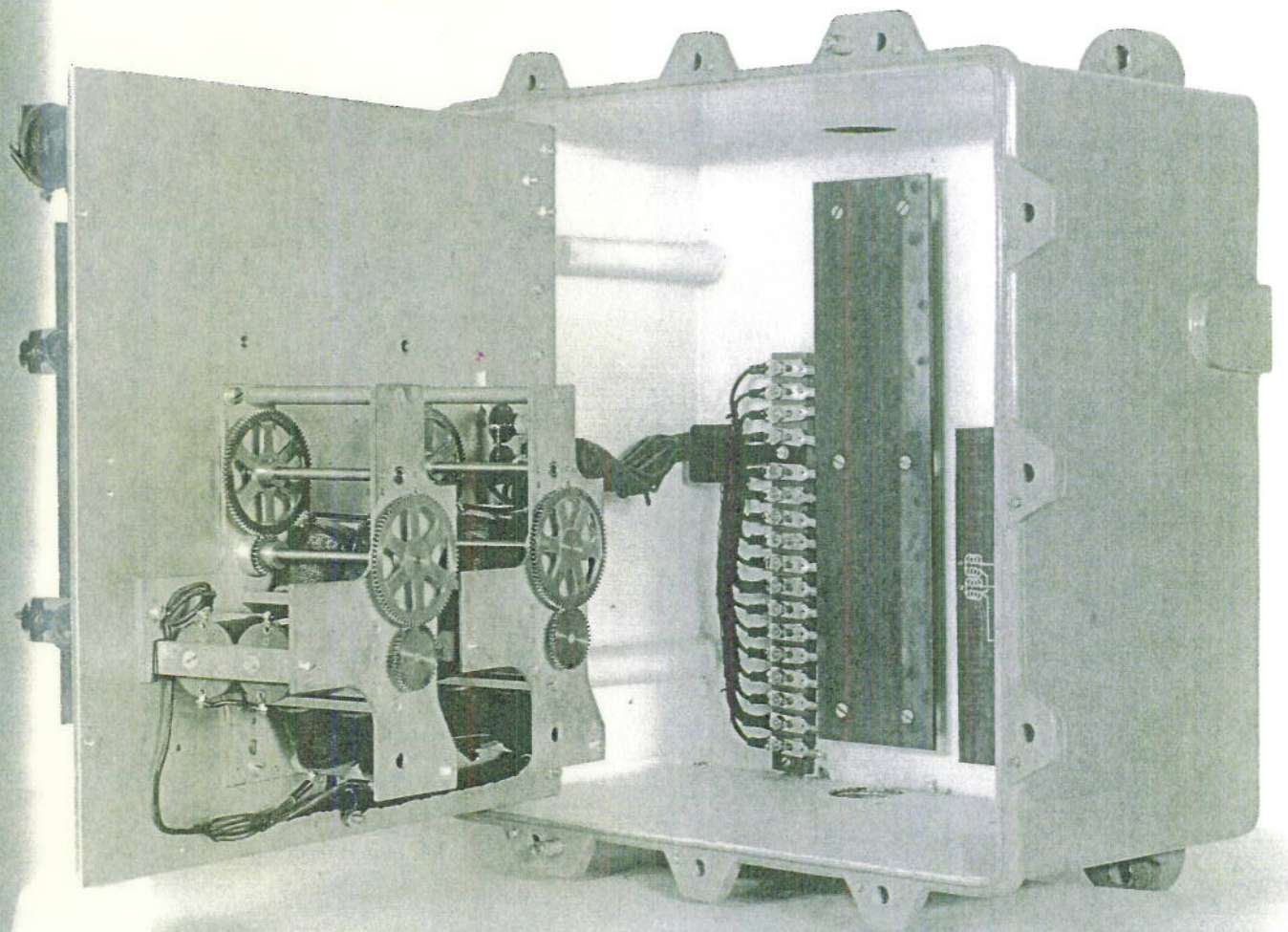
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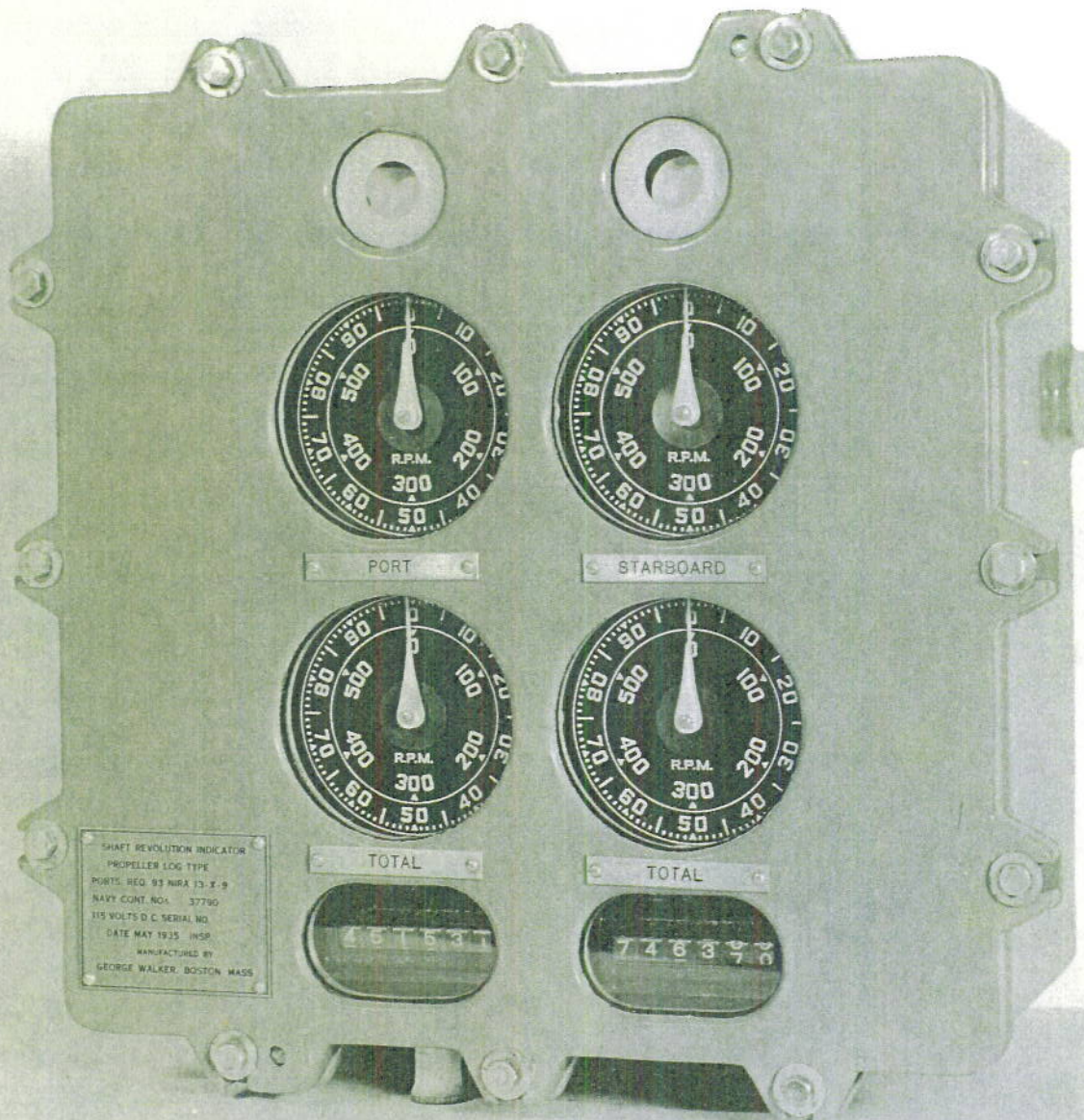
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Plate 5



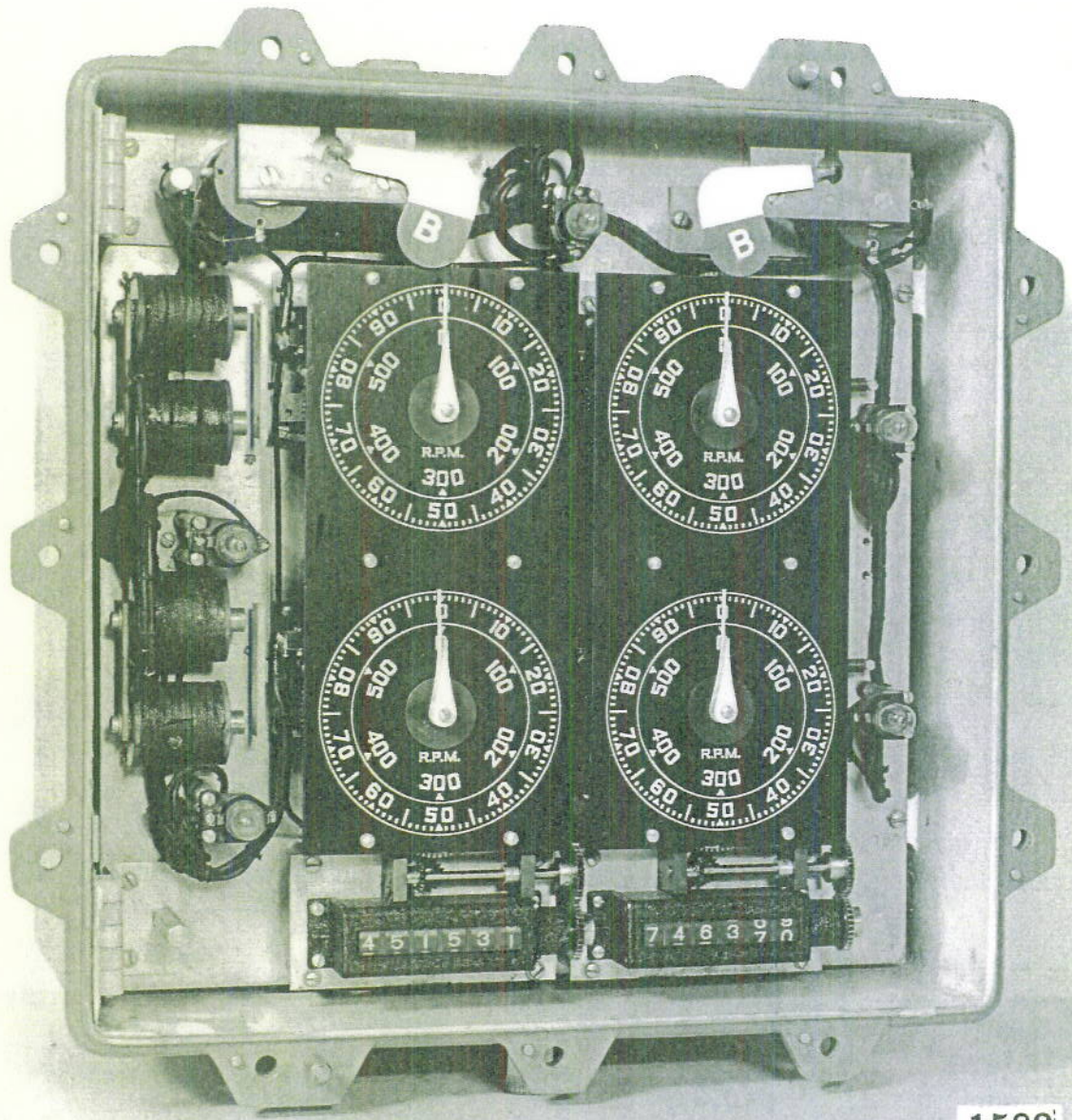
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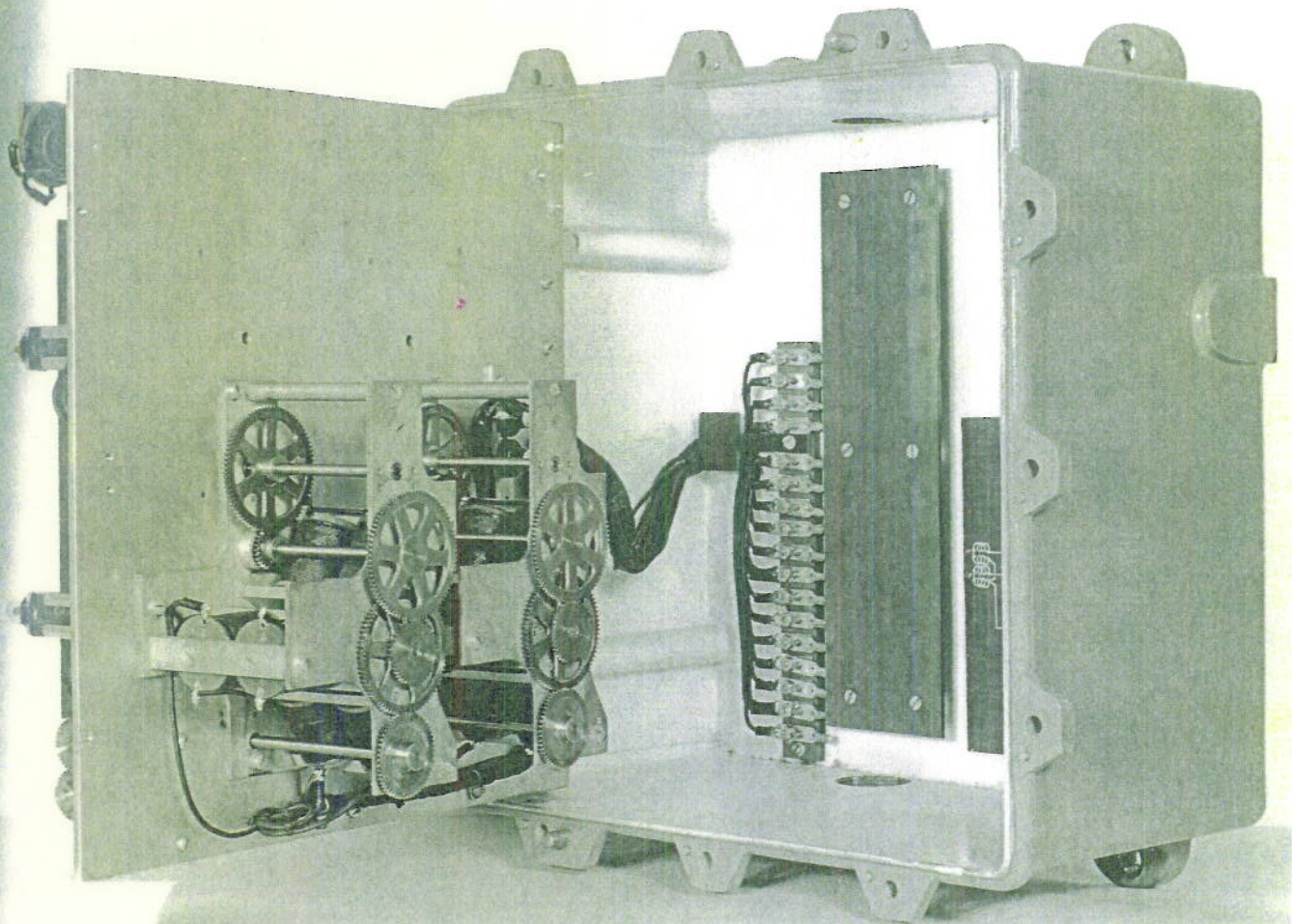
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Plate 7



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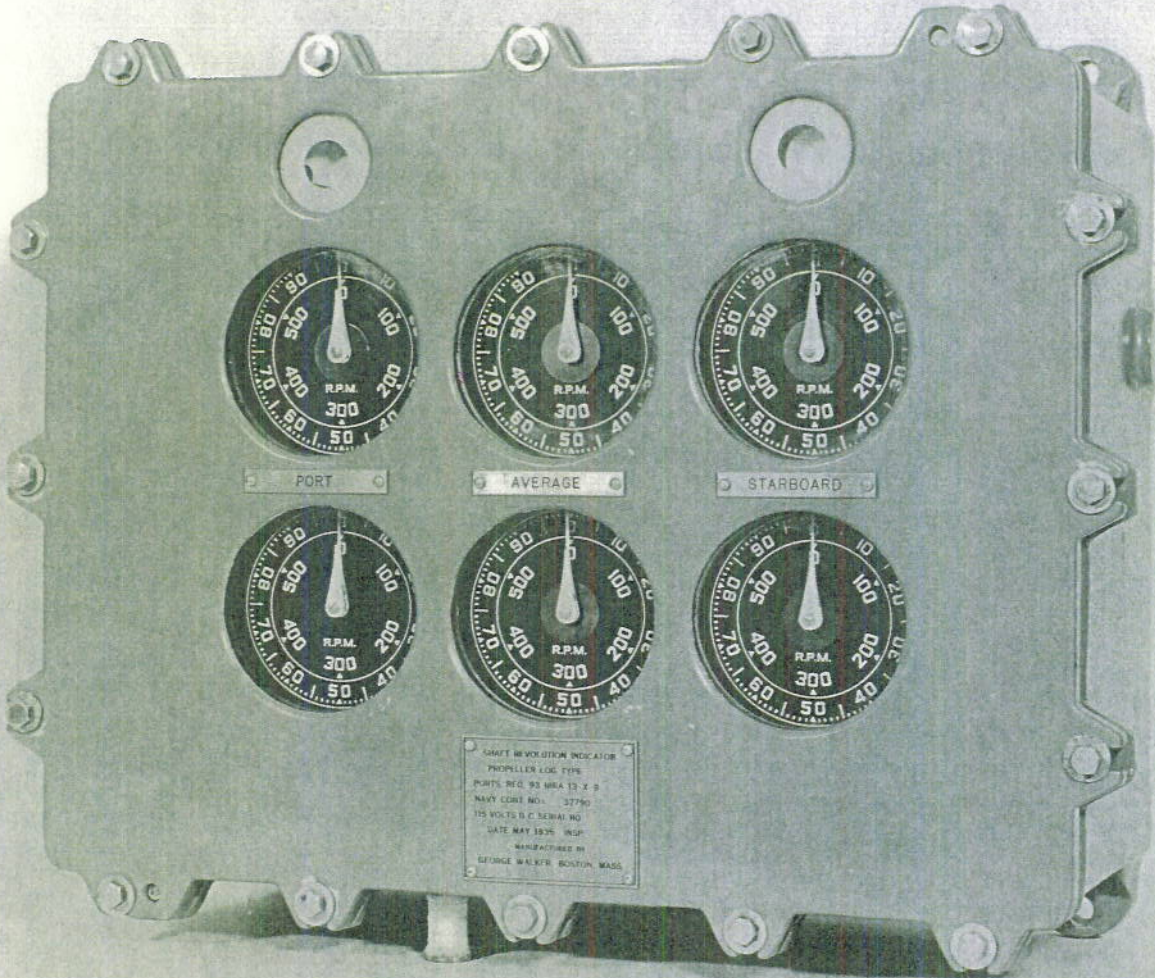
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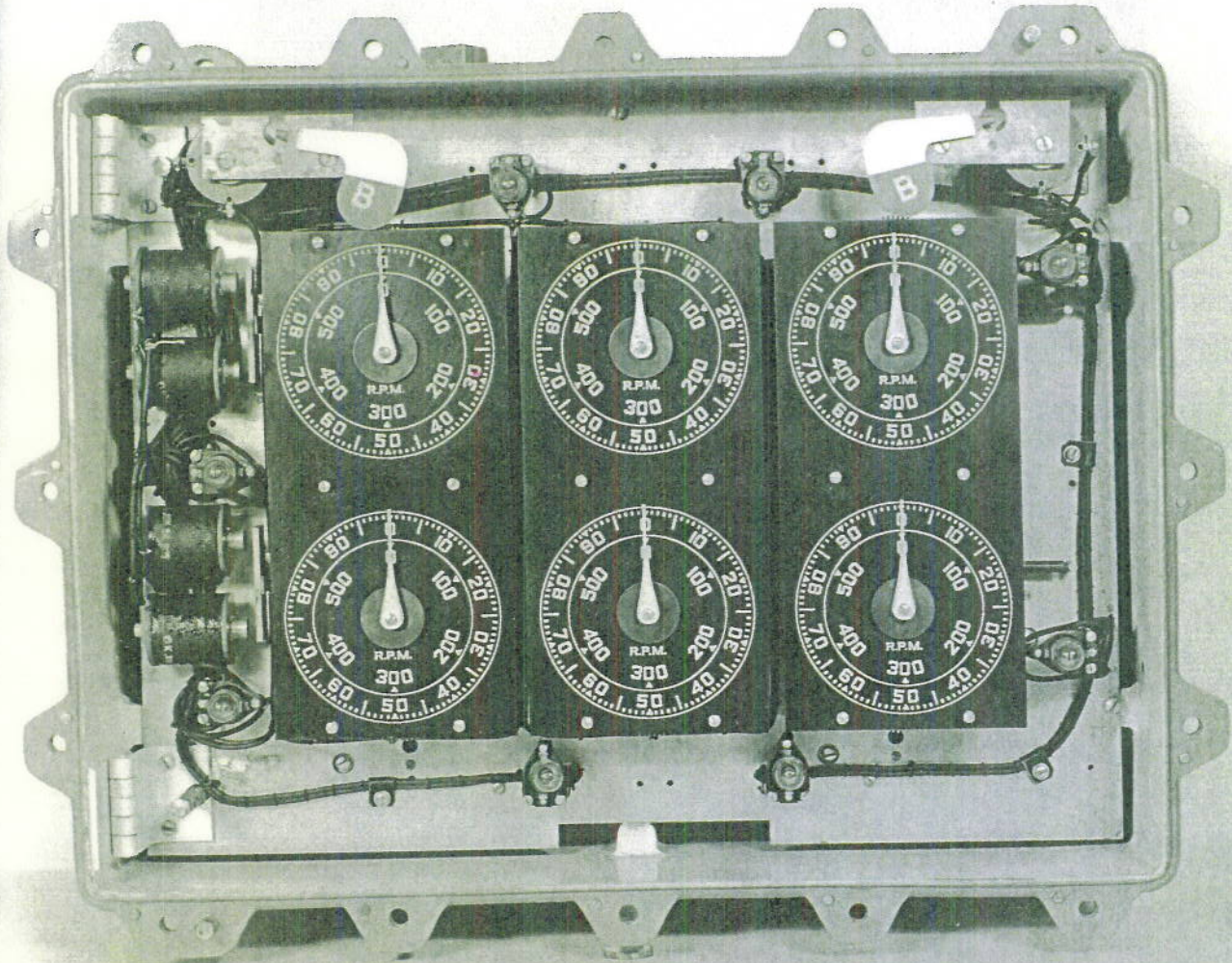
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Plate 9



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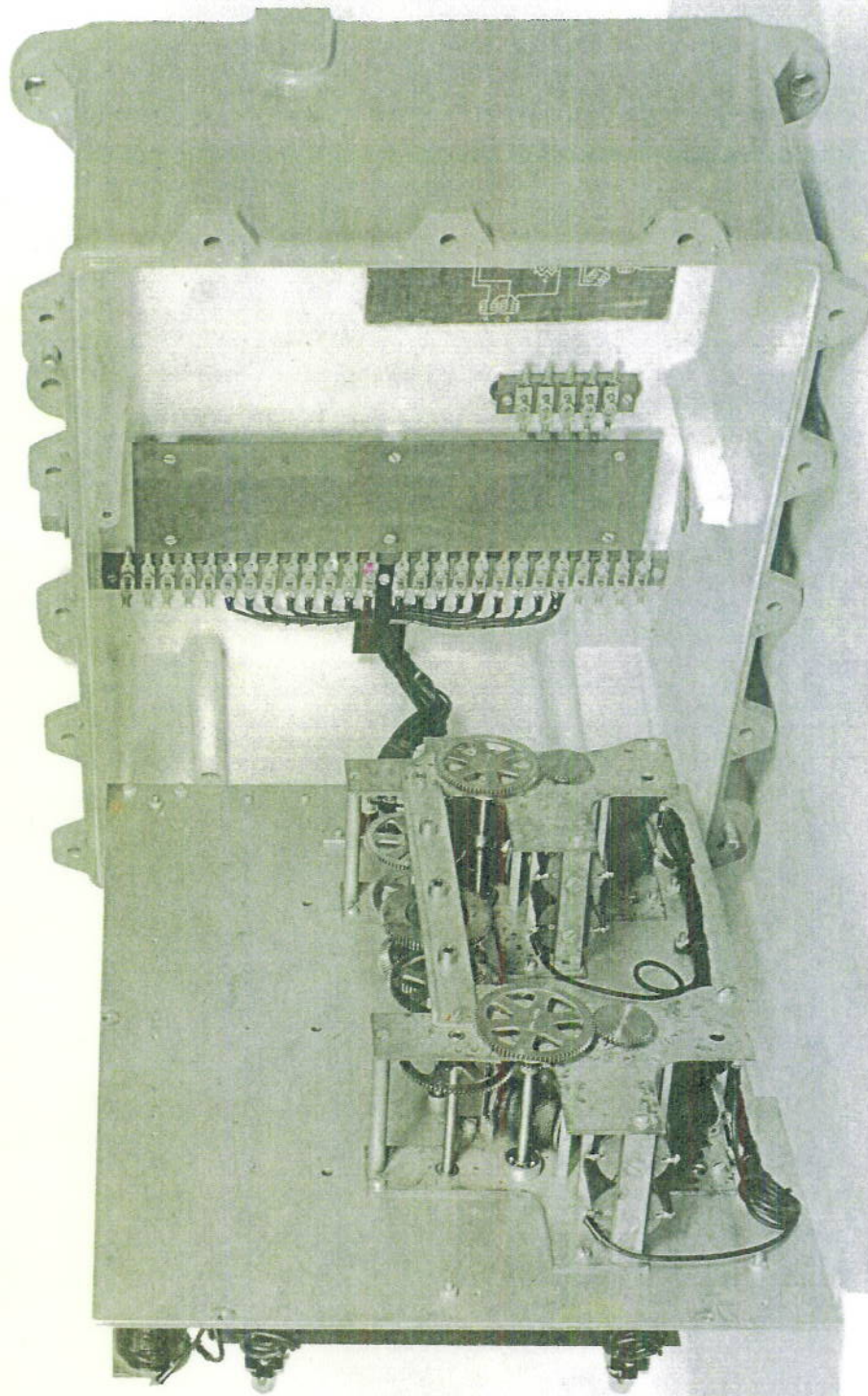
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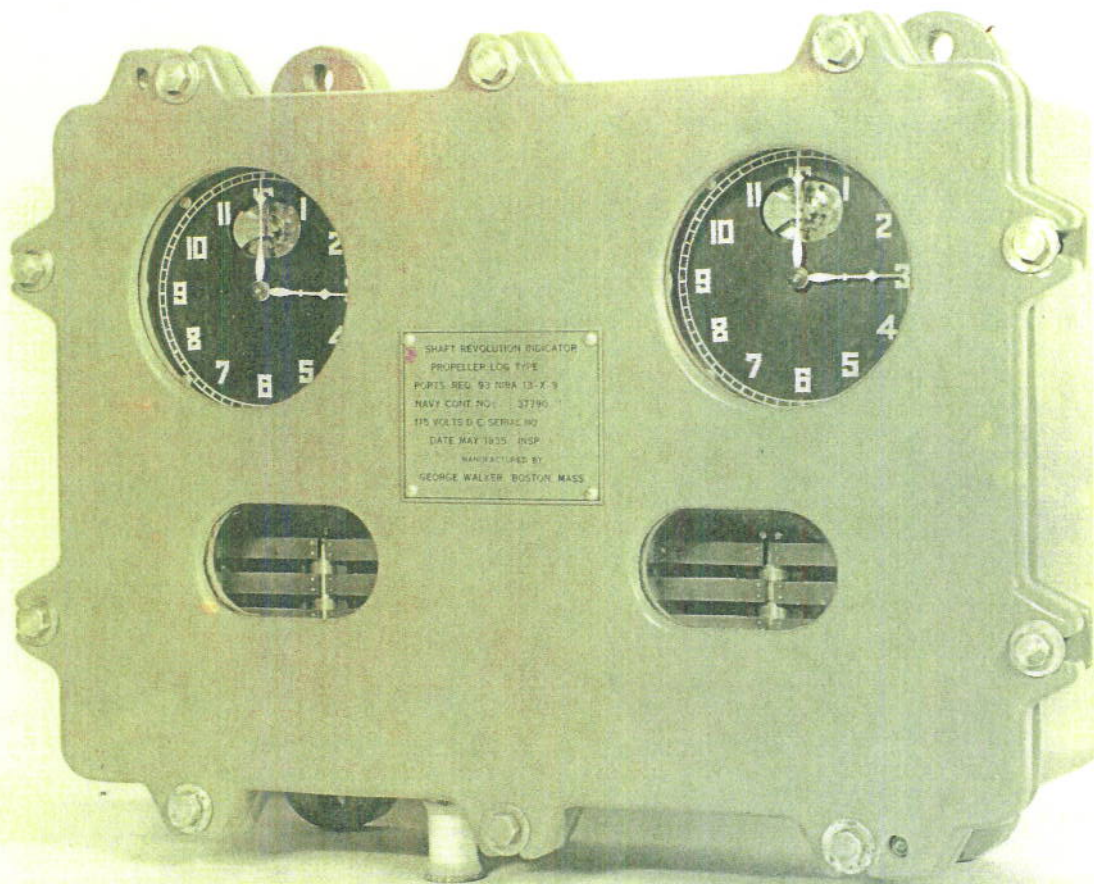
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Plate 11



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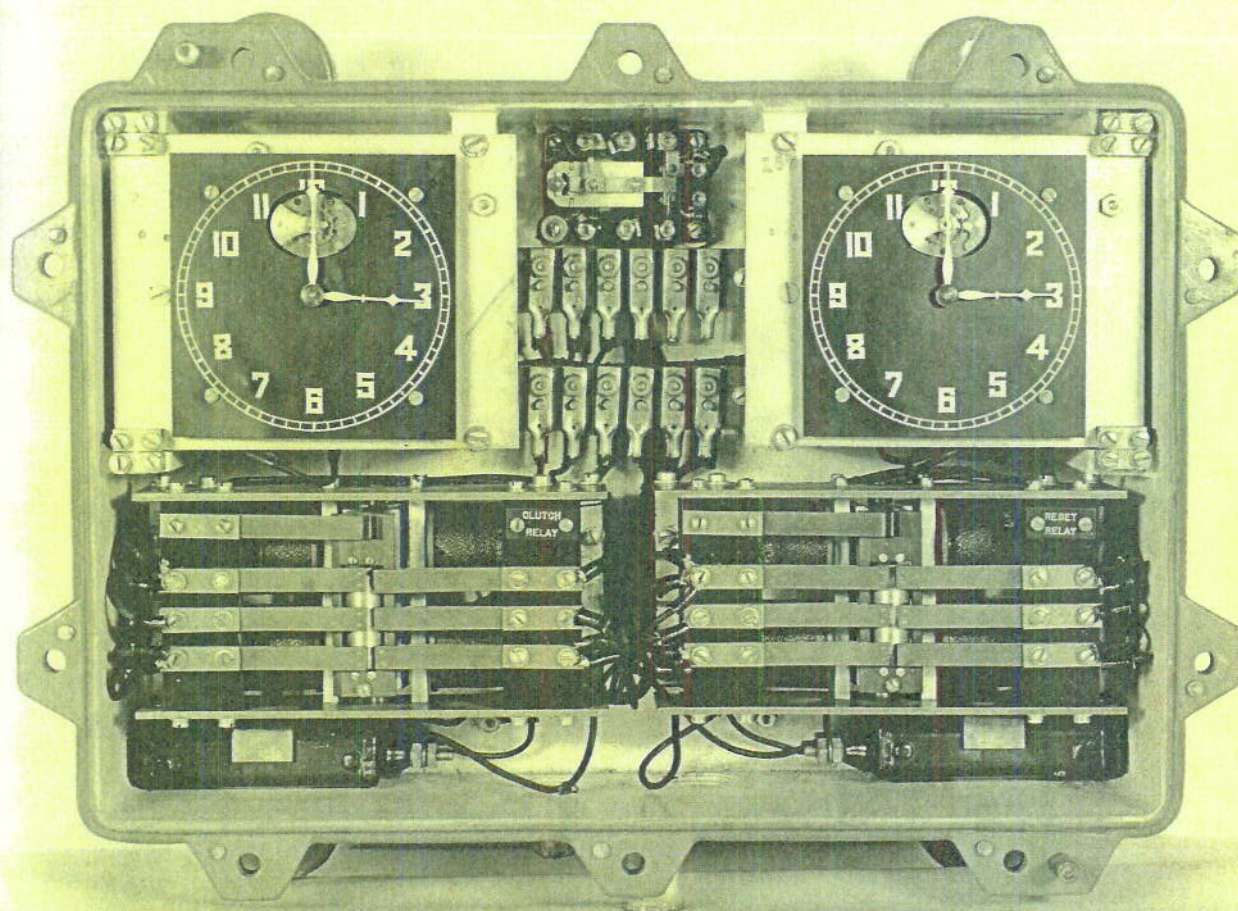


SHAFT REVOLUTION INDICATOR
PROPELLER LOG TYPE
PUPIS REG. 93 NORA 13-X-9
NAVY CONT. NO. 37780
115 VOLTS D. C. SERVIC. NO.
DATE MAY 1935 INSP
MANUFACTURED BY
GEORGE WALKER BOSTON MASS.

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Plate 13



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