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BUREAU OF ENGINEERING

FR-1082

Report of Test

on

Instantaneous Type Shaft Revolution Indicator System

manufactured and submitted

by

Pitometer Log Corporation

New York, N. Y.

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AUTHORIZATION FOR TEST

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

- Ref. (a) BuEng let.NOs-34032(7-14-Ds)of 25 July 1934.
(b) Navy Dept. Specifications SGS(65)10 of 15 April 1934.
(c) Contract NOs-34032.

OBJECT OF TEST

2. The object of this test was to determine the suitability of this instantaneous type Shaft Revolution Indicator System for the Naval Service and compliance with Navy Department Specifications SGS(65)10 of 15 April 1934 as modified by Contract NOs-34032 and approved by the Bureau of Engineering.

ABSTRACT OF TEST

3. The system was set up at this Laboratory and closely observed while under the endurance, accuracy, and shock tests. Total revolutions of the port and starboard shaft transmitters and the master indicators were recorded and compared daily. Both transmitters were rotated ahead at approximately 250 r.p.m. for a period of 500 hours. The direction of rotation of both shafts was reversed for one hour during each day of the test. A careful examination was made of the instruments to ascertain whether the material submitted was in strict accordance with the specifications in the matter of materials, design, workmanship, dimensions, markings, etc.

Conclusions

(a) The instantaneous type shaft revolution indicator system, as submitted by the Pitometer Log Corporation, New York, N.Y., and covered by this report, is considered superior in simplicity, method of r.p.m. indications, ruggedness, accuracy, quietness of operation, and design to any other type of shaft revolution systems observed by this Laboratory.

(b) That the subject equipment be approved as complying with the requirements of the contract subject to comments noted in paragraphs 22, 24, 26, 28, 29, 30, and 31.

(c) That the manufacturer be placed on the Navy Department as a regular list for approved materials.

(d) That the Bureau consider installing the shaft indicator on the shaft instead of the gauge board as a type of instrument.

(e) That method of illumination of dial be studied to provide more satisfactory illumination. A sample dial was submitted in connection with the subject equipment with lamps mounted above the dial, the dial markings being etched through the dial and filled in with red lacquer paint. This type of dial could be easily read at ten feet.

(f) That the Bureau confer with Sellers or manufacturers of red lacquer paint to ascertain the proper coverage and grade of lacquer material for use in connection with dials for Naval service. In this connection, it is also recommended that a system be set up whereby dials with paint may be replaced after a period of time at which the lacquer paint on dials has become inscribed.

(g) If this type of instantaneous shaft revolution indicator system is adopted, it is recommended that each ship be supplied with a calibration unit consisting of a small synchronous motor to drive gear transmitter by known gear ratios so that system can be checked at various speeds.

Recommendations

(b) Due to the satisfactory test and accuracy of the instantaneous type shaft revolution system covered by this report, it is recommended that the Bureau of Engineering modify the existing specifications to allow this type of system for all future installations.

(c) That the subject equipment be approved as complying with the requirements of the contract subject to comments noted in paragraphs 32, 34, 44, 45, 49, 50, and 51.

(d) That the manufacturer be placed on the Navy Department Acceptable List for approved materials.

(e) That the Bureau consider locating the master instruments at the shaft instead of the gauge board due to size of instrument.

(f) That method of illumination of dials be studied to provide more satisfactory illumination. A sample dial was submitted in connection with the subject equipment with lamps mounted under the dials, the dial markings being etched through the dial and filled in with radium luminous paint. This type of dial could be easily read at ten feet.

(g) That the Bureau confer with dealers or manufacturers of radium luminous paint to ascertain the proper coverage and grade of luminous material for use in connection with dials for Naval service. In this connection, it is also recommended that a system be set up whereby dials with paint may be replaced after a period of time at which the luminous paint on dials has become inactive.

(h) If this type of instantaneous shaft revolution indicator system is adopted, it is recommended that each ship be supplied with a calibration unit consisting of a small synchronous motor to drive each transmitter by known gear ratios so that system can be checked at various speeds.

DESCRIPTION OF MATERIAL UNDER TEST

4. The equipment tested was obtained under Navy Contract NOs-34032 and intended for installation on the U.S.S. CHARLESTON. The complete equipment is designed for measuring the speeds of twin propeller shafts and for operation on a 115 volt a.c. 60 cycle controlled frequency. The indications of r.p.m. of each propeller shaft and the average of both shafts at any designated points on the ship are instantaneous. It also gives total counts, direction of rotation, and an indication of asynchronism of propeller shafts. The system consists of the following units:

- 2 - Shaft transmitters
- 2 - Constant frequency supply units
- 1 - Two shaft average transmitter and counter
- 1 - Master r.p.m. indicator and transmitter with direction of rotation signal for shaft no. 1.
- 1 - Master r.p.m. indicator and transmitter with direction of rotation signal and total counter for shaft no.2.
- 1 - Tell-tale, with direction of rotation signal showing asynchronism of shaft no.1 and 2 and direction of rotation of shaft no.1 for location at no. 2 throttle.
- 1 - Master r.p.m. indicator, with two direction of rotation signals, for indication of average r.p.m. and rotation of each shaft.
- 8 - R.p.m. repeaters for location in pairs at various stations.
- 1 - Double intermittent counter with two jacks for location at chart house and log desk.

5. The shaft transmitters consist of a watertight case with an extending shaft. This shaft is to be geared direct to the propeller shaft in such a manner that it turns at a speed exactly three times that of the propeller shaft. Inside of the transmitter case this speed is reduced to 1/10th propeller shaft speed by means of worm gears. This rotation is then transmitted through a uni-directional gear mechanism which drives a work shaft at 1/10th propeller shaft speed. The uni-directional gear mechanism causes the work shaft to rotate in one direction regardless of the direction of rotation of the propeller shaft. The operation of the uni-directional gears also operates contacts for controlling direction of rotation indicators in the various instruments. The work shaft drives a type A self synchronous transmitter at 1/10th propeller shaft speed and also drives a veeder type counter so geared that it counts shaft revolutions. The type A self synchronous transmitter is connected to a type M self synchronous indicator in the master instruments. Frequency control units will be supplied with the subject equipment for supplying 60 cycle controlled frequency for use in driving the constant speed motors in the master instruments. These units are to be submitted at a later date for test and will be covered by a supplementary report.

6. The two shaft average instrument consists of two type M self synchronous indicator motors, one type A self synchronous transmitter motor and three veeder type counters contained in a single instrument case. The input from the respective transmitters is received by two type M indicator motors which drive through a mechanical differential which drives a type A transmitter at 1/10th the average speed of the two propeller shafts and also operates the veeder counters to show the total r.p.m. for each shaft and total average r.p.m. of both shafts. The type A transmitter motor is connected to operate the double intermittent counter.

7. The master r.p.m. indicator and transmitter, with direction of rotation signal for shaft no.1, consists of the following mechanism: a constant speed motor is driven from the constant frequency supply and in turn drives a disc of hardened steel. A roller rides on this disc and is adjustable as to position from the center. This roller drives one side of a differential through fixed ratio gearing. The other side of the differential is driven in the opposite direction by a self synchronous type M motor driven by the shaft transmitter at shaft no. 1. The spider of the differential will rotate at a speed proportional to the difference in speed between the two face gears of the differential. The direction of rotation of the spider is determined by which of the two face gears is running faster. Contacts mounted on and actuated by the spider shaft controls a small induction type motor which drives and positions the friction roller to a position which coincides with the differential in r.p.m. between the actual shaft r.p.m. and speed of the driven hardened steel disc. A pointer for indicating r.p.m. is geared to the lead screw which positions the friction roller. The lead screw also drives a type A self synchronous transmitter which transmits r.p.m. to other instruments. The direction of rotation indicator is actuated by contacts in the respective transmitters.

8. The master r.p.m. indicator at no. 2 throttle is identical to the instrument at no. 1 throttle station except that the self synchronous type M motor also drives a veeder type counter which counts total revolutions of no.2 shaft.

9. The average master indicator is identical to the instrument at no.1 throttle station except that it has two direction of rotation indicators and no r.p.m. transmitter.

10. The tell-tale indicator at throttle station no.2 consists of two self synchronous type M motors. The two motors, driven by the respective transmitters, drive two sides of a differential. The spider shaft thus is stationary if the two motors are running at the same speed. A pointer fixed to the spider of the differential gear indicates the difference in r.p.m. between the following shaft and leading shaft by the rate at which the pointer travels to indicate "too fast" or "too slow".

11. The indicator consists of a self synchronous type M motor. A pointer is fixed to the shaft of the self synchronous motor and indicates by its position the r.p.m. indications of the master to which it is connected. A direction of rotation signal indicates the direction of rotation of the shaft.

12. The double intermittent counter includes a self synchronous type M motor driven by the average revolution transmitter and a manual gear shift, enabling the operator to connect the motor to either of the two veeder counters at will. The instrument is equipped with twenty feet of portable cord and a watertight plug. Two watertight jacks are supplied for the system, one to be installed in the chart house and one at the log desk in the engine room.

13. All indicator instruments are provided with white pointers and black dials marked with radium luminous paint. The dial markings are activated by means of Navy type VG2-A lamps.

METHOD OF TEST

14. The complete system, less frequency control units, was interconnected electrically to a 115 volt a.c., 60 cycle frequency controlled supply. The two shaft transmitters were driven by suitable motors.

15. The transmitters were rotated at approximately 250 r.p.m. for a period of 24 hours in a clockwise direction and then rotated in a counterclockwise direction for a period of one hour. This test was continued until the system had operated 480 hours in the clockwise direction and 20 hours in the counterclockwise direction. Total duration of runs - 500 hours.

16. At conclusion of the 500 hour endurance test, the system was again operated for accuracy at speeds corresponding to shaft speeds of 60, 100, 150, 200, 250, and 300 r.p.m. for a period of six hours at each speed. These speeds were accurately obtained by driving each shaft transmitter with a synchronous motor with known gear ratios.

17. For the shock test, one instrument of each type was placed on a Navy standard shock machine and given the required 20 blows of 250 foot pounds while connected in the system and operating at a speed of 250 r.p.m.

18. The system was again tested for accuracy at the conclusion of the shock test. This accuracy test consisted of the identical test as described above.

19. For the temperature compensation test, one instrument of each type was placed in a suitable compartment and subjected to an ambient temperature of 135°F for a period of 24 hours. The system was operated during this test at a speed of 250 r.p.m. and carefully observed for accuracy.

20. The insulation resistance of the electrical equipment of all the instruments was obtained by means of a 500 volt megger.

21. Each instrument was subjected to a dielectric test of 500 volts, 60 cycle, alternating current between each terminal and ground for a period of one minute.

22. The temperature rise of the various instruments was obtained by placing a bulb of a standard thermometer inside of each case.

23. For watertight integrity one instrument of each type was placed in a tank of water at a depth of three feet for a period of one hour.

24. The efficiency of the dial illumination of all instruments was determined in a dark room.

RESULTS OF TEST

Endurance Test

25. The average revolutions recorded by the starboard and port average transmitter counter during the endurance test of 500 hours were 7,508,540 revolutions.

26. The actual revolutions recorded by the counters of the starboard and port shaft transmitters during the endurance test of 500 hours were 7,645,354 and 7,371,725 revolutions respectively or an average of 7,508,540 revolutions. This checked with the starboard and port of the average transmitter and counter instrument.

Accuracy Test

27. The system was checked for accuracy by driving each shaft transmitter three hours clockwise and three hours counterclockwise. Each shaft was driven by a synchronous motor through known gear ratios at speeds corresponding to shaft speeds of 60, 100, 150, 200, 250 and 300 r.p.m.

28. The maximum error of any indicator throughout the endurance test, at shaft speeds of 60, 100, 150, 200, 250, and 300 r.p.m. was 1 r.p.m. The average error of all the indicators was 0.38 r.p.m. Data recorded during this test are given in Table 1.

29. The pointer on the tell-tale instrument remained stationary throughout the accuracy test. This indicated that both shaft transmitters were being driven at the same speed.

Shock Test

30. For shock integrity, one instrument of each type was placed on a Navy standard shock machine and given the required 20 hammer blows of 250 foot pounds. The instruments, while under shock, were electrically connected in the system and operating at a speed of 250 r.p.m.

31. With the exception of the port master indicator transmitter instrument, all of the instruments withstood the required shock test. This instrument developed an error of 3 r.p.m. after 10 hammer blows of 250 foot pounds and by the twentieth blow the error had increased to 6 r.p.m. In order to proceed with the test it was necessary to determine the cause of this error. After repeated shocks the trouble was discovered in the end bell, gear end assembly of the Bodine constant speed motor. The end bell securing screws were found loose and when subjected to shock the movement of the end bell would change the relation between the driven disc and that of the adjustable friction roller. After tightening the end bell screws on the constant speed motor, the instrument showed no change in r.p.m. when subjected to shocks of 20 hammer blows of 250 foot pounds.

32. In order to insure positive relation between the driven disc and adjustable friction roller, dowel pins should be used in the assembly of the end bell with the constant speed motor.

33. Due to injury of the disc arising from repeated shocks which dented the surface of the disc, it was found necessary to replace the disc with a new one furnished by the manufacturer.

34. To prevent slipping of the unit pointers on all instruments each pointer should be secured to the hub by approved means.

35. The system at conclusion of the shock test showed no loss of accuracy when checked at speeds of 60, 100, 150, 200, 250, and 300 r.p.m.

Temperature Compensation Test

36. Each type of instrument was placed in a suitable compartment at ambient temperature of 135°F for a period of 24 hours. The system was then tested for accuracy while electrically connected in the system and under operation at a constant speed of 250 r.p.m. The system remained accurate while under this test.

Insulation Resistance before and after dielectric test

37. Each instrument was tested with a 500 volt megger between all electrical circuits and case. The minimum insulation resistance was 100 megohms. The minimum allowable insulation resistance is 10 megohms when measured with 500 volt megger.

Dielectric Test

38. Each instrument was subjected to a dielectric test of 500 volts, 60 cycle, alternating current between each terminal and case for a period of one minute. No breakdowns occurred on any of the instruments.

Watertight Test

39. One instrument of each type was tested for watertight integrity by submerging the instrument in three feet of water for a period of one hour. All instruments under this test were watertight with the exception of the shaft transmitter. Approximately 1/2 pint of water leaked into each transmitter case around the shaft. After repacking the watertight glands, both instruments were watertight.

Temperature Rise Test

40. The temperature rise of the various instruments was obtained by placing the bulb of a standard thermometer inside of each case.

41. The maximum temperature rise of all the instruments throughout the test was 10°C at an average ambient temperature of 26°C. The allowable temperature rise is 30°C at ambient of 40°C.

Dial Illumination Test

42. All instruments with the exception of the two shaft transmitters, two shaft average transmitter and counter and double intermittent counter, are equipped with dials and pointers painted with radium luminous paint activated by Navy type VG2-A lamps.

43. For determining the efficiency of the dial illumination one instrument of each type was connected to a 115 volt a.c., 60 cycle supply and placed in a dark room for observation.

44. The distance at which the dial of the two shaft average transmitter and counter can be read is approximately one foot. The poor illumination is due to the lamp electrodes being located below the surface of the dial. For efficient illumination of the instruments the bottom of the lamp electrodes should be installed 1/16" above the face of the dial.

45. All other instruments can be read at a distance of three feet. However, this does not comply with the specifications. The specifications require that dial graduations, pointer positions and counter figures be easily legible to 20/20 vision at a distance of ten feet during daylight, twilight and darkness from any angle position with 45° of the normal to the instrument face.

46. The current consumed by the system is 10 amperes at 115 volts, a.c., 60 cycle.

47. The total weight of the system is 743 pounds. Weight and dimensions of representative instruments are as follows:

<u>Instrument</u>	<u>Weight</u>		<u>Dimensions</u>		
	<u>lbs.</u>	<u>ozs.</u>	<u>Height</u>	<u>Width</u>	<u>Depth</u>
Transmitter	44	12	15.00"	18.1875"	6.00"
Average Transmitter and counter	53	14	11.50"	13.625"	9.625"
Tell-tale	35	14	11.9375"	11.9375"	8.25"
Port Master Ind. and Trans.	68	0	15.4375"	13.9375"	10.625"
Stbd. Master Ind. and Trans.	69	0	15.4375"	13.9375"	10.625"
Avg. Master Ind. and Trans.	63	14	16.3125"	13.50"	10.75"
Intermittent Counter	26	11	6.375"	12.375"	6.9375"
Jack Box	3	14	4.375"	5.75"	3.50"
Repeater	30	13	12.375"	11.0625"	7.75"
Set of Gears	40	13			

48. The two frequency controlled units did not accompany the instruments of the system for test as called for in this contract. This did not interfere with the test due to the current supply being constant at a frequency of 60 cycles.

49. Design of terminal blocks for all instruments is not considered satisfactory for Naval service. An approved type of terminal block is shown on Plate No. 21.

50. Distance between terminal studs and instrument case should be not less than 1/4". Instruments submitted did not meet this requirement.

51. The direction indicators should be painted with radium luminous paint as required by par. E-3c(2) of ref. (b).

CONCLUSIONS

52. The instantaneous type shaft revolution indicator system as submitted by the Pitometer Log Corporation and covered by this report is considered superior in simplicity, method of r.p.m. indications, ruggedness, accuracy, quietness of operation and design to any other type of shaft revolution system observed by this Laboratory.

Table 1

Instrument	Accuracy Data											
	60 rpm		100 rpm		150 rpm		200 rpm		250 rpm		300 rpm	
Port	ahead	back	ahead	back	ahead	back	ahead	back	ahead	back	ahead	back
Transmitter	60.0	60.0	100.0	100.0	150.0	150.0	200.0	200.0	250.0	250.0	300.0	300.0
Average Ind. and Trans.	59.5	59.5	99.5	99.5	149.5	149.5	200.0	200.0	250.5	250.5	300.5	300.5
Repeater	60.5	60.5	101.0	101.0	150.5	150.5	200.0	200.0	250.5	250.5	300.5	300.0
Repeater	59.5	59.5	100.0	100.0	150.0	150.0	200.5	200.0	250.0	250.0	300.0	300.0
Repeater	59.5	59.5	100.5	100.5	150.5	150.0	200.0	200.5	250.0	250.0	300.0	300.0
Repeater	60.5	60.5	100.5	100.5	150.0	150.5	200.5	200.0	250.0	250.5	300.0	300.5
R.p.m. (tachometer)	60.0	60.0	100.0	100.0	150.0	150.0	200.0	200.0	250.0	250.0	300.0	300.0
Starboard												
Transmitter	60.0	60.0	100.0	100.0	150.0	150.0	200.0	200.0	250.0	250.0	300.0	300.0
Average Ind. and Trans.	60.5	60.5	100.5	100.5	150.5	150.5	200.5	200.5	250.5	250.5	300.5	300.5
Repeater	60.5	60.5	100.5	100.5	150.5	150.5	200.5	200.0	250.0	250.5	300.0	301.0
Repeater	61.0	61.0	101.0	101.0	151.0	151.0	201.0	201.0	251.0	251.0	301.0	301.0
Repeater	61.0	61.0	100.5	100.5	150.5	150.5	200.5	200.5	250.5	250.5	300.5	301.0
Repeater	61.0	61.0	100.5	100.5	150.0	150.0	200.5	200.5	250.5	250.5	300.5	301.0
R.p.m. (tachometer)	60.0	60.0	100.0	100.0	150.0	150.0	200.0	200.0	250.0	250.0	300.0	300.0

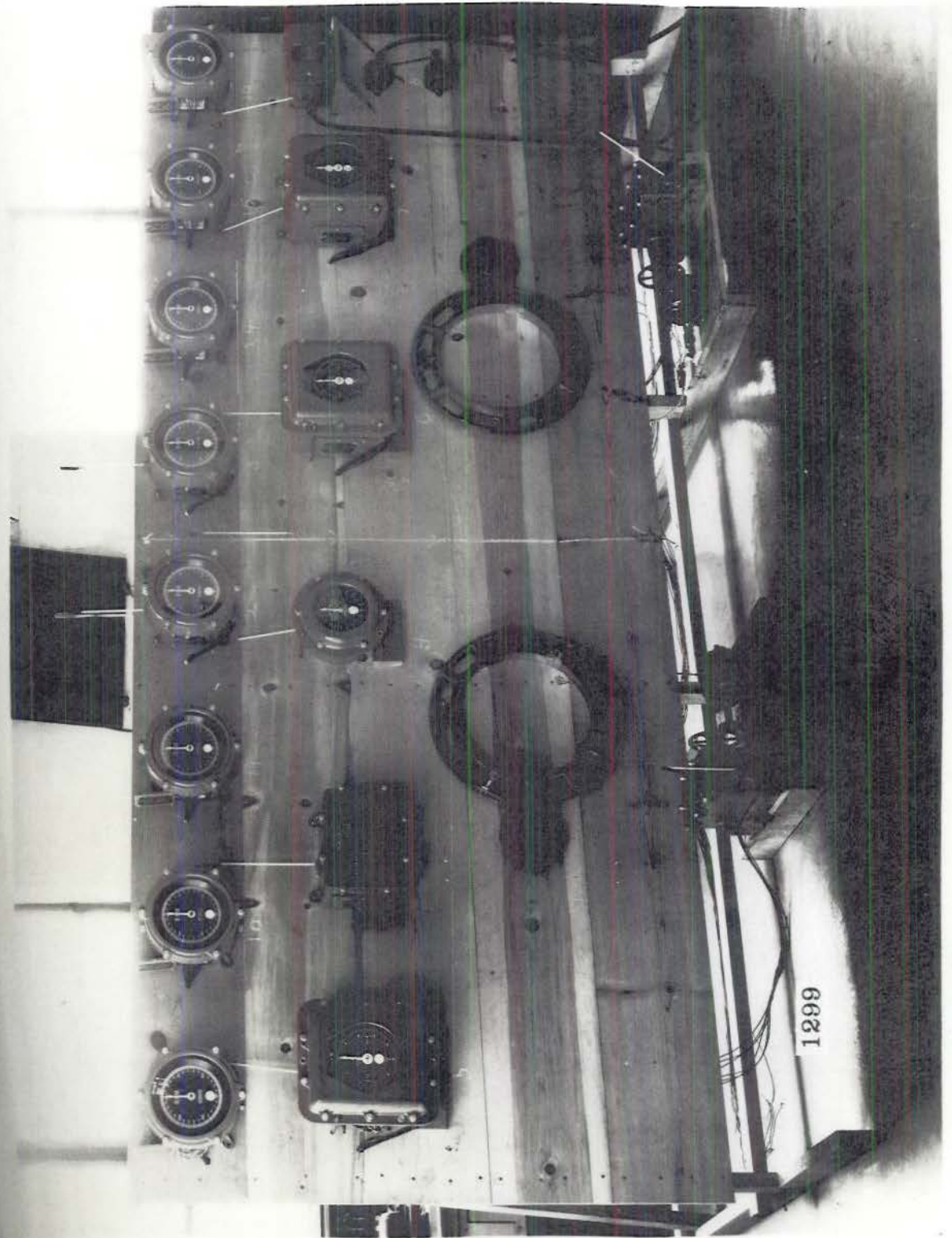


PLATE I

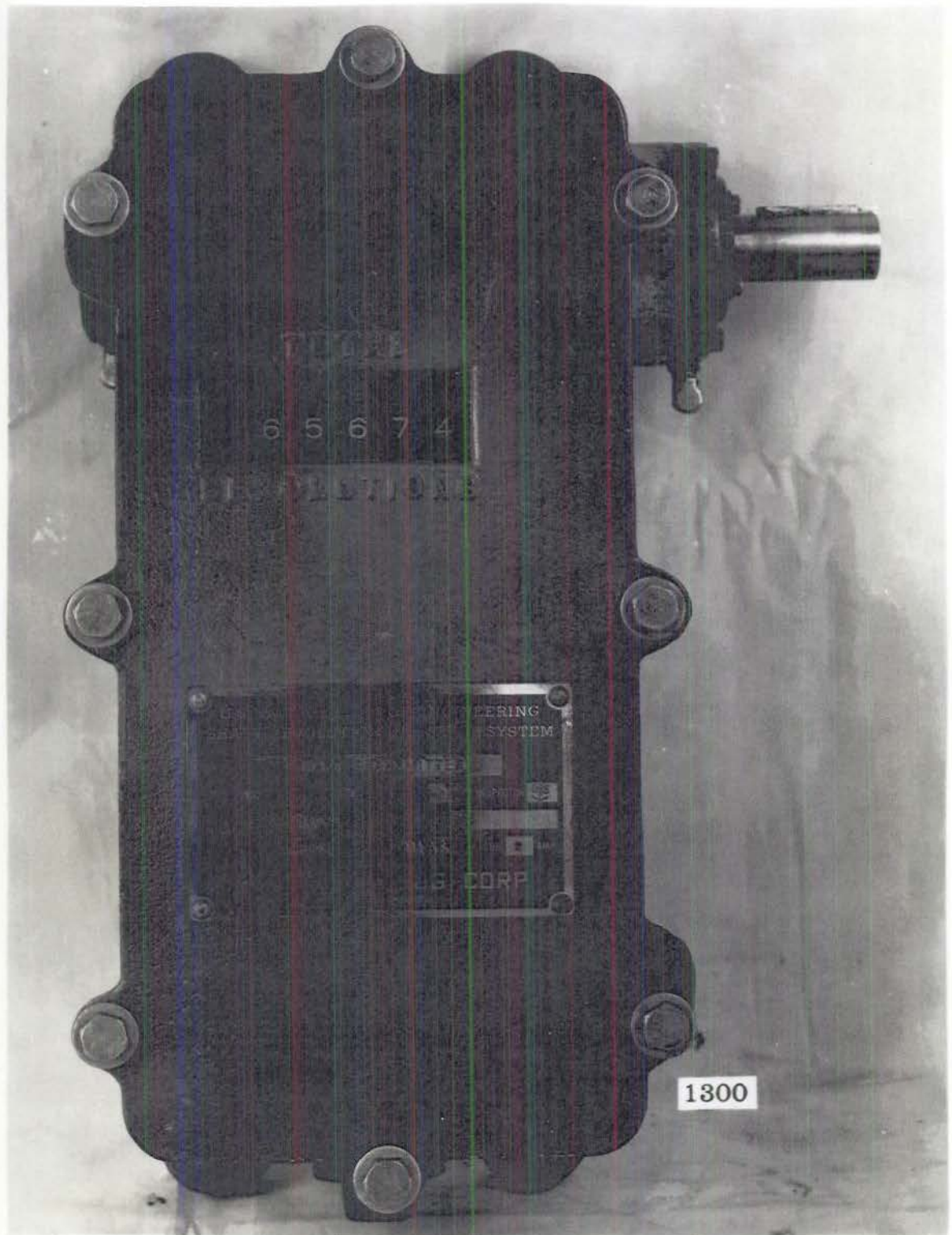


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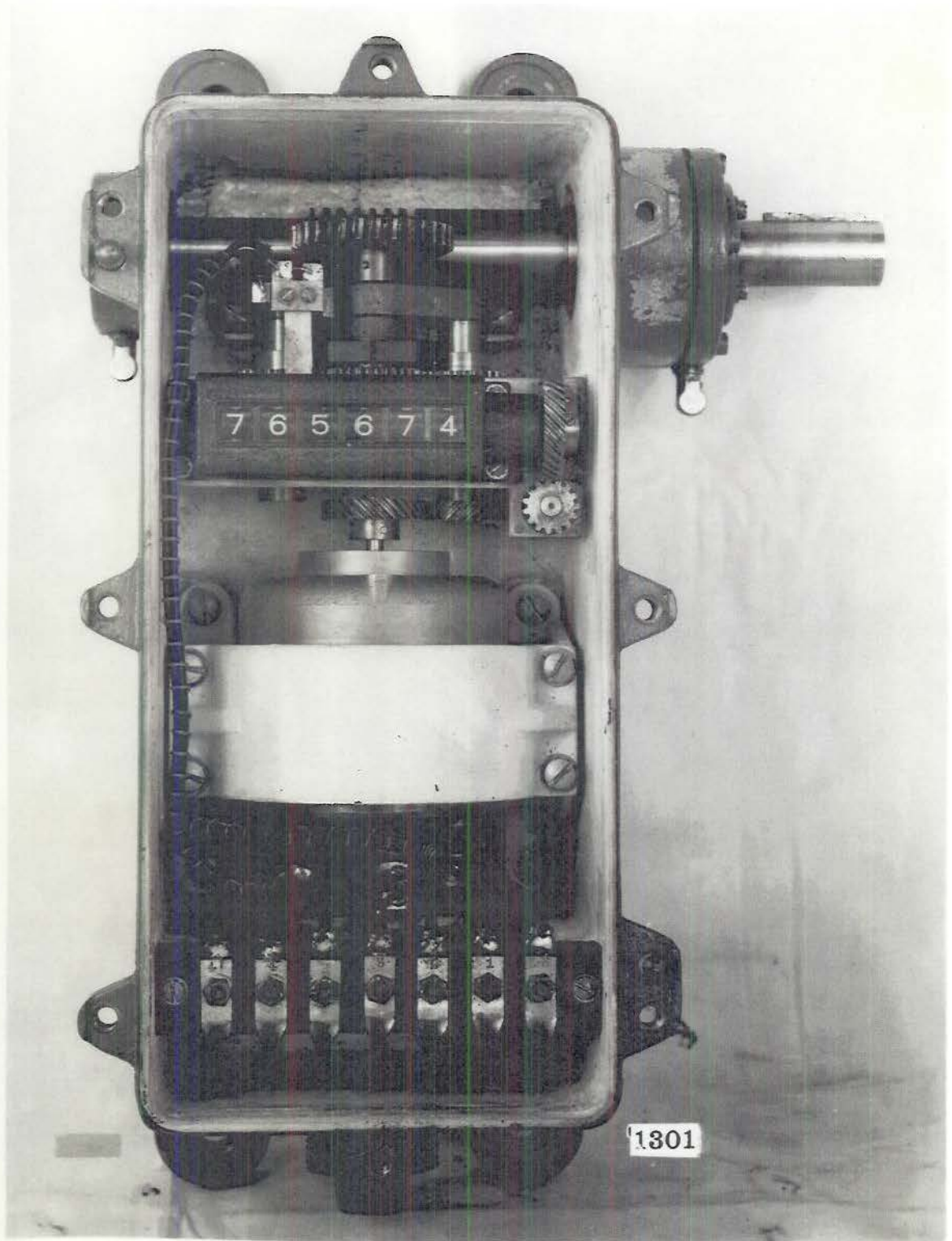


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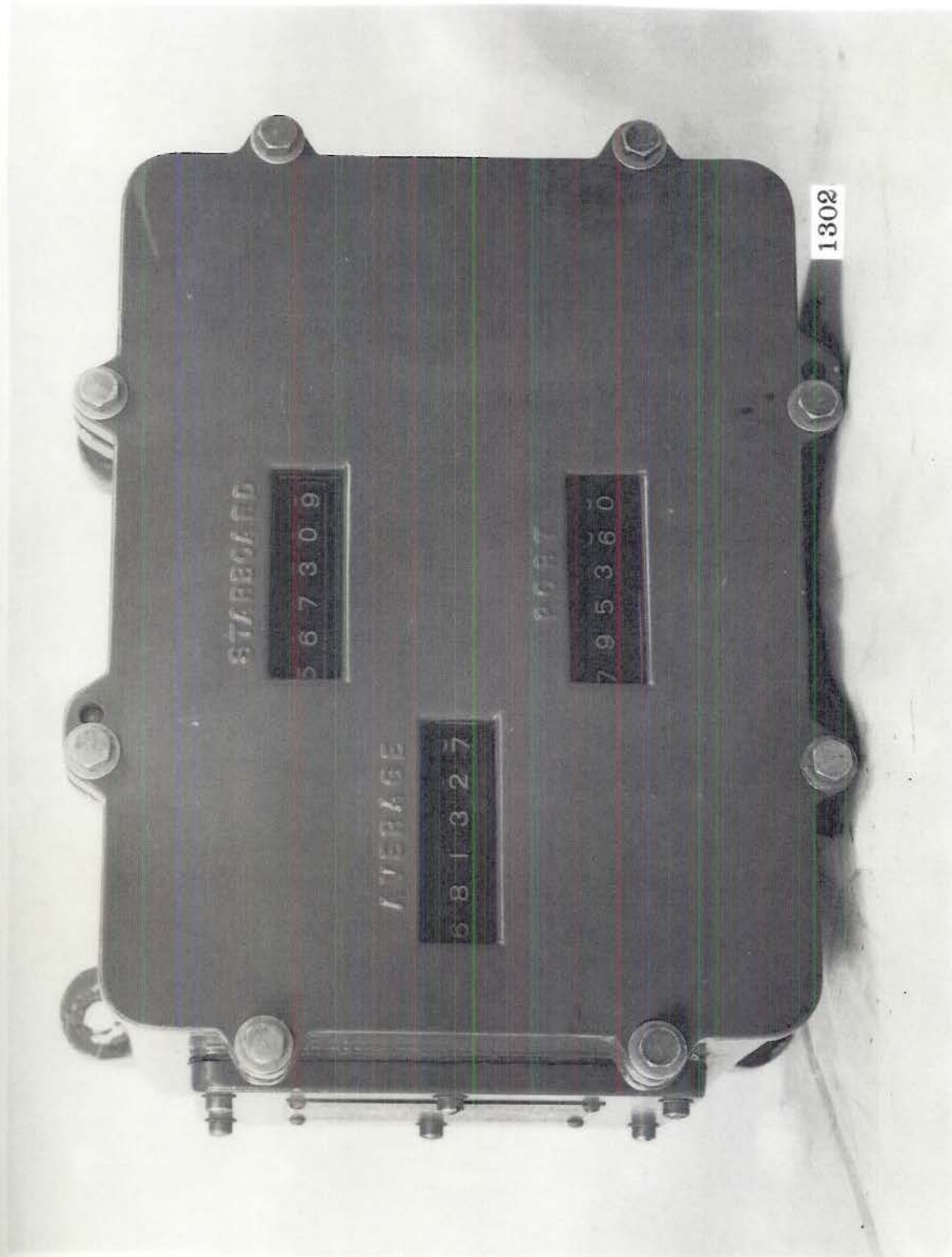
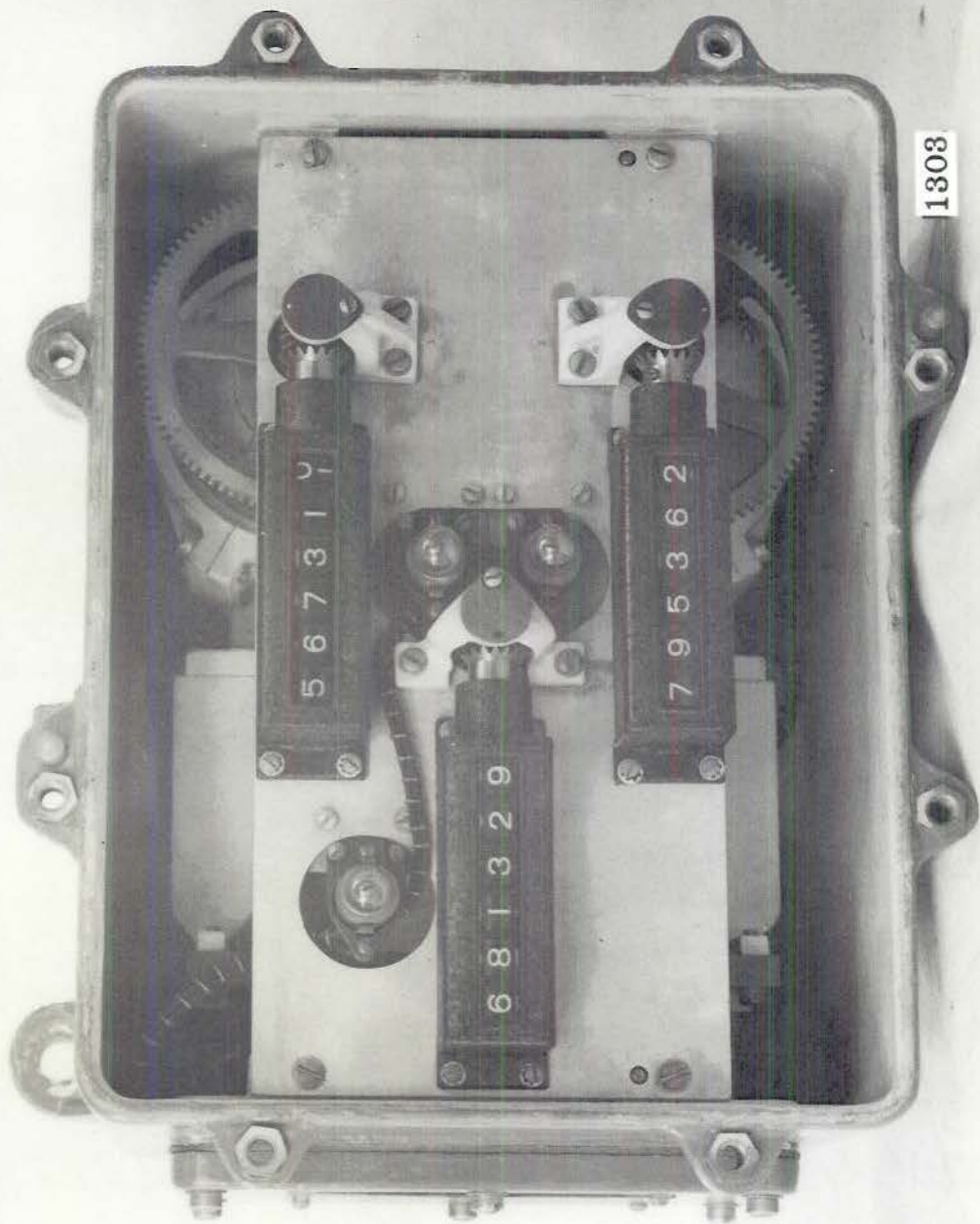
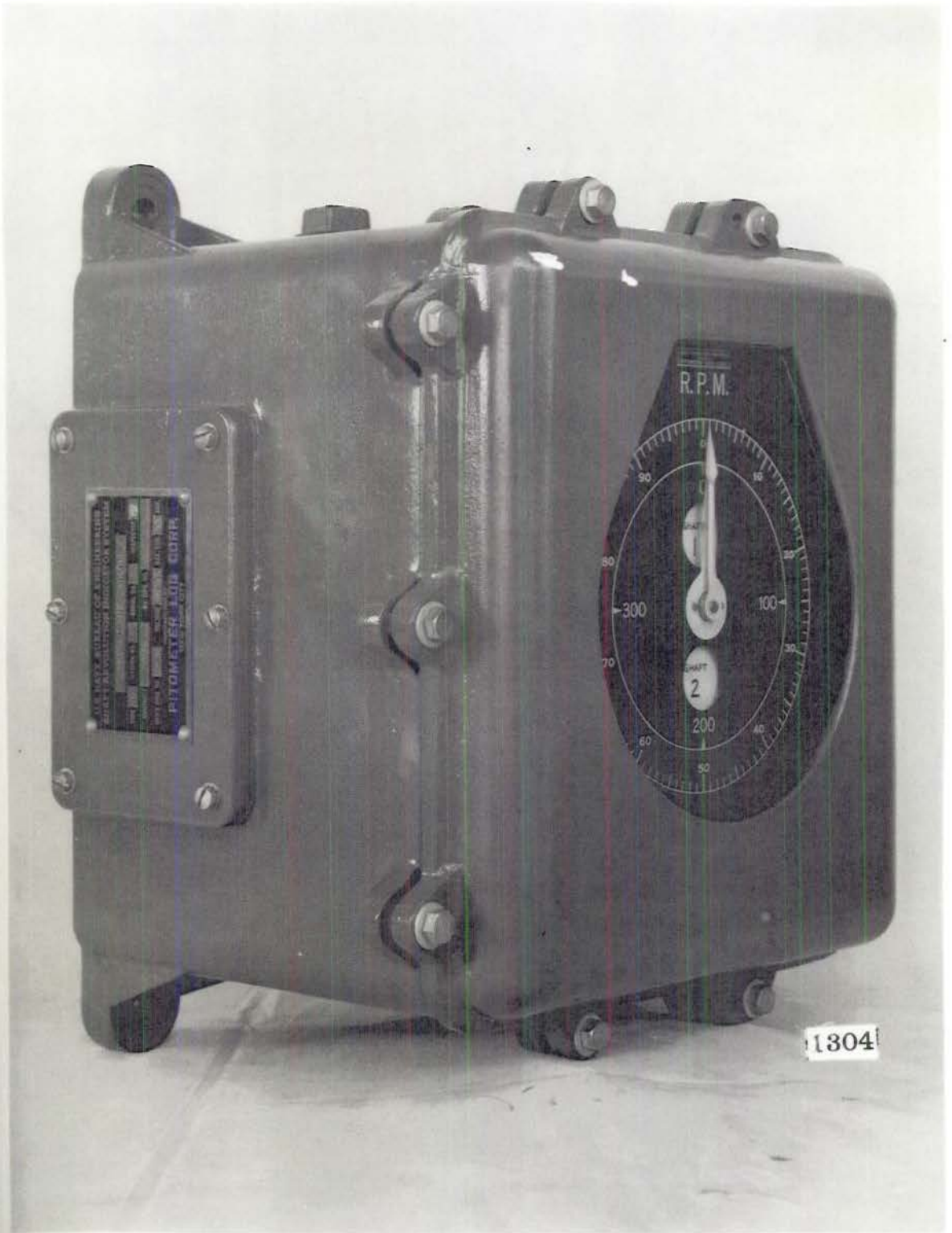
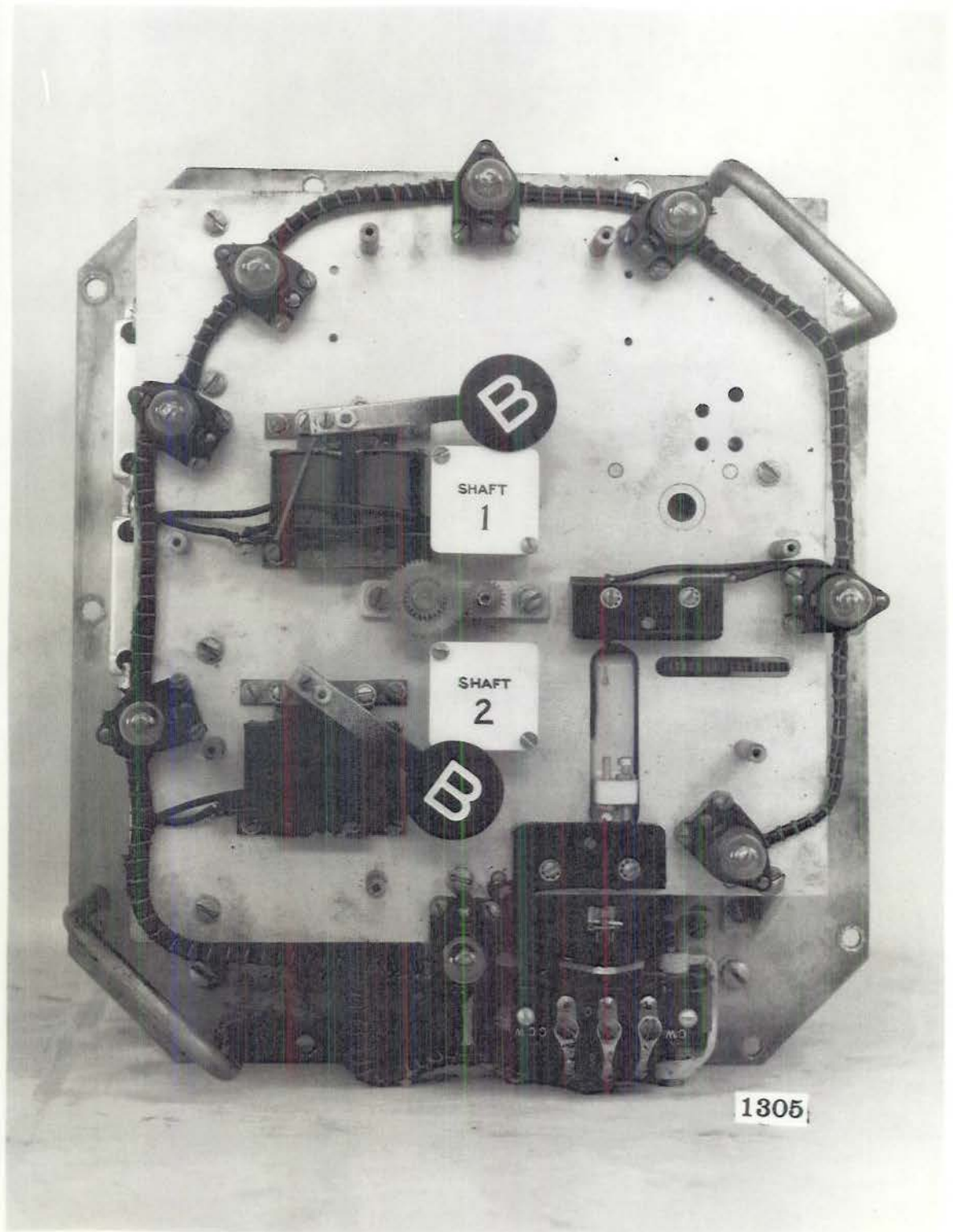


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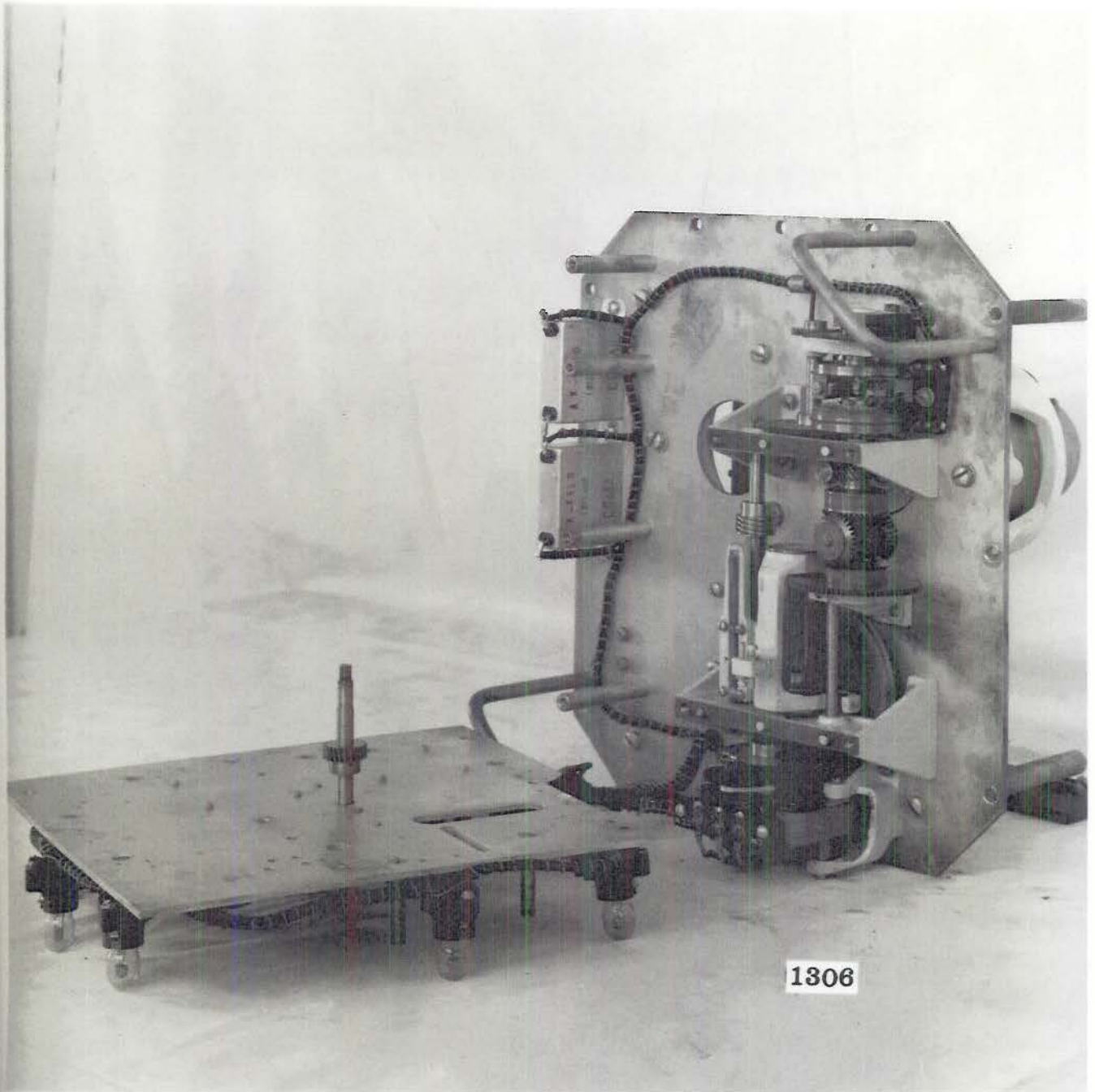


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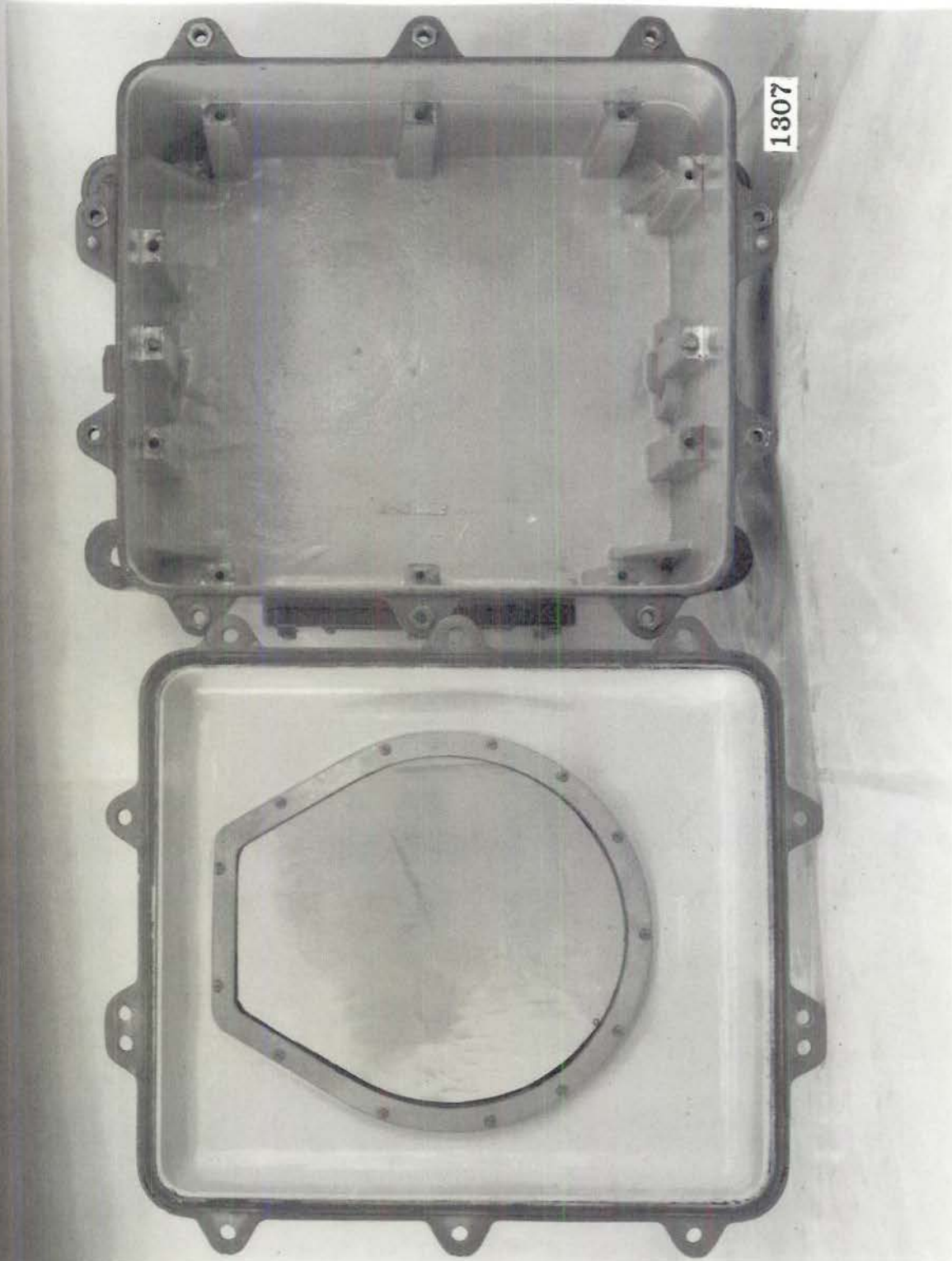




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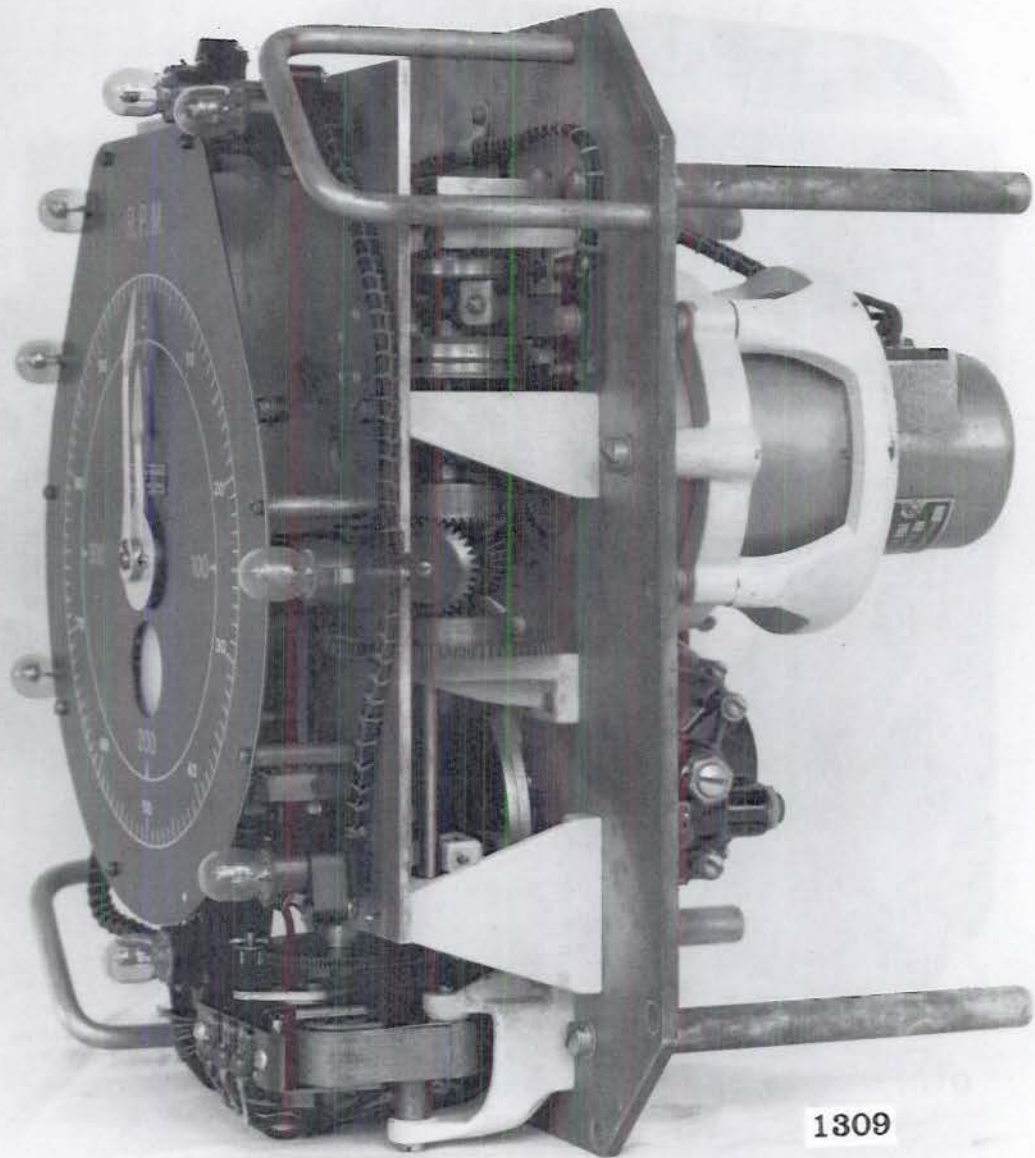


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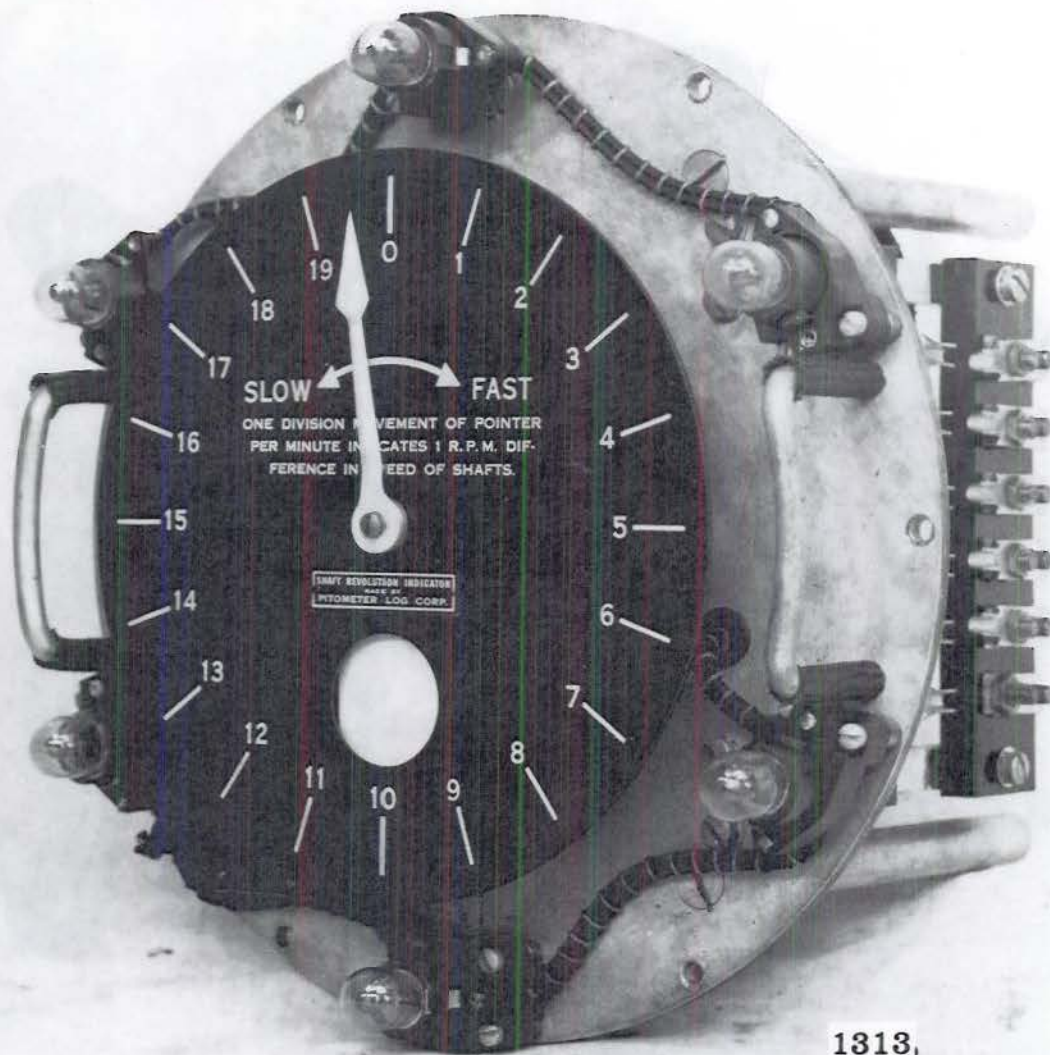


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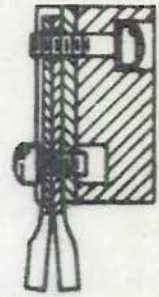
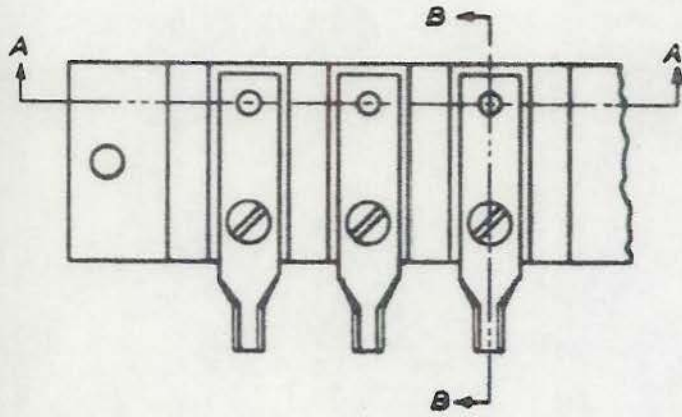
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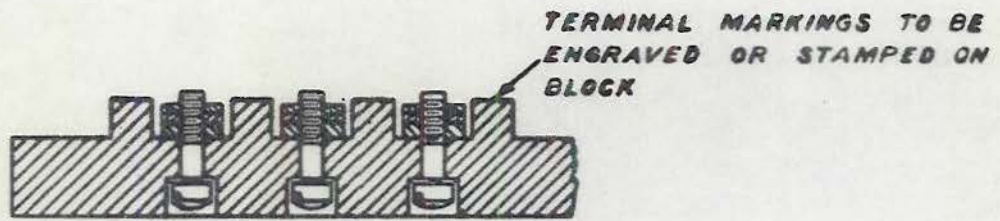
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PLATE 19

PLATE 20



SECTION B-B



SECTION A-A