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Report of Test

on

Shaft Revolution Indicator Equipment

by

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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report of Test

on

Shaft Revolution Indicator Equipment,

Bendix Aviation Corporation,

Manufacturer and Exhibitor.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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Authorization: BuEng.ltr. S65-5/L5(12-16-Ds) of 10 January 1939.

Date of Test: March, April, May 1939.

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AUTHORIZATION FOR TEST

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

Reference: (a) BuEng.ltr. S65-5/L5(12-16-Ds) of 10 January 1939.
(b) Specifications 17-I-18(INT) of 15 January 1938.
(c) Mfr.'s Drwg. CA-3800 - Transmitter.
(d) Mfr.'s Drwg. CC-5492 - Schematic wiring diagram.
(e) Mfr.'s Drwg. CA-5349 - Indicator.

OBJECT OF TEST

2. The object of this test was to determine how closely the subject equipment complied with the specifications, reference (b), in so far as they were applicable, and its suitability for Naval use as propeller shaft indicator equipment.

ABSTRACT OF TEST

3. The subject equipment was set up at this Laboratory and subjected to as many of the tests required for shaft systems as possible. Particular attention was given to the indicator while it was under test for shock and vibration integrity. The usual inspection of the equipment, as to design, material, and workmanship, concluded the test.

CONCLUSIONS

(a) The test results indicate that the equipment requires further development to improve its shock and vibration integrity. Under shock the maximum indicator error attained was 14 r.p.m., and under vibration the error increased to 160 r.p.m. The pointer failed to return to zero when the transmitter was stopped. One of the indicator "Lord" rubber mountings was torn away during these tests.

(b) The transmitter, although of a rugged design, does not function properly when inclined 30° from normal. The unidirectional driving gear does not mesh properly with the transmitter shaft under this condition. Also, a better seal should be provided for the shafts extending through the partition between the gear and contact chambers to prevent leakage of the lubricant. The use of a rubber gasket for the gear chamber cover is questionable.

(c) It appears possible that this type of indicator can be made to comply with the accuracy requirements for shaft r.p.m. repeaters, but not for master indicators. The temperature compensation feature is considered effective as there was no increase in error over an ambient temperature range of 0°C. to 65°C. The pointer oscillates considerably when the indicator is deliberately rocked by hand, and, although the oscillation might not occur with the normal motion of a ship, it is believed that the pointer movement should be more damped.

(d) The indicator driving motor requires a current of 0.85 amperes for reliable operation while causing the pointer to indicate 400 r.p.m. The voltage required to maintain this current varied from 12.4 volts at 24°C. to 14.2 volts at 65°C. The temperature rise of the motor windings was not measured as the design voltage of the equipment submitted would not be satisfactory.

DESCRIPTION OF MATERIAL

4. The equipment submitted for test consists of a transmitter and an indicator designed to operate from a supply of 12 volts, direct current, which is fed to the transmitter. A schematic wiring diagram is given as Plate 1.

5. In operation, the transmitter supplies impulses of current to the indicator motor windings by means of its switching action, two slip rings and a commutator being used for this purpose. Unidirectional gears are provided so that the switching sequence will not reverse when the shaft rotation is reversed. The transmitter case is divided into two (2) parts, one containing the gear train (1:2) and unidirectional gears, the other housing the commutator and brush assembly. The work shaft enters the BE case through a stuffing gland. The gear chamber is partly filled with a lubricant. Four (4) mounting lugs and a boss tapped for a 1 inch terminal tube, and backing contacts are provided.

6. The indicator motor is of the step-by-step type having a four (4) pole rotor and a "Y" connected three (3) pole field. The motor shaft carries a four (4) pole permanent magnet which displaces a disc and pointer restrained by a coiled spring. The eddy currents set up in the disc by the rotating magnet cause it to be displaced in proportion to the speed of the rotating magnet.

7. The pointer positioning unit is housed in a cylindrical brass case having a free fit in a retaining ring. Three (3) machine screws, projecting from the case, contact three (3) separate bimetallic strips, supporting the case and establishing the air gap between the magnet and the disc. A portion of the case flange is cut in the form of a gear and meshes with a worm type adjustment screw. By means of this screw, the case may be rotated so that the set screws contact the bimetallic strips at points of different leverage, thus determining the amount of temperature compensation. The pointer spindle is mounted in jeweled bearings and the driving motor is provided with ball bearings.

8. The dial has white lettering and graduations on a black background, graduated from 0 to 400 r.p.m. in steps of one r.p.m. Numerical markings are provided in steps of 50 r.p.m.

9. The indicator case is of cast aluminum alloy, designed for flush mounting, and employs four (4) "Lord" rubber mountings located in a steel mounting flange. A boss, tapped for a 3/4-inch terminal tube, is located in the rear of the case. Further details are given by Plates 2, 4, and 5. The lighting equipment, shown by Plate 2, was not included in the sample submitted.

METHOD OF TEST

10. The system was first tested for endurance, during which time its speed was varied from 100 to 400 r.p.m. at a rate of change of 40 r.p.m. This test was continued for 500 continuous hours.

11. It was next checked for accuracy by driving the transmitter at known speeds corresponding to shaft speeds of 100, 150, 200, 300 and 400 r.p.m. During this test it was checked for accuracy at ± 10 per cent of rated voltage while the indicator was inclined 45° from normal in all planes.

12. Next followed tests for temperature compensation by placing the indicator in a temperature controlled cabinet at temperatures of 0°C. and 65°C. During this test the indicator was operated at a known speed corresponding to a shaft speed of 300 r.p.m.

13. The indicator was next placed on a standard Navy shock stand and, while operating at 300 r.p.m., subjected to shocks varying from 25 to 250 foot pounds each.

14. Following the shock test the indicator was placed on a vibration machine and while operating at 300 r.p.m. subjected to shocks of 3 foot pounds each for six thirty-minute periods at frequencies of 100, 150, 200, 250, 300 and 350 v.p.m.

15. An inspection of the equipment to note any defects resulting from the tests and compliance with the specifications in the matter of design, material, and workmanship, concluded the test.

RESULTS OF TESTS

16. The test results obtained when the system was subjected to the tests in the order outlined in paragraphs 10 to 14 inclusive were as follows:

Requirements	Test Values
Voltage: 115 volts, a.c., 60 cycles, unless otherwise specified.	*12 volts, d.c.
Current consumption: Not specified.	Average current of 0.85 amperes at 12.4 volts while indicating 400 r.p.m.
Endurance: Shall be operated for 500 continuous hours at speeds varying from 100 to 400 r.p.m. at the rate of change of 40 r.p.m.	Complied.

Requirements	Test Values
Accuracy: The maximum error for repeaters shall not exceed ± 3 r.p.m.	*Greatest error was + 4 r.p.m. at 400 r.p.m., but it was necessary to raise supply voltage to 12.4 volts to reduce error to this value.
Accuracy at over and under voltage: The maximum error for repeaters shall not exceed ± 3 r.p.m.	* -50 r.p.m. at 400 r.p.m. with 12 volt supply. -50 r.p.m. at 300 r.p.m. with 11.8 volt supply (-10%) (see Table 1).
Accuracy while inclined: The maximum error for repeaters shall not exceed ± 3 r.p.m. with the indicator inclined 45° from normal in all planes.	*No apparent change.
Temperature compensation: The accuracy requirement of ± 3 r.p.m. for repeaters shall be met over any ambient temperatures from 0°C. to 65°C.	*No apparent change in accuracy, but it was necessary to increase the supply to 14.2 volts to maintain accuracy at 65°C.
Shock integrity: Shall withstand 20 shocks of 250 foot pounds each while energized and electrically connected in the system.	*Unsatisfactory (see remarks under "Conclusions").
Vibration: Shall withstand shocks of 3 foot pounds each for six 30-minute periods at frequencies of 100, 150, 200, 250, 300 and 350 v.p.m.	*Unsatisfactory (see remarks under "Conclusions").
Weight: Repeater weight shall not exceed 35 pounds and the transmitter 50 pounds.	Repeater - 6 pounds. Transmitter - 30 pounds.
Dimensions: Shall not exceed the following: Repeater - 12" x 12" x 8" Transmitter - 15" x 10" x 8"	Repeater - 7-3/8" x 7-3/8" x 6-1/2" Transmitter - 5-7/8" x 7-1/2" x 14"

* Denotes failure to comply with the specifications.

CONCLUSIONS

17. The test results indicate that the equipment requires further development to improve its shock and vibration integrity. Under shock, the maximum indicator error attained was 14 r.p.m., and under vibration the error increased to 160 r.p.m. The pointer failed to return to zero when the transmitter was stopped. One of the indicator "Lord" rubber mountings was torn away during these tests.

18. The transmitter, although of a rugged design, does not function properly when inclined 30° from normal. The unidirectional driving gear does not mesh properly with the transmitter shaft under this condition. Also, a better seal should be provided for the shafts extending through the partition between the gear and contact chambers to prevent leakage of the lubricant. The use of a rubber gasket for the gear chamber cover is questionable.

19. It appears possible that this type of indicator can be made to comply with the accuracy requirements for shaft r.p.m. repeaters, but not for master indicators. The temperature compensation feature is considered effective as there was no increase in error over an ambient temperature range of 0°C. to 65°C. The pointer oscillates considerably when the indicator is deliberately rocked by hand, and, although the oscillation might not occur with the normal motion of a ship, it is believed that the pointer movement should be more damped.

20. The indicator driving motor requires a current of 0.85 amperes for reliable operation while causing the pointer to indicate 400 r.p.m. The voltage required to maintain this current varied from 12.4 volts at 24°C. to 14.2 volts at 65°C. The temperature rise of the motor windings was not measured as the design voltage of the equipment submitted would not be satisfactory.

TABLE 1

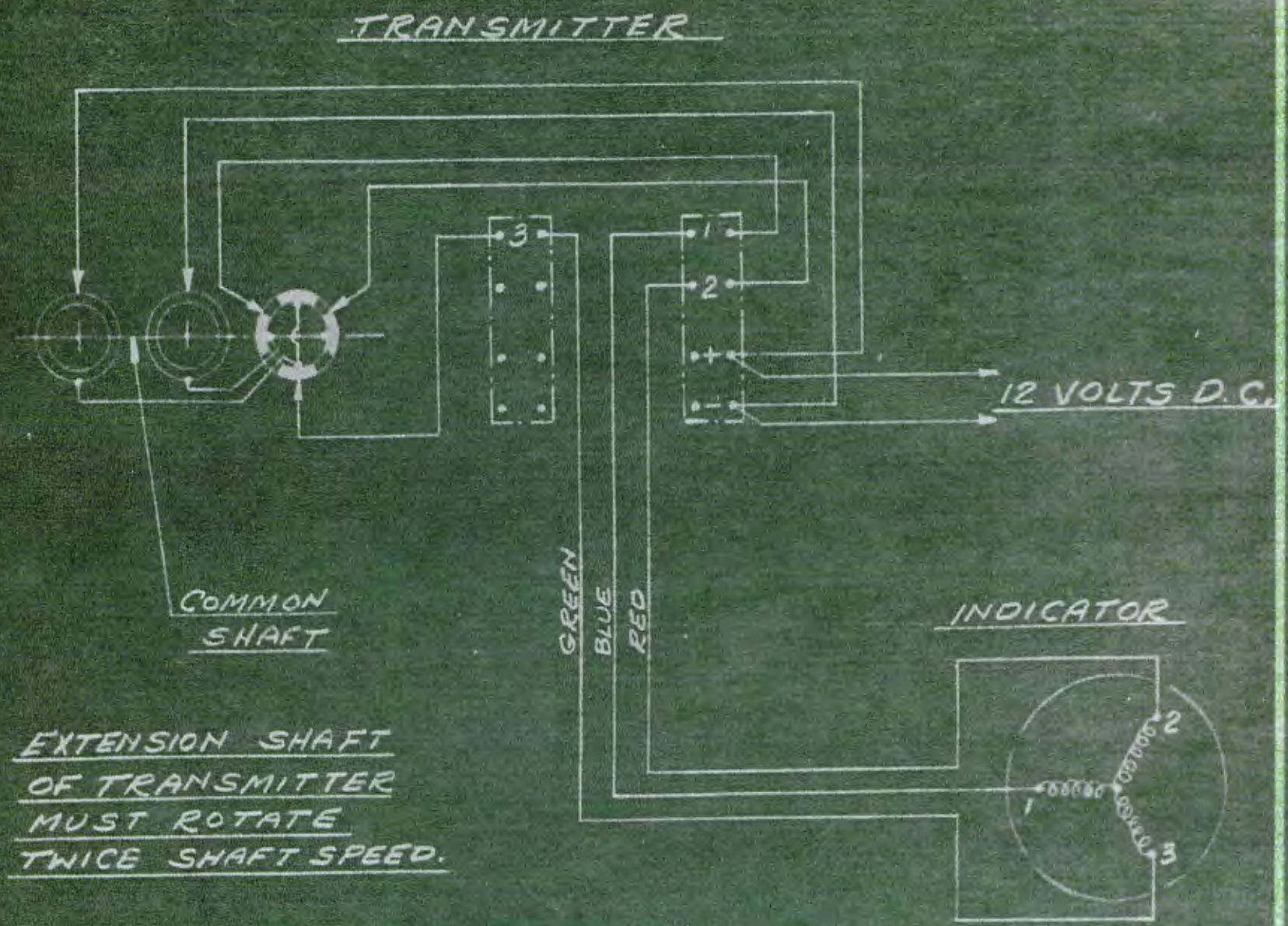
ACCURACY TEST RESULTS

Equivalent Shaft Speeds R.P.M.	At 12 Volt D.C. Supply R.P.M.		At 12.4 Volt D.C. Supply R.P.M.	
	Indicated	Error	Indicated	Error
100	102	+2	102	+2
150	152	+2	152	+2
200	203	+3	202	+2
300	303	+3	303	+3
400	350	-50	404	+4

Note: All results at room temperature (approximately 24°C.).

PATT. NO.

NAME SCHEMATIC DIAGRAM



EXTENSION SHAFT OF TRANSMITTER MUST ROTATE TWICE SHAFT SPEED.

ALTERATIONS | DATE

TOLERANCE ON DECIMAL DIM. = ± .005" UNLESS OTHERWISE SPECIFIED
" " FRACTIONAL " = ± 1/64" " " "

Plate 1

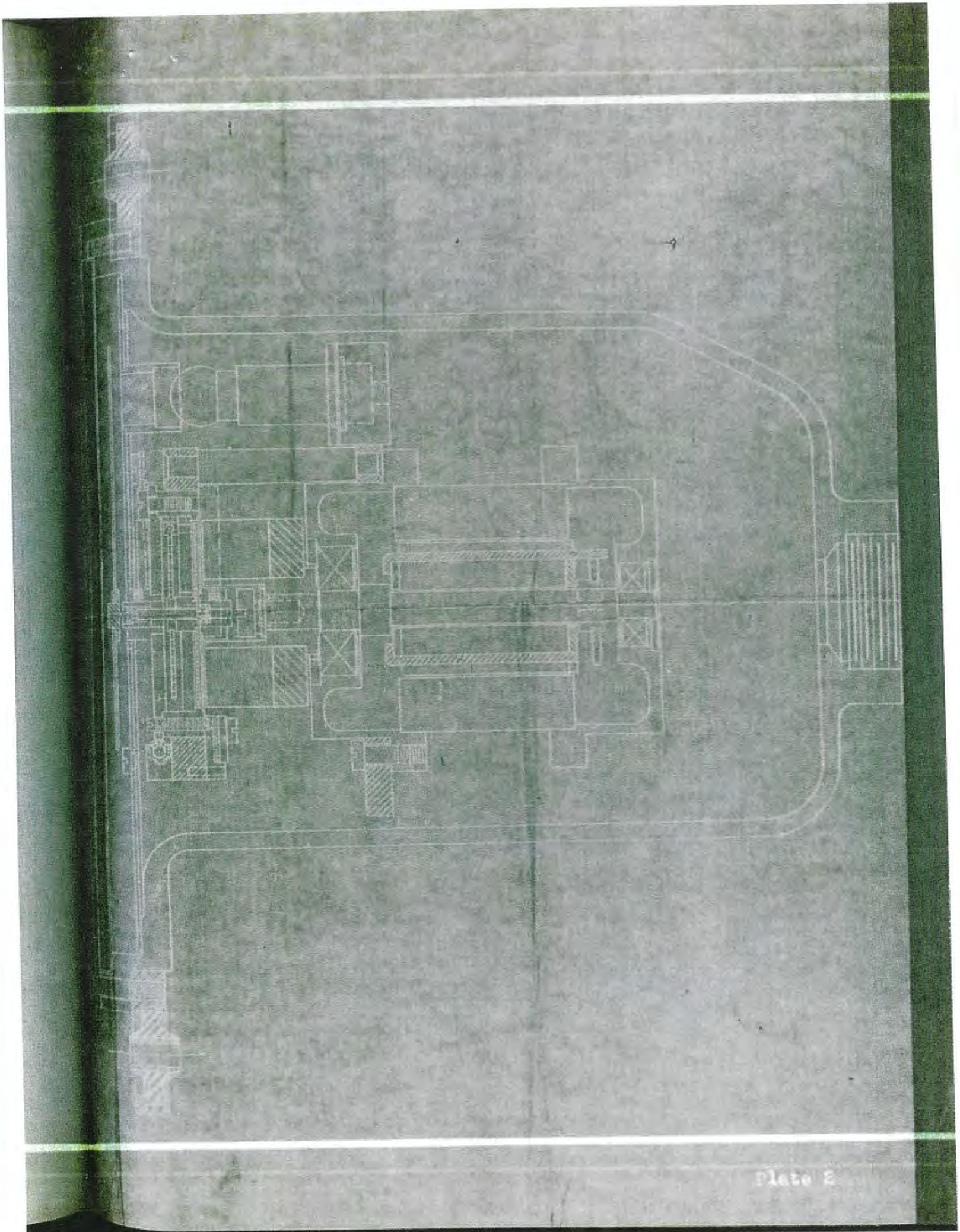
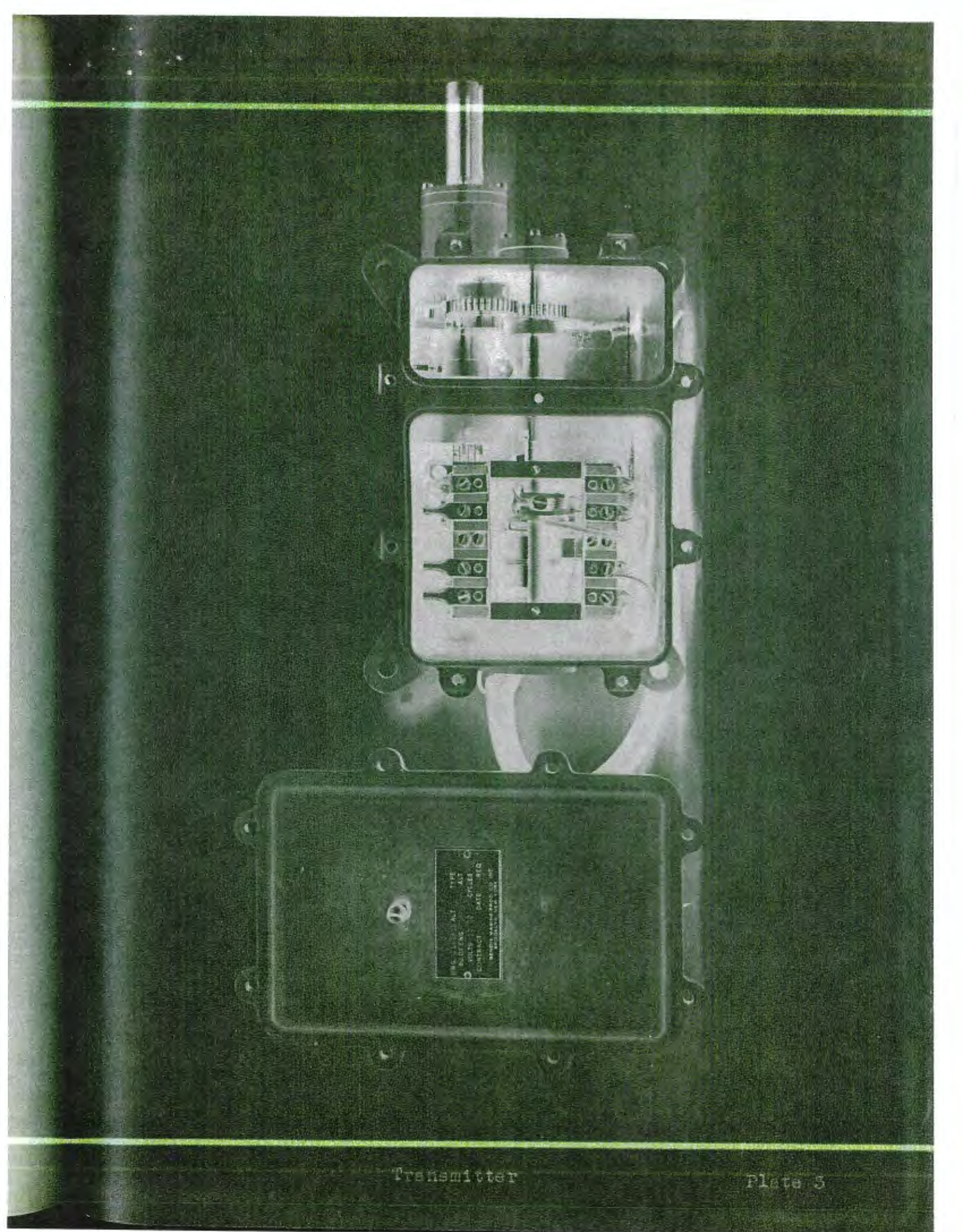


Plate 2

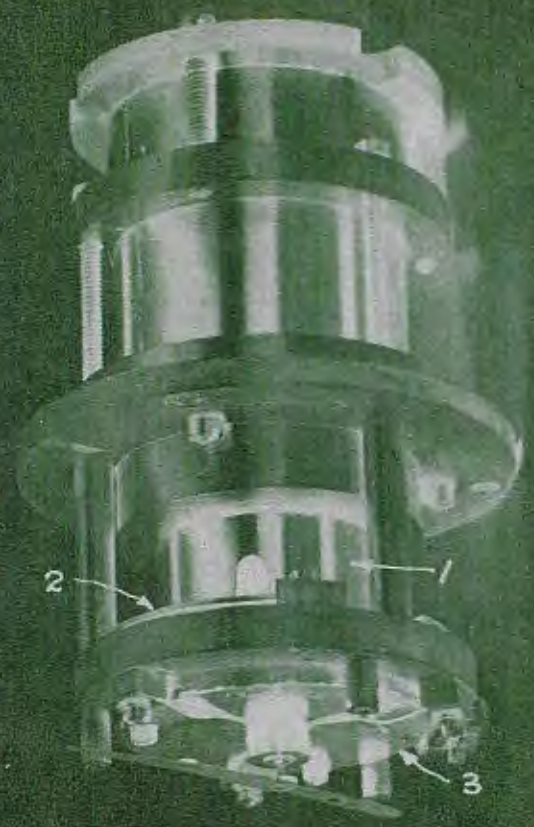


Transmitter

Plate 3

Tore away under shock and vibration test.

Fully Assembled Indicator



Indicator Unit Removed from Case.

1 - Rotating Magnet.
2 - Bimetallic Strip.
3 - Pointer Positioning Unit.

Plate 5

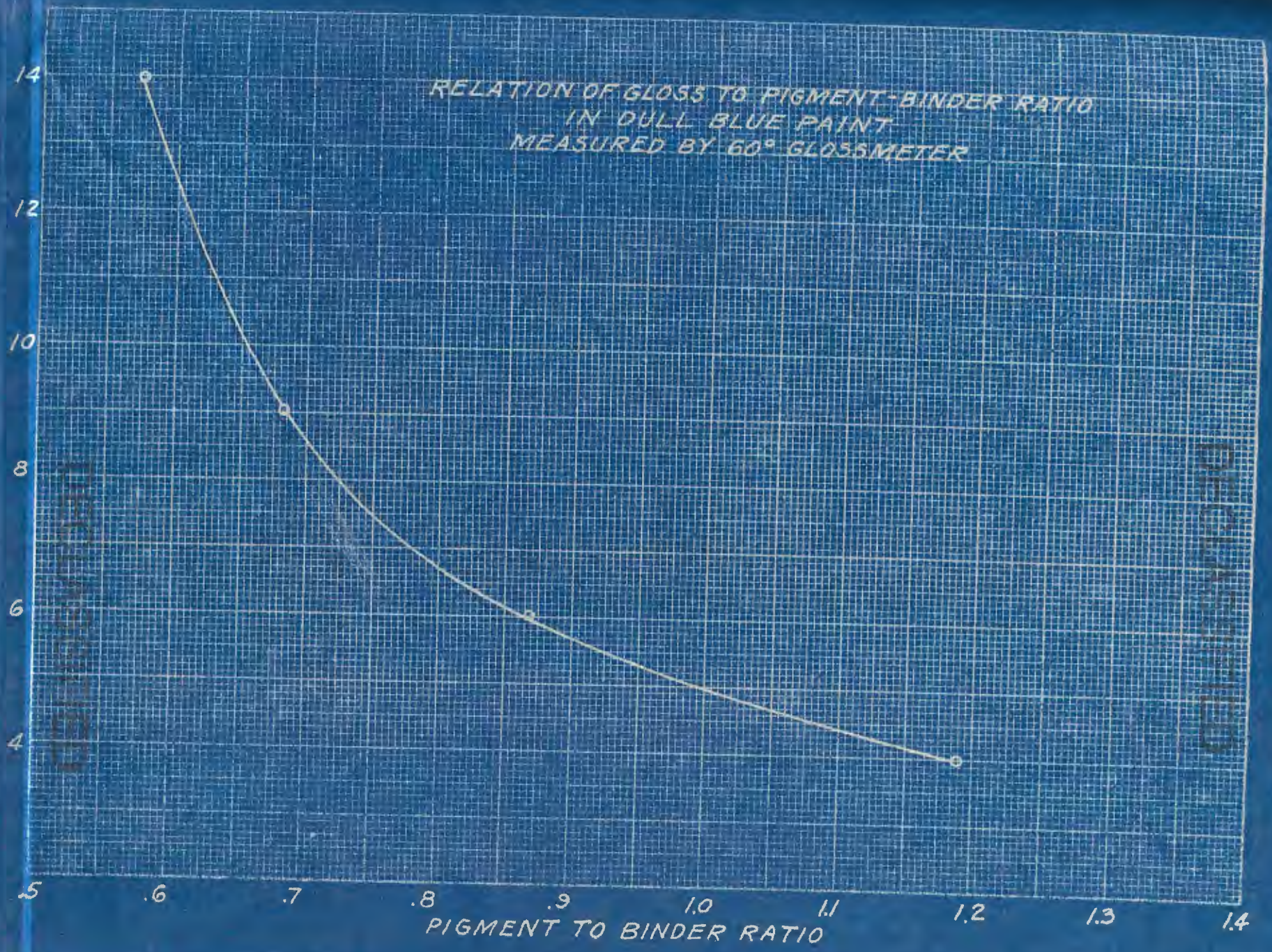

RELATION OF GLOSS TO PIGMENT-BINDER RATIO
IN DULL BLUE PAINT
MEASURED BY 60° GLOSSMETER
SPECULAR GLOSS
14
12
10
8
6
4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
PIGMENT TO BINDER RATIO

PLATE 6

DATE