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NAVY DEPARTMENT

BUREAU OF ENGINEERING

FR-1283

Report on

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

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON D.C.

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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), (c) and (d).

Reference: (a) Bu.Eng.ltr.S65-5/L5(2-12-Ds) of 17 April 1936.
(b) Specifications SGS(65)-10a of 1 March 1936.
(c) Manufacturer's Drawing, Master Instrument, No. 2119.
(d) NRL Report No. B-1237 of 12 February 1936.

OBJECT OF TEST

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

ABSTRACT OF TEST

3. The two (2) shaft propeller system, shown by Plate 1, was interconnected electrically and tested for conformance with the specifications in so far as they were applicable. Particular attention was given the system over the entire test period to note whether it had any defects such as those discovered and reported under reference (d). In view of no constant frequency control unit accompanying the system, the synchronous motors located in the Master Indicator and Transmitter units were energized from the same source of a.c. 60 cycle supply as that supplying the constant speed motors used for driving the shaft transmitter. The usual inspection of the equipment, relative to materials, design and workmanship, concluded the test.

CONCLUSIONS

(a) This system, in so far as the electrical characteristics, endurance, accuracy in operation prior to and following the application of shock were concerned, complied with the specifications, reference (b).

(b) Its performance during the period of the test was satisfactory and it is considered to be far superior to the system tested and reported under reference (d).

(c) A few minor defects discovered during the tests were as follows:

(1) Under shock, the pointer indicating hundreds in one of the Master instruments bent out and became locked with the unit pointer.

(2) In one instance during the test, the zero Burgess switch, shown on upper portion of drawing, Plate 13, failed to function due to insufficient spring tension on the operating lever. This prevented the disc motor from starting, causing the follow-up system to drive the carriage to the maximum speed position where it was stopped by the limit switch. This was corrected by increasing the spring tension.

(3) The maximum distance from which the repeater indicator targets could be read in a dark room was approximately two feet. This was determined by providing a temporary target. The numerals 1 and 2 identifying the pointers could be read from a distance of not more than three feet. There was considerable light leakage visible from any angle greater than 45° from normal.

(d) Under inspection of materials, the following features on the repeater indicator, shown by Plates 9 and 10, were noted as being undesirable.

(1) Hand hole cover for dial lamps cannot be removed when the instrument is mounted on the gauge board.

(2) Under the same conditions, the rheostat handle will be inaccessible.

(3) Only three mounting lugs can be used for mounting the instrument due to location of the hand hole cover.

(4) The light shield for the lamps is too flimsy.

RECOMMENDATIONS

(a) In view of the satisfactory test results, it is recommended that the subject system be given type approval subject to the following changes:

(1) The pointers should be made of heavier material.

(2) The spring for the operating lever of the zero cut-off switch should also be made of heavier material.

(3) Correction of defects in the case design of the repeater indicator noted under "Conclusions", paragraph (d), should be made.

(4) The resistance of the rheostat used for dimming the dial lamps should be decreased to a point where the potential at the lamps will be 3.5 volts, with full resistance in the circuit.

(5) Master instruments should be furnished in watertight cases.

DESCRIPTION OF MATERIAL UNDER TEST

4. The system submitted is of the instantaneous type and is designed to indicate the speeds of twin propeller shafts and register total revolutions of each shaft. To operate, it requires a supply of 115 volts, a.c., 60 cycles. It is important to note that the current to the synchronous motors located in each of the Master Indicator Transmitters, must be frequency controlled.

Shaft Transmitters (Drawing No. 2100)

5. Each Shaft Transmitter includes one type "A" motor, one six-wheel mechanical counter, one unidirectional gear assembly and a terminal block enclosed in a composition BE case of watertight construction. It is driven from the propeller shaft by means of bronze and phenolite spur gears having 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.

6. 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 embodies a unidirectional gear, so that regardless of the direction of the propeller shaft rotation, the type "A" motor rotates in the same direction -- counterclockwise when viewed from the shaft end.

7. The six-wheel "Veeder" 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. A glass window of watertight construction is located in the case cover for reading the counter.

8. The unidirectional gear train embodies a contact switch to operate the direction of rotation targets located in the various instruments.

9. The speed of the transmitter motor is 80 r.p.m. when the propeller shaft speed is 400 r.p.m.

10. The Shaft Transmitter is shown by Plates 2 and 3.

Master Indicator and Transmitter (Drawing No. 2119) See Plates 11, 12, 13 & 14.

11. Located in this instrument is a type "A" motor driving gear (E), one half of a differential. This motor is driven by the propeller shaft transmitter at a speed proportional to the r.p.m. of the propeller shaft. The other half of the differential, internal gear (B), is driven by the friction Wheel (W) through a slip clutch (C). The differential motion between friction wheel (W) and gear (E) is imparted to gear (F).

12. The friction wheel (W) is rotatably mounted on a nut (N) held by a roller (R) in a guide (G). It is in contact with a steel faced friction disc (D) driven at a constant speed of 120 r.p.m. by an 1800 r.p.m. synchronous motor (S) through a gear ratio of 15:1.

13. The nut (N) can only move backward or forward through the rotation of the screw-shaft (A).

14. The differential gear (F) carries an arm (H) which engages a double contact mechanism (J). All contacts are short-circuited at zero differential speed. The circuit to the follow-up motor is completed through three slip rings and brushes.

15. When the speed of (W) nad (E) are unequal, one contact is opened to operate the follow-up motor (K), which drives the screw-shaft (A) in the proper direction until the speeds of (W) nad (E) are again equal. When this occurs, the three contacts are again shorted and the follow-up motor is immediately stopped through dynamic breaking.

16. *The pointers are positioned by suitable gears connecting to screw-shaft (A). The revolution counter is driven from gear (E) at a proportionate propeller speed.*

17. *For any speed of the propeller shaft there is a definite location* for the friction wheel (W) along the screw-shaft (A). The amount of rotation of the screw-shaft, which positions the friction wheel, is transmitted to the pointers and is an accurate measurement of the propeller shaft r.p.m.

18. A type "A" transmitting motor (MT) is positioned by worm and gear (L) and drives the repeater indicators.

19. A magnetic type backing signal energized from the shaft transmitter is provided.

20. At zero shaft speed, the 1800 r.p.m. synchronous motor driving the disc is cut off by means of a Burgess micro-switch operated through intermittent gearing of the "Geneva motion" type. See Plate 13.

21. A second Burgess switch is provided to limit the travel of the nut assembly and prevent it from jamming. In addition, a protective feature in the form of a slip clutch is provided.

22. The entire mechanism of this instrument is mounted on the front of an aluminum base plate housed in a temporary gauge board case having a bakelite cover. The dial furnished was of paper, having black lettering on a white background. It 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. A slot is cut in the dial for reading the six-wheel mechanical counter. No provisions are made for dial illumination. Further details of construction are shown by photographs, Plates 4, 5 and 6, and drawings, Plates 11, 12, 13 and 14.

Repeater Indicator.

23. This instrument is a combined two shaft repeater indicator having two type "M" motors, each positioned by its respective Master instrument. Provision is made for two backing targets, but they were not furnished with the instrument.

24. The dial is black with white markings and is 7"0 in diameter, being graduated from 0 to 400 in steps of 2 r.p.m.

25. The pointers are red and green and are identified by numerals "1" and "2".

26. Cory glass ring-type lighting using Mazda 55, 6-8 volt lamps is employed. The lamp voltage is controlled by a rheostat connected in the secondary circuit of a transformer having a rating of 5 VA, 115/7.5 volts.

27. The watertight aluminum alloy case is designed for gauge board mounting and has a packing gland provided for the rheostat shaft. A hand hole cover is provided in the rear of the case for access to the terminal block. A second cover, located on one side of the case, is provided for reaching the lamps. Two bosses, tapped for 1-1/4" terminal tubes, are spaced 180° apart and located near the back of the case. Steel inserts, threaded into the case, are provided for the rear hand hole cover cap screws. A square rubber gasket is provided for the case cover and flat rubber gaskets are used for the hand hole covers.

28. Two instruments of this type were received; the one used during the test is shown by Plates 1, 7 and 8; the one shown by Plates 9 and 10 was submitted later without motors or direction targets. The second instrument was submitted for dial illumination and watertight tests only.

METHOD OF TEST

29. The system, shown by Plate 1, was first tested for endurance by energizing it from a local 115 volt, a.c., 60 cycle supply and driving the shaft transmitters at a speed corresponding to a shaft speed of 400 r.p.m. This test was continued for 500 hours, using synchronous motors and suitable gears for driving the transmitters. The direction of rotation of the driving motors was reversed for one hour in each twenty-four hours.

30. 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 counterclockwise.

31. Following this, the system, less the synchronous motors of the Master instruments, was tested for voltage and frequency compensation under power supply variations of ±10% in voltage and ±5 cycles in frequency.

32. A test was then made to determine whether the accuracy of the Master instruments would be affected by derangement of the repeater circuit. Tests were also made to determine the operating characteristics of the system when the Master instruments were inclined 30° from the vertical in all planes.

33. One of the Master instruments was then placed on a standard shock stand and tested for shock integrity by subjecting it to 20 blow of 250 foot pounds each. During this test, the unit was operating in the system at the maximum speed of 400 r.p.m.

34. The accuracy test, outlined in paragraph 30, was then repeated.

35. Since it was realized that the follow-up mechanism functioned but little during the previous tests, the following additional test was conducted for a period of 24 hours.

> With the test set-up arranged to drive the system at 400 r.p.m., a Telechron timing device was connected in series with the driving motors so as to alternately energize and de-energize them for periods of three minutes each. This cycling allowed ample time for the system to indicate 0 and 400 r.p.m.

36. An additional test was made to determine the temperature rise of the synchronous motor of one Master instrument at ambient temperature of 150°F. The capacitor used in connection with this motor was examined to note any leaks at this temperature, after which it was subjected to 1000 volts d.c. for one minute.

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

RESULTS OF TEST

Endurance

38. Under conditions specified in paragraph F-2c(1)a of reference (b), the system functioned satisfactorily. The maximum error observed was minus 0.5 r.p.m. on No. 1 Master instrument and minus 0.25 r.p.m. on No. 2 Master. There was no observable difference in the indicated r.p.m. of the repeater indicator and its Master instrument. The revolution counters of the Master instruments checked with those of the shaft transmitters.

39. Accuracy tests before application of shock.

Driven Speed	No. 1 Master Instrument		No. 2 Master Instrument	
r.p.m.	Indicated r.p.m.	Error r.p.m.	Indicated r.p.m.	Error r.p.m.
60	59.50	-0.50	59.75	-0.25
100	99.50	-0.50	99.75	-0.25
150	149.50	-0.50	149.75	-0.25
200	199.75	-0.25	199.75	-0.25
250	249.75	-0.25	249.75	-0.25
300	299.75	-0.25	299.75	-0.25
400	399.50	-0.50	399.75	-0.25

Note: The repeater indications during this test were the same as the indicated r.p.m. on their respective Master instruments.

40. The accuracy of the system was unaffected when a ±10% change in the voltage or ±5 cycles in frequency occurred in the supply to the type "A" and "M" motors.

41. The accuracy of the Master instruments was unaffected when their respective indicator pointers were locked at zero and the shaft transmitters accelerated from 0 to 400 r.p.m.

Shock Test

42. With one of the Master instruments mounted on a standard shock machine and operating at 400 r.p.m., 20 blows of 250 foot pounds each were applied. It was noted that a slight change in the indications of this Master and its repeater occurred at the instant of shock impact. This error, however, was corrected by the Master instrument within a few seconds. It was also noted that after application of several shocks, the small pointer, indicating hundreds, bent out and became meshed with the unit pointer, locking both.

Accuracy Test Following Shock Test

43. There was apparently no change in the error of the system following the application of shock.

Additional Tests

44. A test was made to determine the shaft speed at which the "Burgess" micro-switch operated and cut off the follow-up motor which determines the maximum r.p.m. that the system can indicate. It was found that the pointers stopped at 454 r.p.m. At zero shaft speed, the synchronous motor driving the disc was cut off by a second limit switch.

45. During the test described in paragraph 35, the follow-up mechanism functioned perfectly and in no case was the error greater than that given in paragraph 39. During this test, an interval of 25 seconds was required for the system correctly to indicate a speed of 60 r.p.m. starting from zero and 20 seconds to return to zero when the driving motor was cut off. At a speed of 400 r.p.m., the corresponding intervals were 46 and 38 seconds, respectively.

46. The temperature rise of the synchronous motor in one Master instrument was 21.9°C at ambient temperature 65.5°C. The capacitor used in connection with this motor did not leak and successfully withstood 1000 volts d.c. applied for one minute.

47. The minimum insulation resistance by 1000 volt megger on any instrument was 200 megohms.

48. No breakdowns occurred under a dielectric test of 1500 volts, a.c., 60 cycles, applied for one minute between all current-carrying parts and ground.

49. The maximum distance from which the repeater indicator dial could be read was approximately six feet when viewed in a dark room with the maximum potential of 7 volts applied to the lamps. The current consumed by the two Mazda 55 lamps was 0.76 amperes at 7 volts.

50. The only instrument suitable for the watertight integrity test was the repeater indicator, shown by Plates 9 and 10. When submerged in water to a depth of 3 feet for a period of one hour, no leaks occurred.

51. The current consumption of the synchronous motors in the Master instruments was 0.260 amperes at 115 volts, a.c., 60 cycles.

52. When inclining any of the instruments 30° from the vertical in all planes, there was no observable change in the operation of the system.

CONCLUSIONS

53. This sytem, in so far as the electrical characteristics, endurance, accuracy in operation prior to and following the application of shock were concerned, complied with the specifications, reference (b).

54. Its performance during the period of the test was satisfactory and it is considered to be far superior to the system tested and reported under reference (d).

55. A few minor defects discovered during the tests were as follows:

(a) Under shock, the pointer indicating hundreds in one of the Master instruments bent out and became locked with the unit pointer.

(b) In one instance during the test, the zero Burgess switch shown on upper portion of drawing, Plate 13, failed to function due to insufficient spring tension on the operating lever. This prevented the disc motor from starting, causing the follow-up system to drive the carriage to the maximum speed position where it was stopped by the limit switch. This was corrected by increasing the spring tension.

(c) The maximum distance from which the repeater indicator targets could be read in a dark room was approximately two feet. This was determined by providing a temporary target. The numerals 1 and 2 identifying the pointers could be read from a distance of not more than three feet. There was considerable light leakage visible from any angle greater than 45° from normal.

56. Under inspection of materials, the following features on the repeater indicator, shown by Plates 9 and 10, were noted as being undesirable.

(a) Hand hole cover for dial lamps cannot be removed when the instrument is mounted on the gauge board.

(b) Under the same conditions, the rheostat handle will be inaccessible.

(c) Only three mounting lugs can be used for mounting the instrument due to location of the hand hole cover.

(d) The light shield for the lamps is too flimsy.

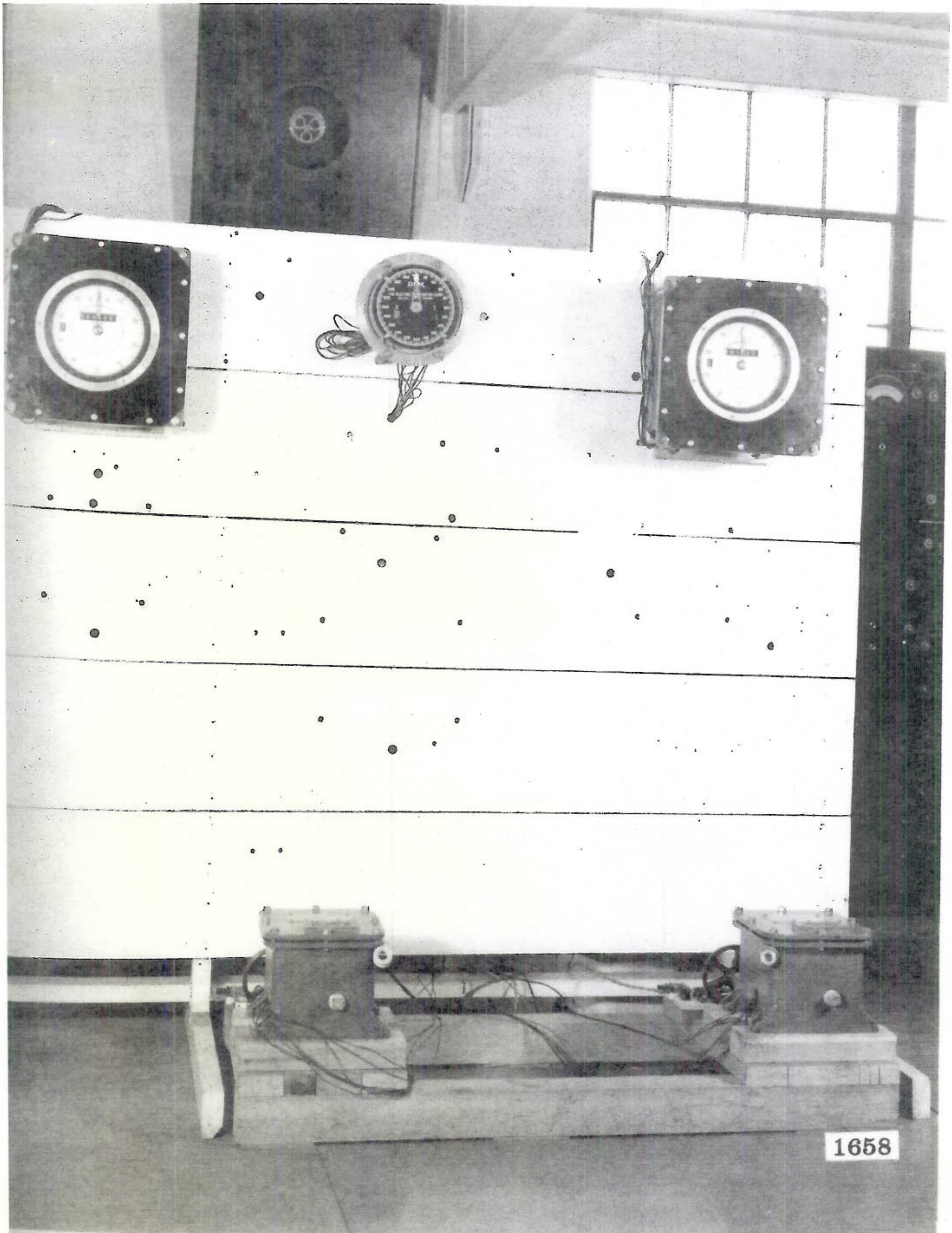

PLATE I

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WASHINGTON, D.C.

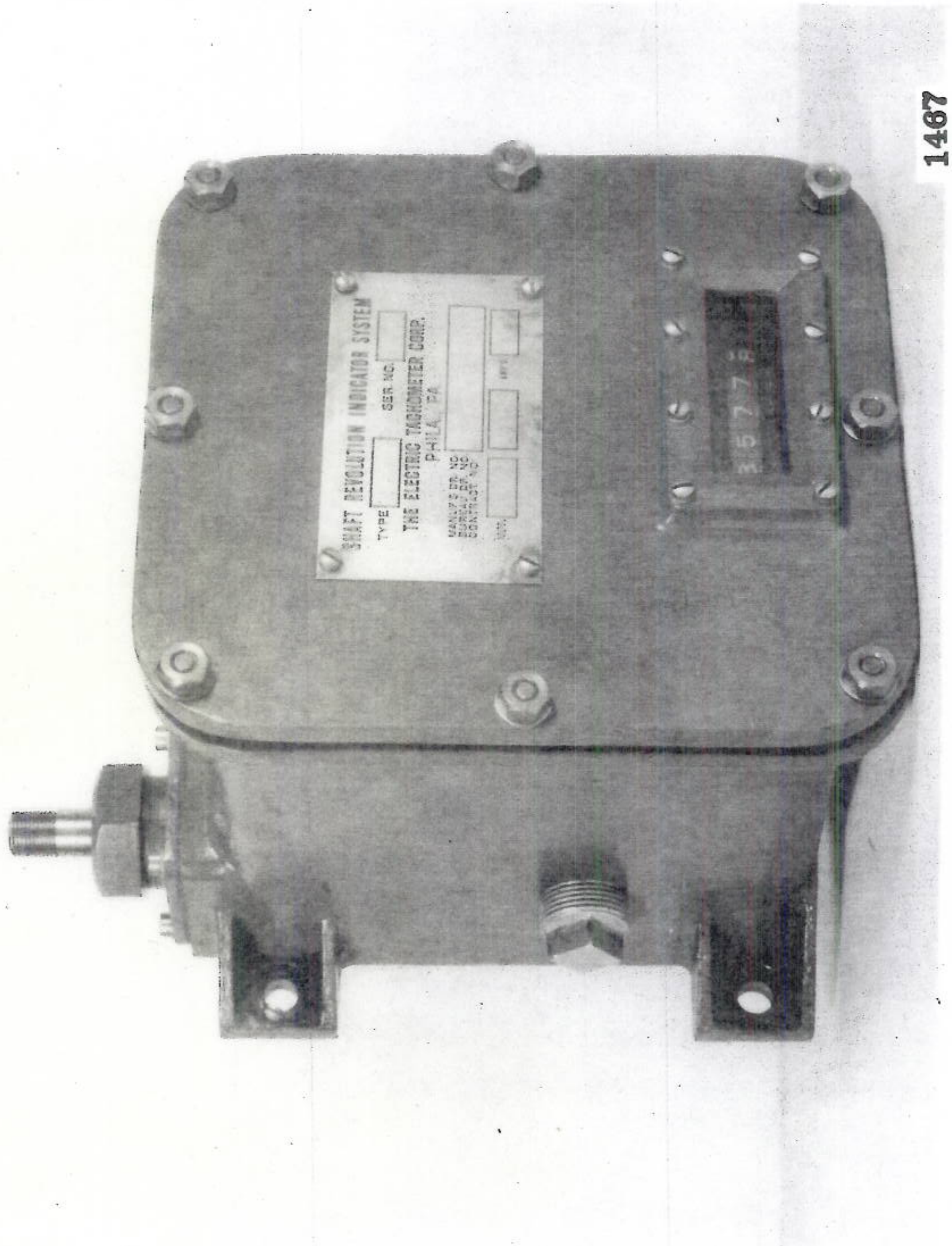

PLATE 2

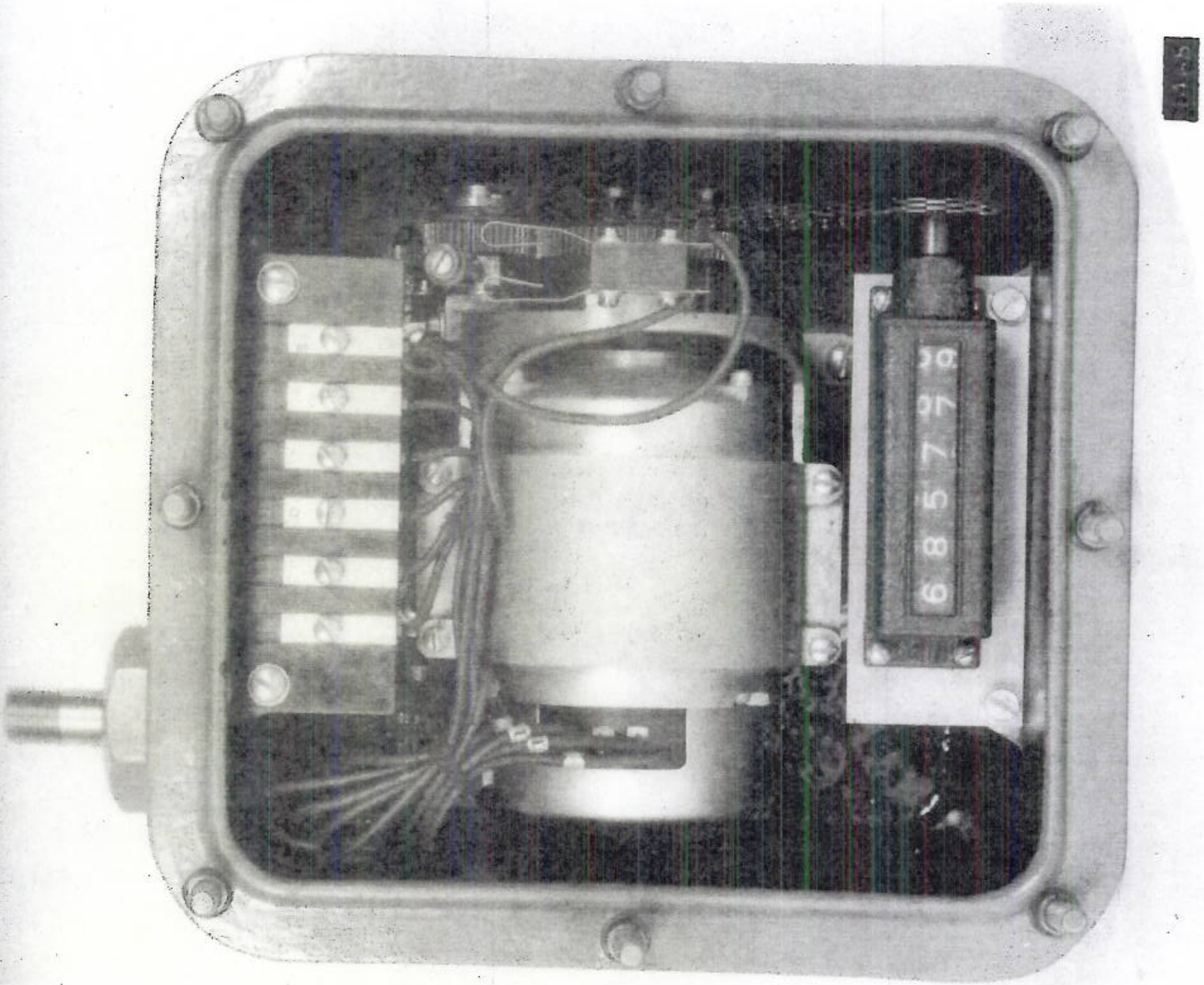

PLATE 3

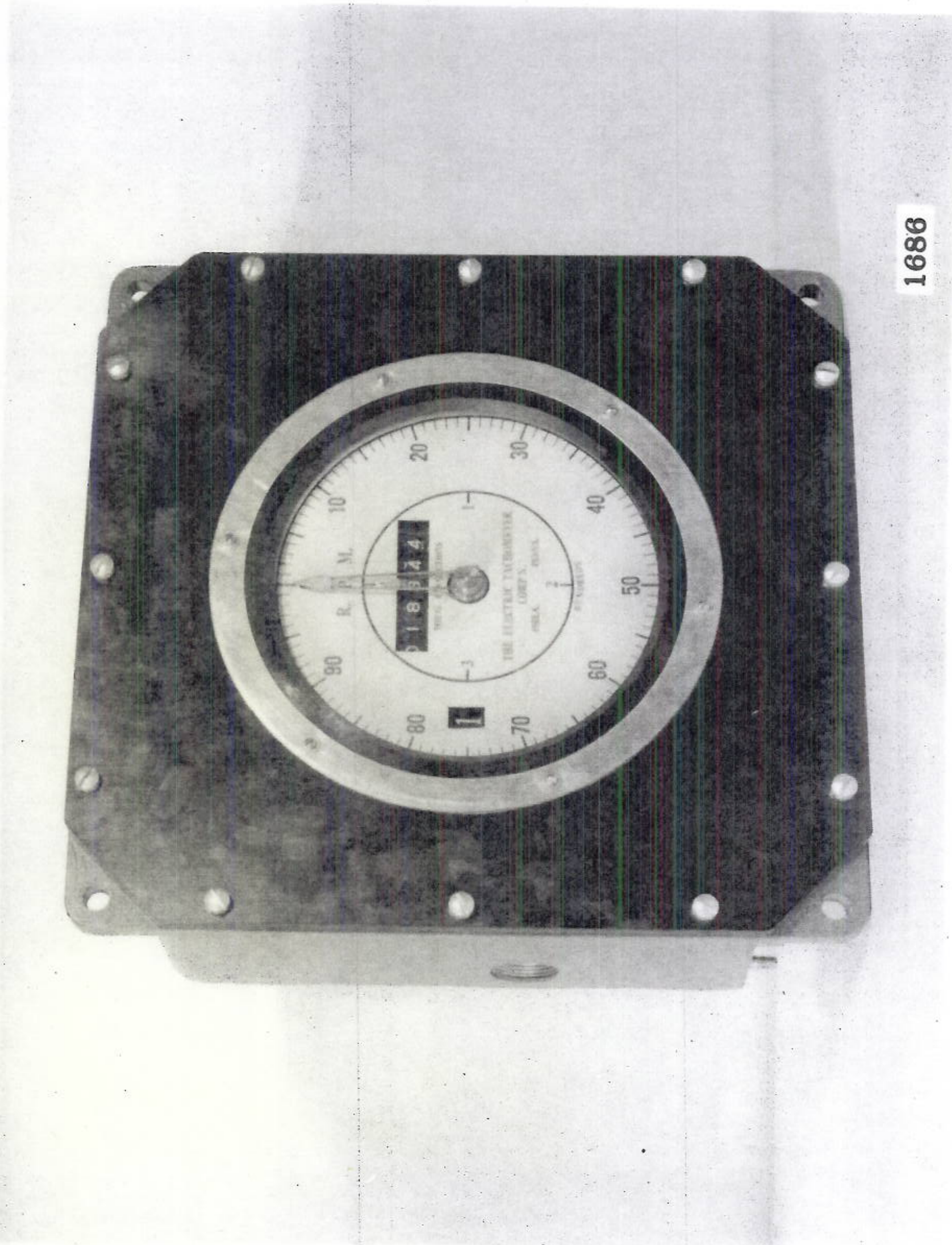

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PLATE 4

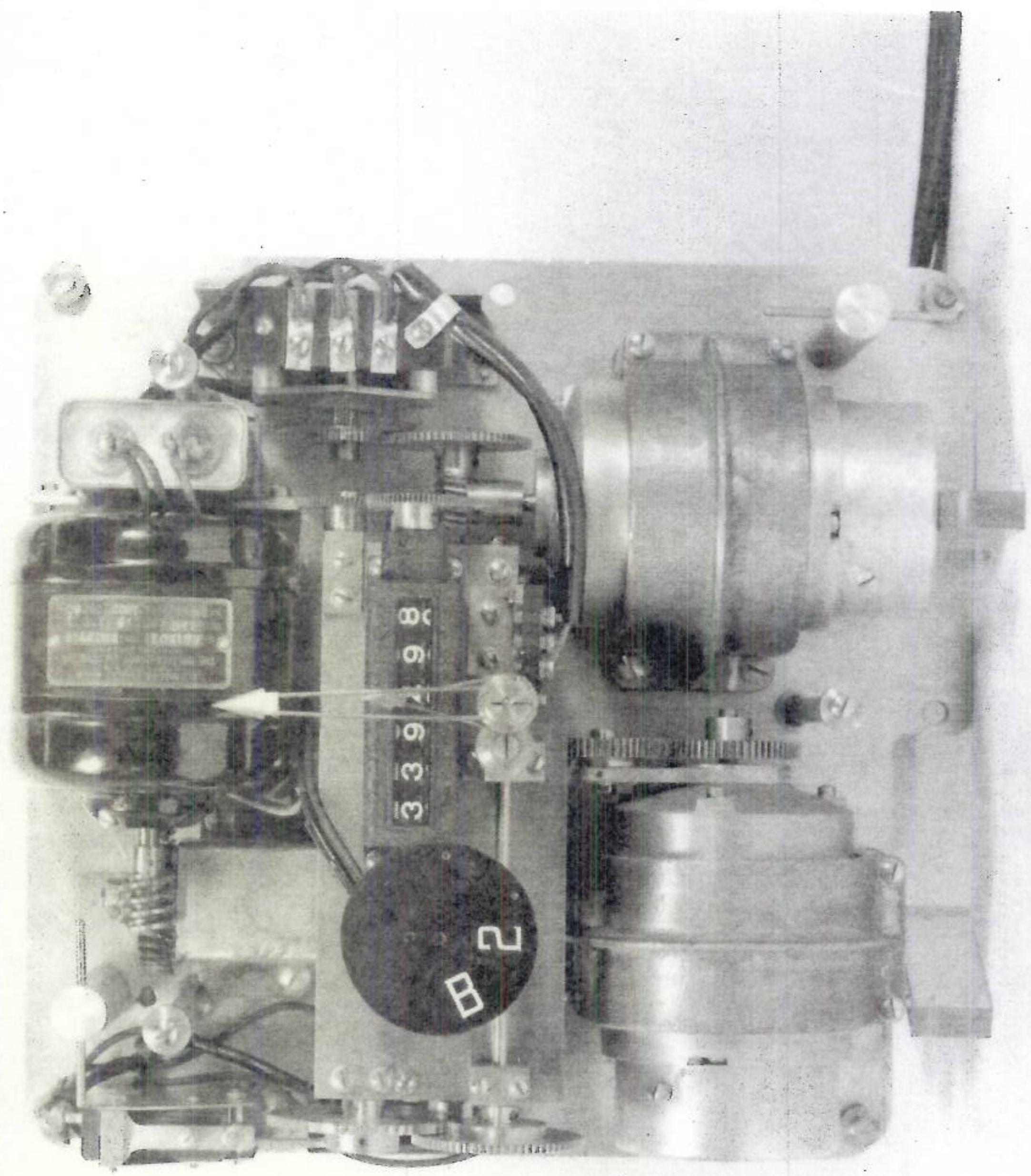

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PLATE 5

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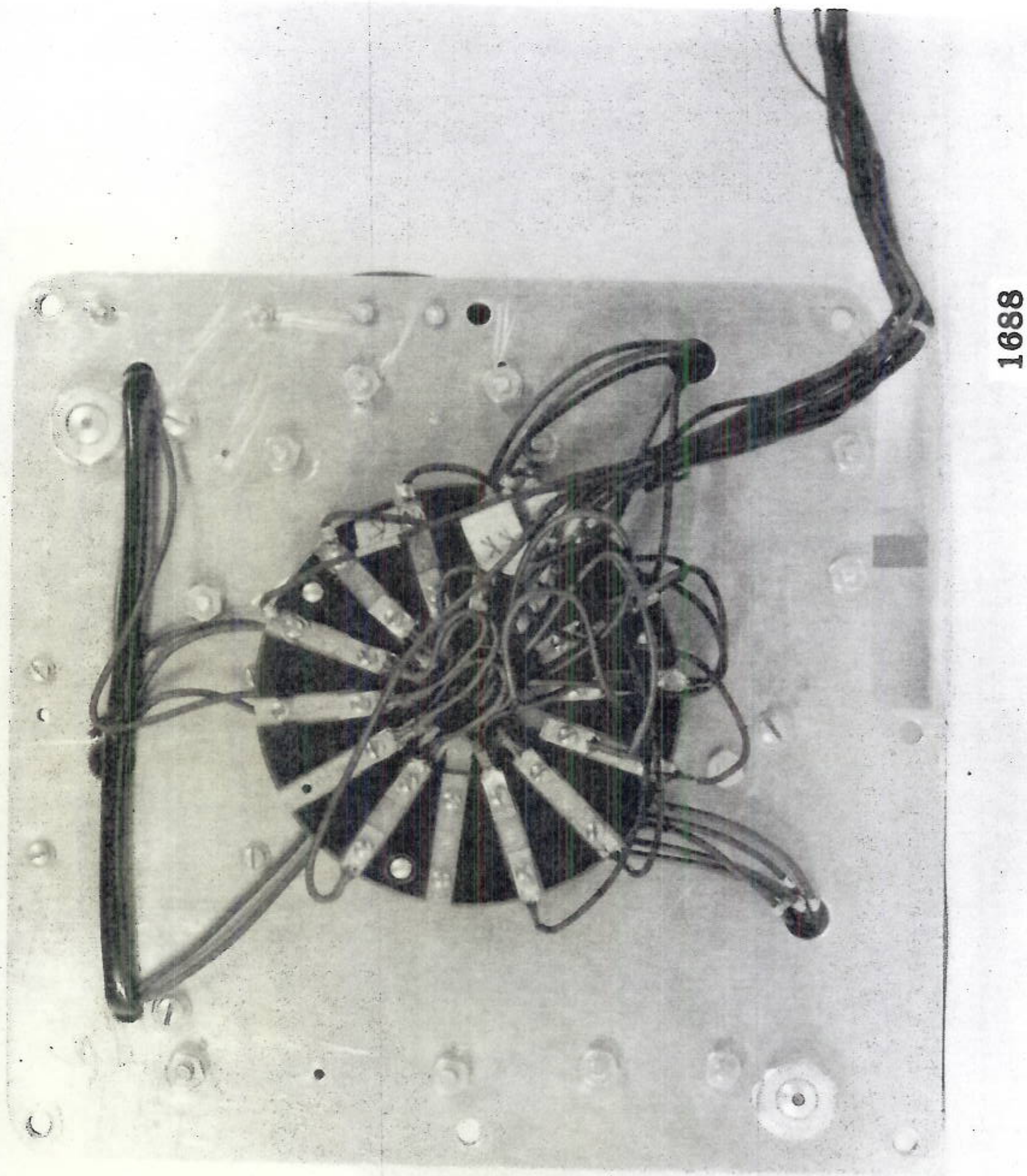

PLATE 6

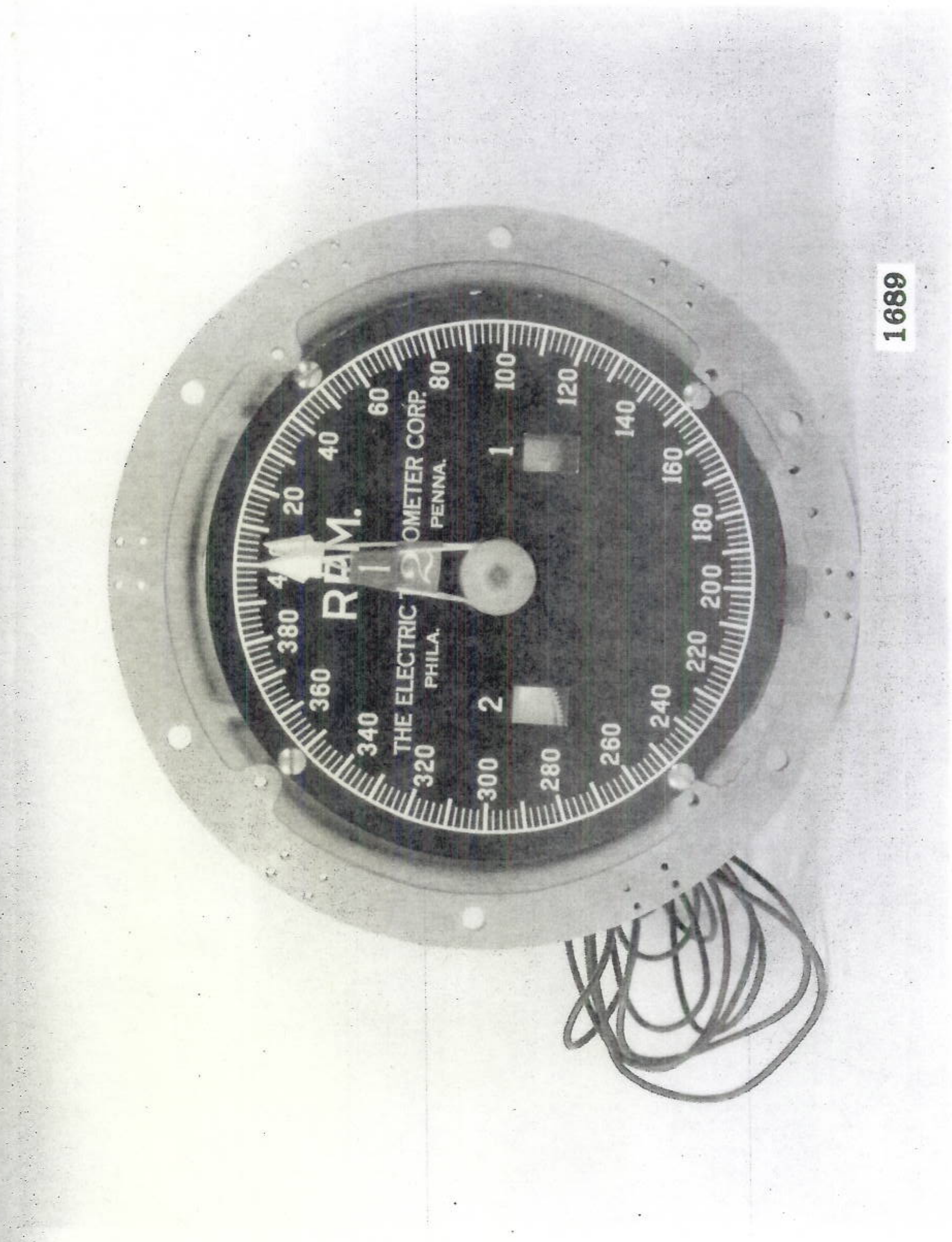

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PLATE 7

Naval Research Laboratory
Anacostia Station
Washington, D.C.

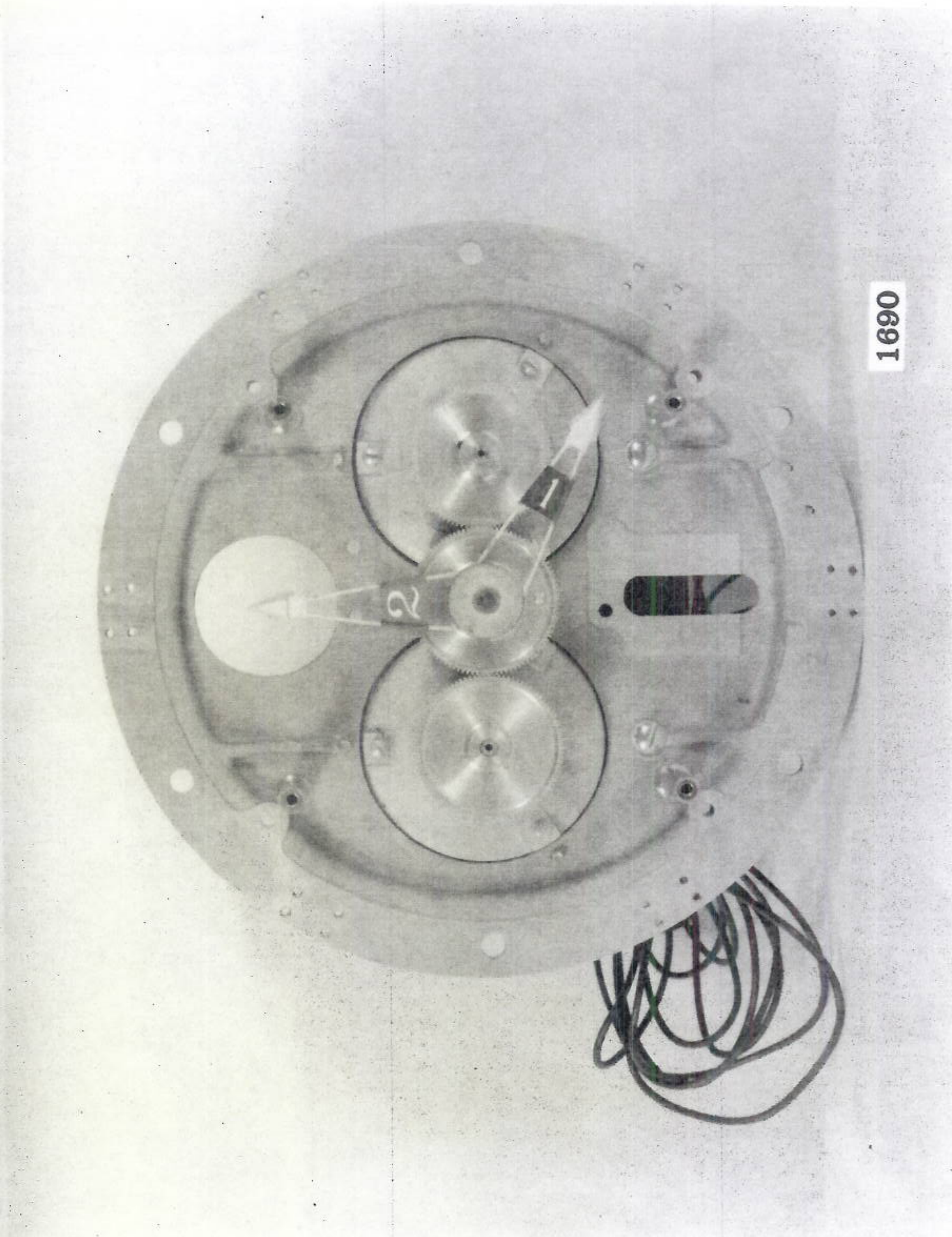

PLATE 8

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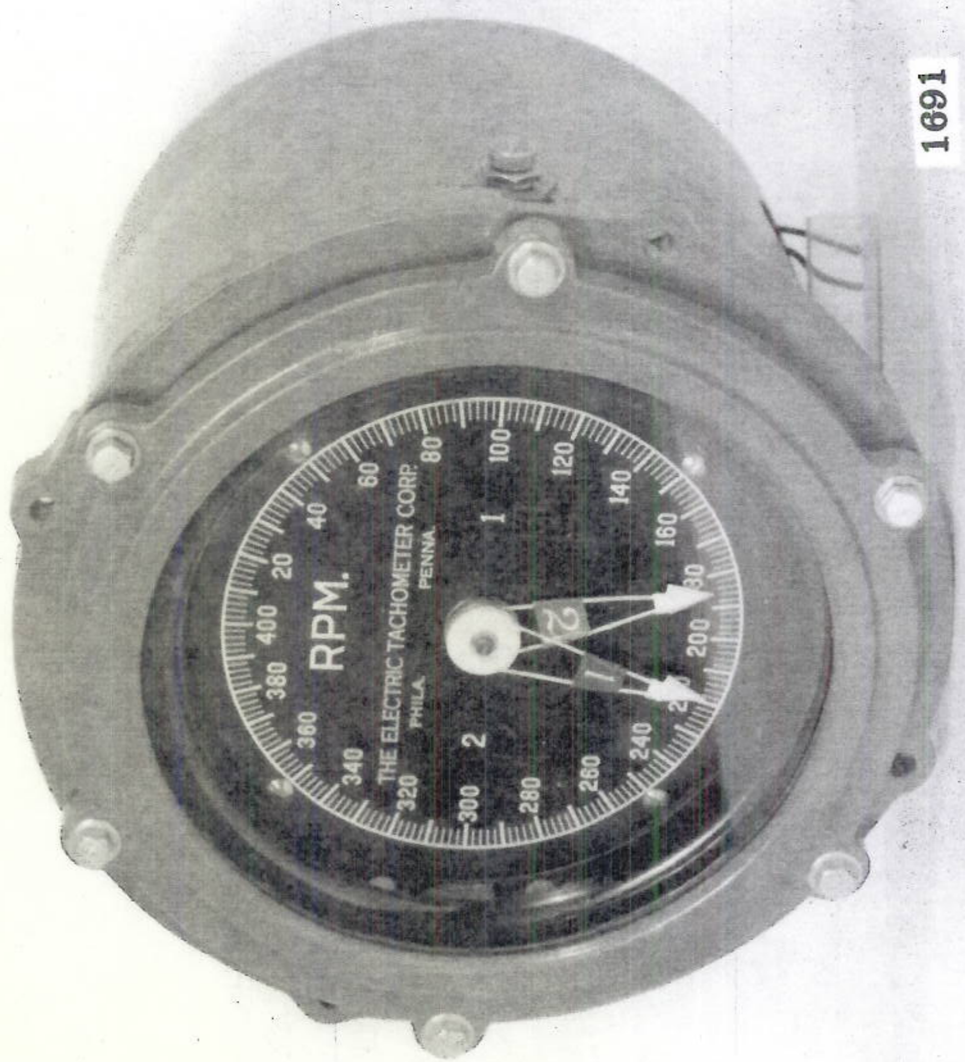


PLATE 9

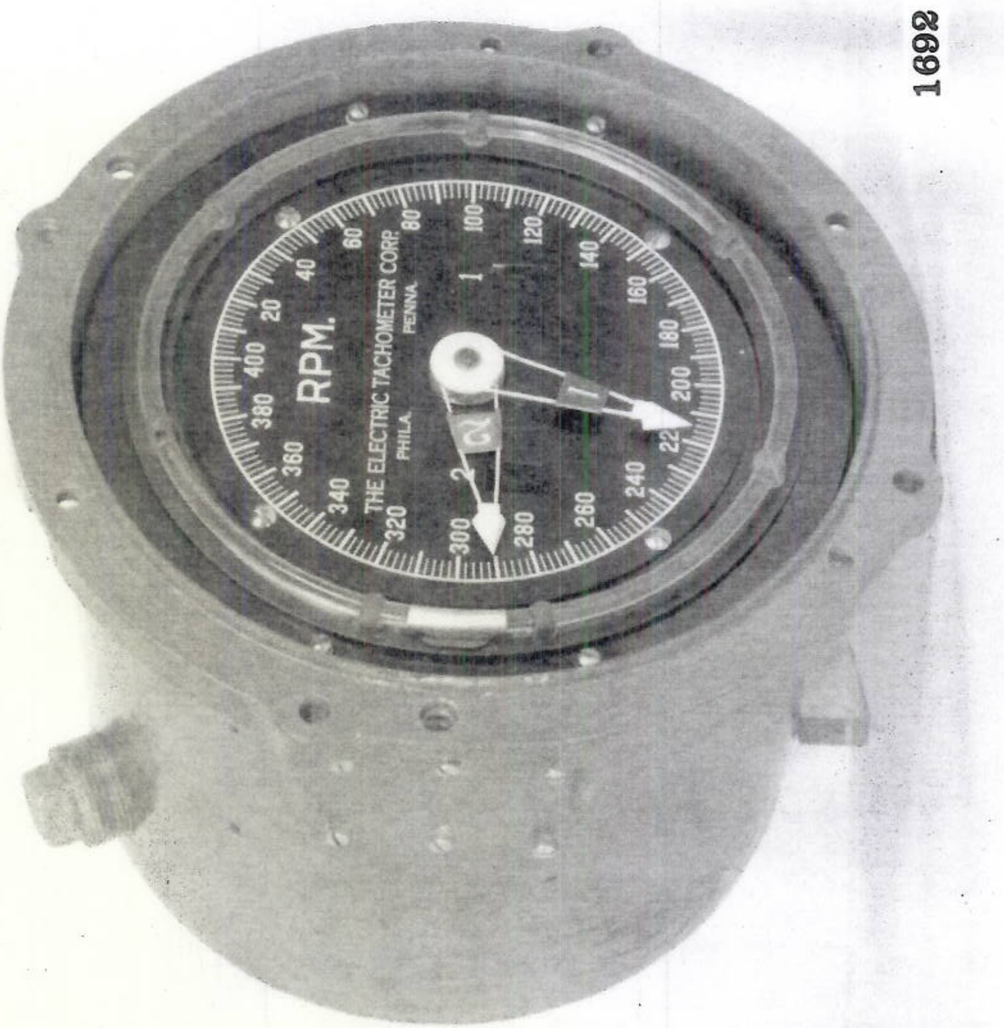


PLATE 10.

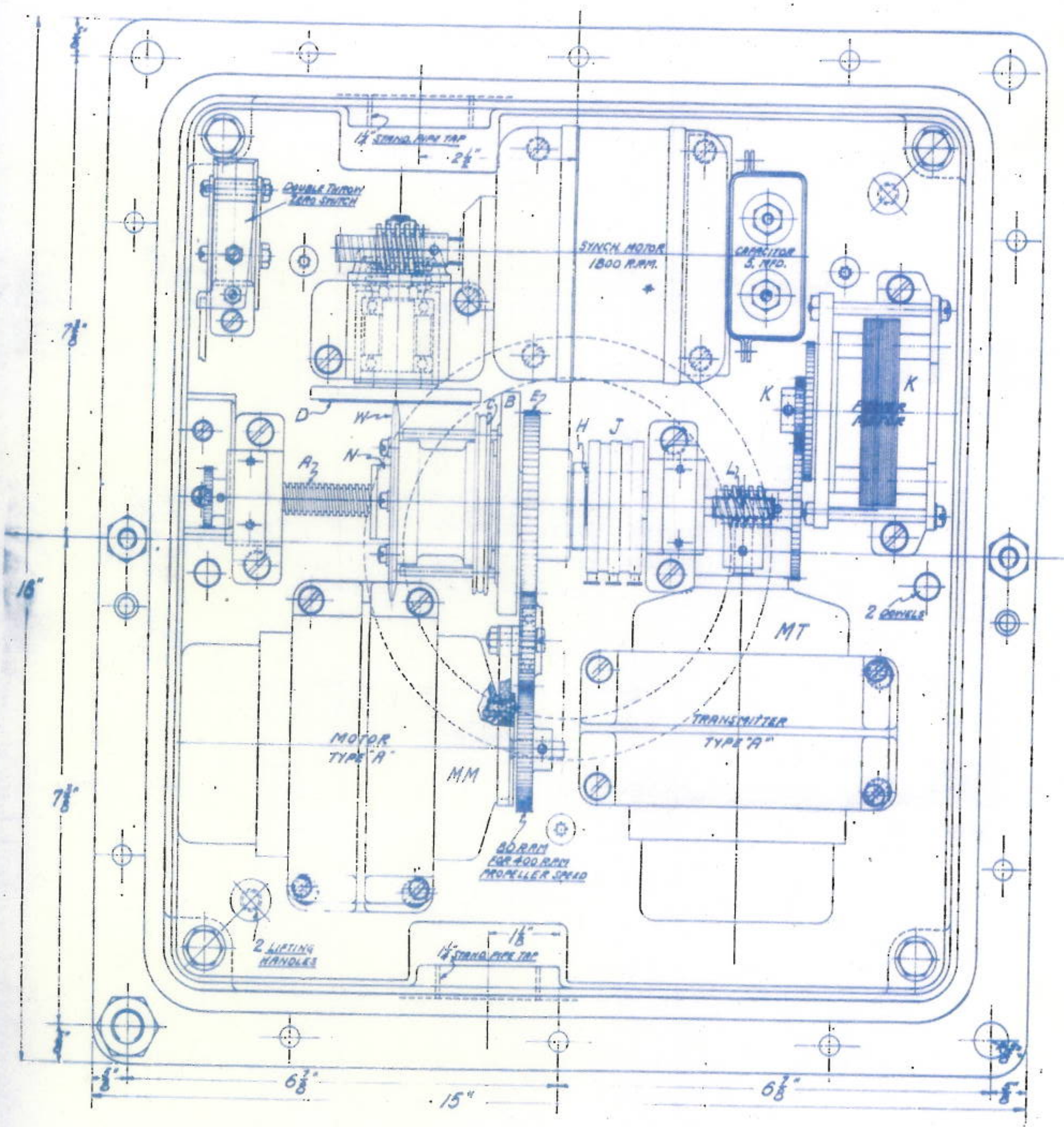

1¼" STAND. PIPE TAP
2½"
DOUBLE THROW ZERO SWITCH
SYNCH. MOTOR
1800 R.P.M.
CAPACITOR
5 MFD.
K
K
D
W
B
E
H
J
A
N
L
2 DOWELS
MT
16"
7⅞"
7⅞"
TRANSMITTER
TYPE "A"
MOTOR
TYPE "A"
MM
80 R.P.M.
FOR 400 R.P.M.
PROPELLER SPEED
2 LIFTING HANDLES
1¼" STAND. PIPE TAP
6⅞"
15"
6⅞"

Plate 11

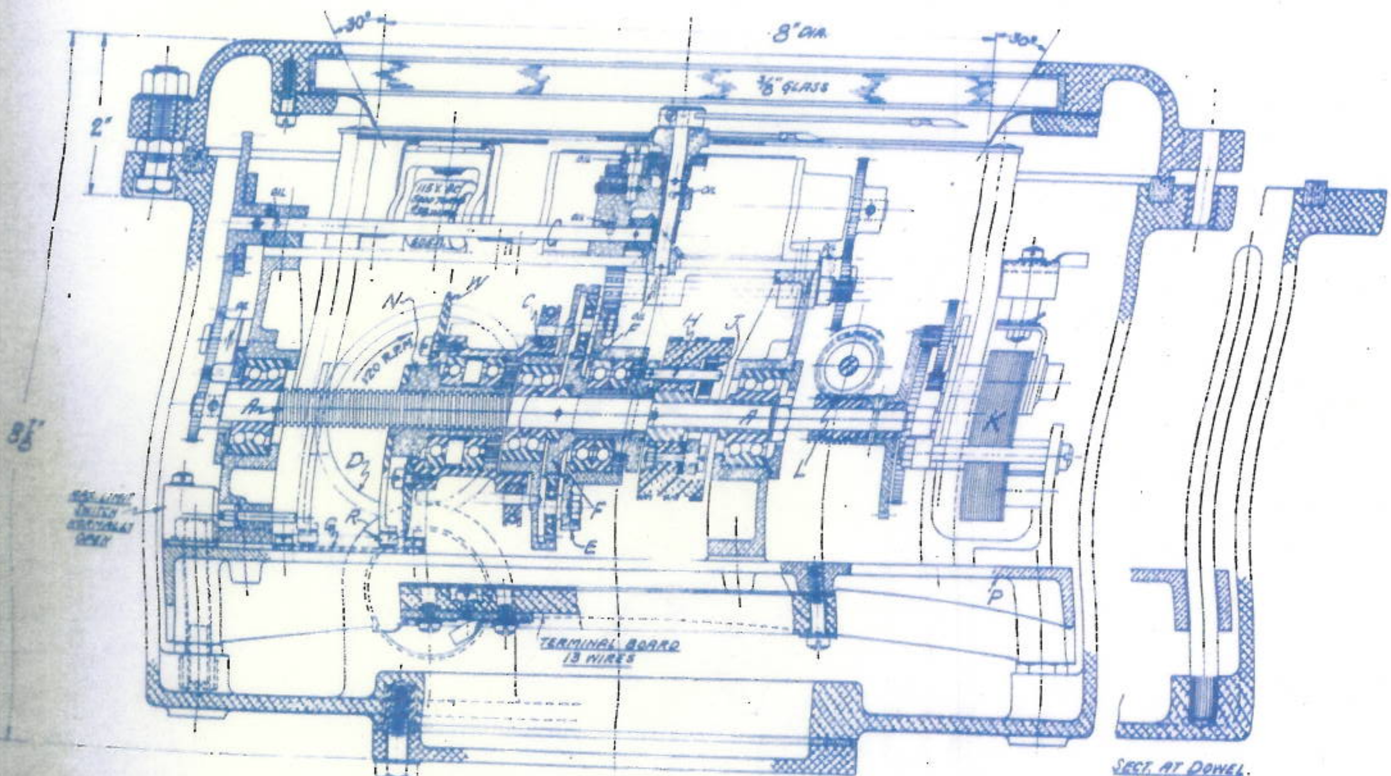


Plate 12

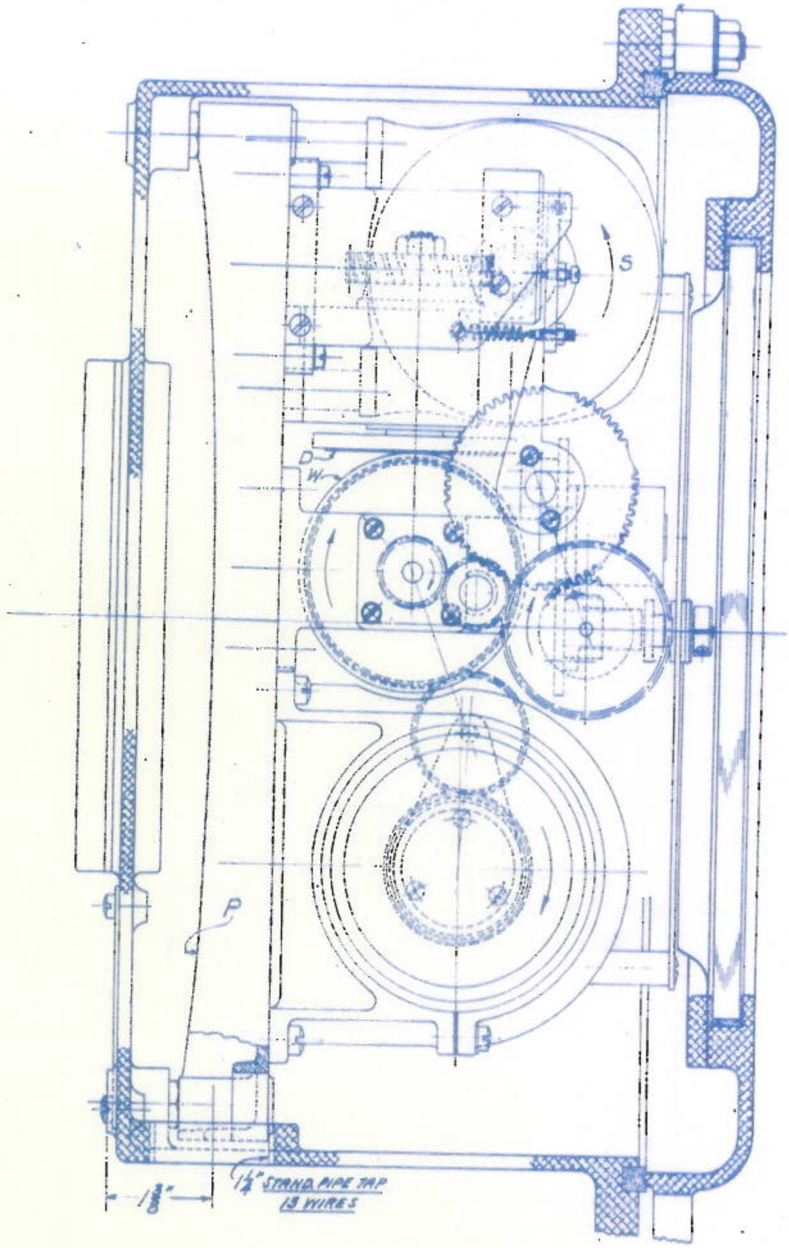
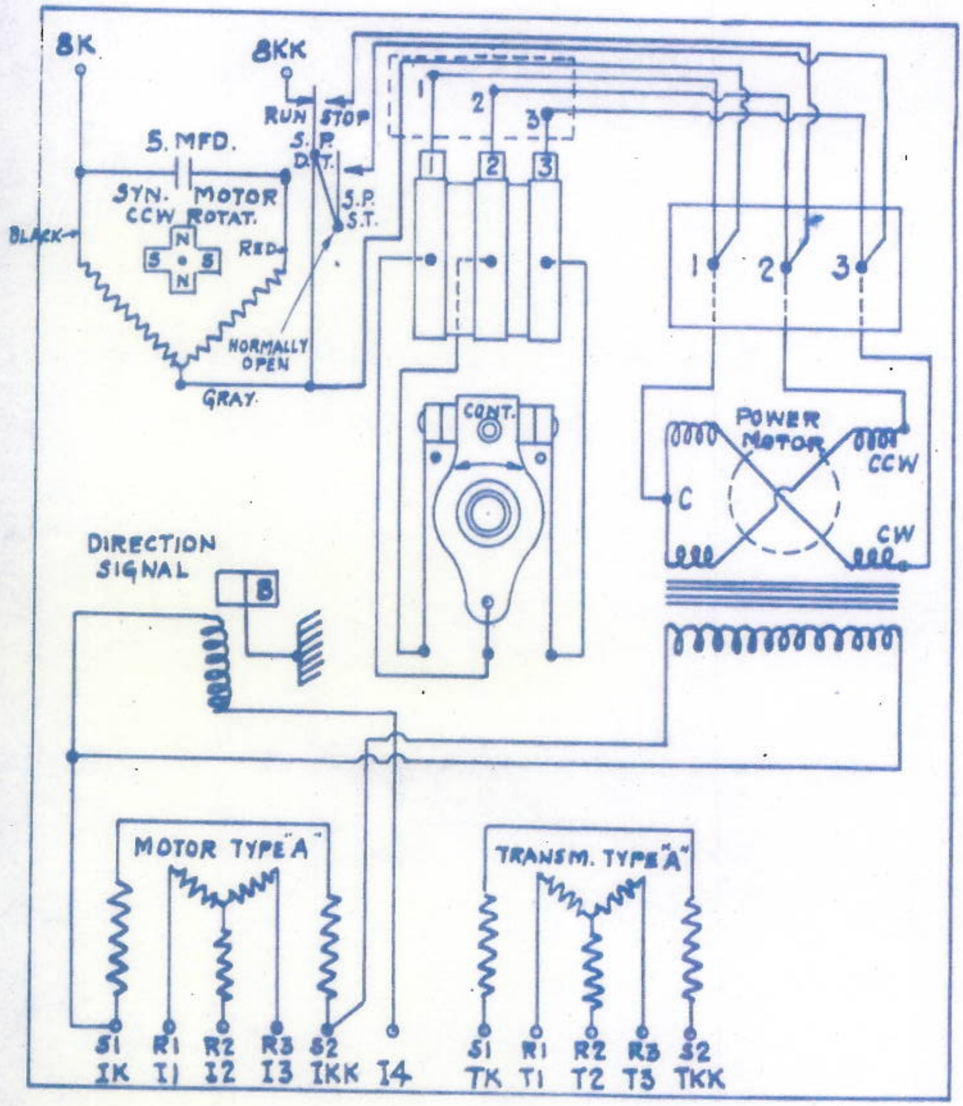


Plate 13



WIRING DIAGRAM.