70-4

REPORT NO. B-1405

DATE 21 October 1937

FR-1405

SUBJECT

Test on Rotary Balance Log System

manufactured and submitted by

Pitometer Log Corporation, New York, N.Y.

BY

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report of

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NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Number of Pages: Text - 7 Tables - 3 Plates - 1

Authorization: BuEng let.S65-5/L5(6-22-Ds) of 2 July 1937.

Date of Test: August and September 1937.

Tested by:

J. R. Coomes, Sr. Eng. Aide

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Prepared by:

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R. A. Gano, Lieutenant, U.S.N.

Approved by:

H. M. Cooley, Captain, U.S.N., Director

Distribution: BuEng (5)
LP

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Appendices

AUTHORIZATION

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

References: (a) BuEng let.S65-5/L5(6-22-Ds) of 2 July 1937.
(b) Specifications SGS (65)-151a of 1 Feb.1937.
(c) NRL Report No. B-1358 of 27 April 1937.

OBJECT OF TEST

2. The object of this test was to determine how closely the electric log equipment complied with the specifications, reference (b), and its suitability for the Naval service.

ABSTRACT OF TEST

3. The subject system, shown by photograph, Plate 4, was set up at this Laboratory and its performance was carefully observed while under test in conformance with the specifications, reference (b). All tests were made in the order specified and were concluded with an inspection to ascertain whether all units were in strict accordance with the requirements in the mat ter of materials, design, and workmanship.

Conclusions

(a) This Rotary Balance Log System manufactured by Pitometer Log Corporation and submitted for type approval test under reference (a), failed to comply with the following requirements:

(1) The system failed to function after 486 hours during tests for endurance. An examination disclosed that this was due to the failure of the "Bodine" centrifugal pump motor. The brushes were worn excessively and several wires had become unsoldered from the segments of the commutator. This indicated high temperature, resulting from the arc between the brushes and the commutator. In order to complete the test it was necessary to use replacement brushes and holders furnished by the manufacturer, resolder the armature wires, and clean the commutator.

(2) The system, after having completed the 500-hour endurance test, again failed to operate after completion of tests for inclination. An examination again disclosed worn brushes and a blackened commutator. The commutator and brushes at the conclusion of the test are shown by photograph, Plate 11.

(3) During tests for shock integrity, the contacts in the control instrument changed their adjustment, thereby resulting in erroneous indications. When readjusted, however, the system again functioned properly.

(b) Under inspection at the conclusion of all tests, the following objectionable features were noted:

(1) The pointer screw of the speed indicator does not clear the surface when the unit is removed from the case and placed upside down on a table. The handles should support the entire unit.

(2) The external terminal block of the pump motor is not accessible and should be eliminated. The motor wires should extend directly to the internal connection block.

(3) The present guard around the external pump gears does not afford adequate protection against injury.

(c) The Bureau's attention is invited to the fact that a supply of 115 volts, direct current, is required for the centrifugal pump motor in order to obtain readings within the accuracy limitations of the specifications. For example, with the system operating at 39 knots, true speed, for 1/2 hour, and the voltage lowered to 103.5 volts, the average of three readings of the speed indicator was 35.6 knots, or 8.51 per cent error. The error in the total distance traveled was 9.74 per cent. The allowable error for a speed of 39 knots is 1 per cent.

(d) Tests at 40 knots were not conducted in view of the fact that it would have been necessary to increase the normal supply voltage (115 volts) to the pump motor.

(e) The system, when operated at speeds below 4 knots, was extremely erratic.

Recommendations

(a) This system, as at present manufactured, cannot be recommended for Naval use primarily because of the failure of the pump motor on two occasions during the required 500-hour endurance test. This 1/3 h.p. compound motor is the basic unit of the system and requires further development for this application.

(b) The Bureau's attention is invited to the fact that the performance of the system during tests for shock and vibration integrity was exceptionally good. In addition, it has the advantage of requiring no "manometer," but produces a linear scale for knot indications.

GENERAL DESCRIPTION OF ROTARY BALANCE LOG

4. In service, a rodmeter projects through the hull of the ship at the bottom. It is provided with an opening in its leading edge which picks up the dynamic pressure produced by the motion of the ship through the water, plus the static pressure, due to the head of water above the rodmeter. There are also two side openings which pick up the static pressure alone. The difference between these two pressures is expressed by the formula -

$$V^2 = 0.9216 \times 2gh$$

where
V = velocity in feet per second.
g = acceleration of gravity in feet per second.
h = differential pressure, expressed in feet head of the liquid through which the rodmeter is moving.

5. The pressure from the dynamic orifice is led directly to the outer orifice of a centrifugal pump. The center orifice of this pump is led to a sensitive dynamic bellows and the pressure from the static orifices to a similar bellows called the static bellows.

6. The dynamic bellows and the static bellows are mounted one each side of, and equidistant from, the pivot of a contact bar. This bar is provided with a pair of contacts at one end, cooperating with fixed contact disposed on each side of the contact bar. Thus, when the contact end of the bar moves up, one pair of contacts is closed, and when it moves down, the other pair is closed. Any unbalance in the pressures in the two bellows will move the bar in one direction or the other.

7. It will be seen that with the ship stationary and the pump stopped, the pressure in the two bellows will be equal. At the time the ship moves, however, there is transmitted to the dynamic bellows an increased pressure which will deflect the bar. If now the pump is rotated, it will be found that there is a pump speed which will produce a pressure equal to the dynamic component of the pressure in the dynamic bellows. With the pump running at this speed the bar will return to its original position. At the time the ship's speed is reduced the bar will deflect in the opposite direction due to the excess pressure in the static bellows. The pump driving motor is a direct current motor having a wide range of speed control due to the use of both field and armature resistances. These are positioned by a follow-up motor controlled by the dynamic and static sylphon units. The pump motor is thus automatically controlled in such a way that the pressure developed in the pump balances the dynamic component of the pressure developed in the rodmeter.

8. Since the pressure developed in the pump is proportional to the square of its speed, it will be seen that the speed of the pump is always proportional to the speed of the ship.

9. The problem of measuring the speed of the pump motor is solved through the use of a roller and disc type "instantaneous" indicator depending upon controlled frequency for the timing element. This instrument is remote from the pump unit and is operated by means of a synchronous motor driven by a self-synchronous motor in the rotary transmitter. Suitable gears in both transmitter and indicator drive counters which count nautical miles.

DESCRIPTION OF MATERIAL UNDER TEST

10. The subject system submitted for test consists of one rotary transmitter, one control unit, and one speed indicator. It is known as a rotary balance log and is an instrument for measuring the speed of a ship through the water and indicating the number of miles traveled.

Rotary Transmitter - Type RB1 - Manufacturer's Drawing No. 32.

11. This instrument is shown by photographs, Plates 5 and 6, and consists of the following units:

One centrifugal pump.
Three variable resistors.
One small Barber-Colman, 115 volt, a.c., reversible induction motor.
Two self-synchronous motors.
One six-digit mechanical counter.
One small Barber-Colman, 115 volt, a.c., non-reversible induction motor.
Three Burgess micro-switches.

12. The pump motor field and armature resistors, the a.c. reversible type motor, and Burgess micro-switches are located on a brass plate, secured to the bottom of the aluminum alloy case with three "Lord" rubber mountings. For ship's speed of 40 knots, the pump motor rotates 6000 r.p.m.

13. The case is provided with a removable cast aluminum alloy cover, four mounting lugs equipped with "Lord" rubber mountings, and three bosses, two tapped for 3/4-inch (IPS) and one for 1-1/4-inch (IPS), to accommodate standard terminal tubes. Located on the top and bottom sides of the case are openings for ventilation. The cast aluminum alloy cover is secured to the case with ten 5/16-inch hexagonal brass machine screws which thread into steel inserts. Steel liners in the cover holes prevent contact of the brass screws with the aluminum cover. A window in the cover is provided for reading the total distance traveled. The case is painted white on the inside and gray on the outside.

14. The centrifugal pump and motor are secured externally on the underside of the case with four 5/16 steel machine screws, cadmium plated, which thread into steel inserts, located in bosses cast integral with the case.

15. The self-synchronous motor on the left is geared to the pump motor so that it turns over exactly 180 revolutions per mile and actuates a speed indicator.

16. The self-synchronous motor on the right is geared to the pump motor so that it turns over exactly 360 revolutions per mile. It is used to drive the distance mechanism of the "Dead Reckoning Tracer System."

17. The six-digit reset counter located between the two self-synchronous motors is geared to the pump motor in such a way that it counts miles and hundredths of a mile.

18. Located in the top of the case is an opening for expelling the hot air by means of a small Barber-Colman, 115 volt, a.c., 60 cycle, induction motor equipped with a fan. A fan attached to the centrifugal pump shaft assists in lowering the temperature of the pump.

19. A Burgess micro-switch opens the centrifugal pump motor circuit at zero ship's speed. Micro-switches are also connected in series with the clockwise and counter-clockwise windings of the follow-up motor. One of the switches opens the clockwise winding at zero ship's speed, the other opening the counter-clockwise winding at maximum ship's speed.

20. Two molded phenolic material terminal blocks, equipped with 9-S-1841-L terminals, are provided. The blocks are supported by hexagonal steel studs which thread into steel inserts, threaded into bosses located in the bottom of the case.

21. A nameplate of non-magnetic material having relief etching is secured to the case cover with four steel cadmium plated drive pins.

22. The rotary transmitter weighs 101 pounds, 2 ounces, is 21.75 in width, 18.75 in height, and 6.875 in depth.

Control Unit - Type RB1 - Manufacturer's Drawing No. 33.

23. This instrument is shown by photographs, Plates 7 and 8, and consists of two sylphon units and a contact-making device installed in a cast BE metal case having a removable cover. The case is provided with four mounting lugs and two bosses tapped for 3/4-inch (IPS) standard terminal tubes. A nameplate of non-magnetic material, having relief etching, is secured to the BE case cover with four steel, cadmium-plated drive pins.

24. The control unit weighs 28 pounds, 2 ounces, is 13.375 in width, 13.0 in height, and 4.625 in depth.

25. All parts of the hydraulic system are provided with blow-off cocks in order that the system can be freed of air.

Speed Indicator

26. This instrument is shown by photographs, Plates 9 and 10, and is of the roller and disc type, depending on regulated frequency for accuracy. It is identical to the shaft revolution indicator tested and reported under reference (c), except that the dial is graduated from 0 to 40 knots instead of from 0 to 400 r.p.m., and the gear ratio to the counter is such that it counts miles and hundredths instead of revolutions.

27. The test set-up is shown by photograph, Plate 4. The hydrostatic pump shown was used for obtaining the necessary dynamic pressures. The manometer shown with a graduated scale was used for checking the accuracy and is not a part of the system.

METHOD OF TEST

28. The system was first tested for endurance by operating it for 500 hours at normal supply voltages and frequency (115 volt, a.c., 60 cycles and 115 volt, d.c.). This test was continuous except for an interruption at the end of the first 50 hours to permit tests for shock and vibration integrity and accuracy tests. During the latter 200 hours, the system was operated as specified under paragraph F-2h (Inclination Tests).

29. Tests for shock integrity were made by placing each unit of the system on a Bureau of Engineering shock stand and applying 20 shocks of 250 foot-pounds each (10 blows normal to the face of the instrument, and 10 blows at right angles thereto). During these tests the system was electrically connected and operating at 30 knots.

30. The vibration tests consisted of placing each of the units on a false panel of 5-pound steel plate, having an anvil affixed at its bottom edge. Three foot-pound shocks were delivered for period of 30 minutes each at frequencies of 100, 150, 200, 250, 300, and 350 vibrations per minute. During these tests the system was operating at 30 knots.

31. Next followed tests for operation of the system at 10 per cent under voltage at 65 cycles, and 10% over voltage at 55 cycles.

32. A test for watertightness of the speed indicator was made by immersing it in water to a depth of 3 feet for a period of one hour.

33. The next tests conducted were for dielectric strength and insulation resistance, followed by an inspection of each unit to ascertain whether or not it conformed with the specifications relative to materials and workmanship.

RESULTS OF TEST

34. The results of the tests conducted in the order required under the specifications, reference (b), follow:

Requirements	Test Values
Voltage: 115	115 volts
Voltage to centrifugal pump motor:	115 volts, d.c. (not covered by specifications)
Current: Alternating	Alternating
Frequency: 60 cycles	60 cycles

Requirements	Test Values
Endurance: Par. F-2g	*See comments under CONCLUSIONS.
Shock integrity: Par. F-2.	*See comments under CONCLUSIONS.
Vibration integrity: Par. F-2i.	Satisfactory, system unaffected by vibrations.
Accuracy tests: Par. F-2j, sub-paragraph (1).	Complied, see Table 1 and Plate 1.
Over and under voltage and frequency tests: Par. F-2j, sub-paragraph F-2j(4).	Complied, see Table 2 and Plate 2.
Inclination tests: Par. F-2h.	Complied, see Table 3 and Plate 3.
Watertight test: Par. F-2k.	Complied, no leaks occurring in the speed indicator.
Dielectric: Par. F-21(1).	Complied.
Insulation: Par. F-21(2).	Complied.
Current consumption: Not specified.	115 volt, a.c., 60 cycles - 3.5 amps. 115 volt, d.c. - 3.5 amps.

CONCLUSIONS

35. This Rotary Balance Log System manufactured by Pitometer Log Corporation and submitted for type approval test under reference (a), failed to comply with the following requirements:

(a) The system failed to function after 486 hours during tests for endurance. An examination disclosed that this was due to the failure of the "Bodine" centrifugal pump motor. The brushes were worn excessively and several wires had become unsoldered from the segments of the commutator. This indicated high temperature, resulting from the arc between the brushes and the commutator. In order to complete the test it was necessary to use replacement brushes and holders furnished by the manufacturer, resolder the armature wires, and clean the commutator.

(b) The system, after having completed the 500-hour endurance test, again failed to operate after completion of tests for inclination. An examination again disclosed worn brushes and a blackened commutator. The commutator and brushes at the conclusion of the test are shown by photograph, Plate 11.

(c) During tests for shock integrity, the contacts in the control instrument changed their adjustment, thereby resulting in erroneous indications. When readjusted, however, the system again functioned properly.

36. Under inspection at the conclusion of all tests, the following objectionable features were noted:

(a) The pointer screw of the speed indicator does not clear the surface when the unit is removed from the case and placed upside down on a table. The handles should support the entire unit.

(b) The external terminal block of the pump motor is not accessible and should be eliminated. The motor wires should extend directly to the internal connection block.

(c) The present guard around the external pump gears does not afford adequate protection against injury.

37. The Bureau's attention is invited to the fact that a supply of 115 volts, direct current, is required for the centrifugal pump motor in order to obtain readings within the accuracy limitations of the specifications. For example, with the system operating at 39 knots, true speed, for 1/2 hour, and the voltage lowered to 103.5 volts, the average of three readings of the speed indicator was 35.6 knots, or 8.51 per cent error. The error in the total distance traveled was 9.74 per cent. The allowable error for a speed of 39 knots is 1 per cent.

38. Tests at 40 knots were not conducted in view of the fact that it would have been necessary to increase the normal supply voltage (115 volts) to the pump motor.

39. The system, when operated at speeds below 4 knots, was extremely erratic.

Table 1

ACCURACY TEST RESULTS
(1/2 Hour Runs)

Knots by Manometer	Allowable Error ± %	Indicated Knots			Transmitter		Indicator	
		Minimum	Maximum	Error - %	Counted Miles	Error - %	Counted Miles	Error - %
4	-6	3.6	4.1	-3.75	2.05	+2.5	2.05	+2.5
6	-4	5.7	6.1	-1.66	3.02	+ .66	3.02	+ .66
9	-3	8.8	9.2	±2.22	4.51	+ .22	4.51	+ .22
16	-2	15.9	16.1	± .625	7.99	- .125	7.99	- .125
20	-1	19.9	20.1	± .50	9.98	- .20	9.98	- .20
25	-1	24.9	25.1	± .40	12.51	+ .08	12.51	+ .08
30	-1	29.9	30.1	± .33	14.98	- .133	14.98	- .133
35	-1	34.9	35.1	± .286	17.51	+ .057	17.51	+ .057
39	-1	38.9	39.1	± .256	19.56	+ .310	19.56	+ .310

OVER AND UNDER VOLTAGE AND FREQUENCY TESTS
(1/2 Hour Runs)

Knots by Manometer	Indicated Knots		Error - %	Transmitter		Indicator	
				Counted Miles	Error - %	Counted Miles	Error - %
16 Knots	Min.	Max.					
115 V. 60 cycles	15.9	16.1	±.625	8.01	+.125	8.01	+.125
103.5 V. 65 cycles	15.9	16.1	±.625	8.02	+.250	8.02	+.250
126.5 V. 55 cycles	15.9	16.1	±.625	7.98	-.250	7.98	-.250
2% Allowable at 16 knots.							
30 Knots							
115 V. 60 cycles	29.9	30.1	±.33	15.01	+.066	15.01	+.066
103.5 V. 65 cycles	29.9	30.1	±.33	15.02	+.133	15.02	+.133
126.5 V. 55 cycles	29.9	30.1	±.33	15.02	+.133	15.02	+.133
1% Allowable at 30 knots.							
39 Knots							
115 V. 60 cycles	38.9	39.1	±.256	19.55	+.256	19.55	+.256
103.5 V. 65 cycles	38.9	39.1	±.256	19.56	+.309	19.56	+.309
126.5 V. 55 cycles	38.9	39.1	±.256	19.58	+.410	19.58	+.410
1% Allowable at 39 knots.							

NOTE: During this test regulated 60 cycle current was supplied to the timing element in the indicator.

(1/2 Hour Runs)

Knots	Normal		45° Back		45° Ahead		45° Right		45° Left	
	Counted Miles	Indicator Knots	Counted Miles	Indicator Knots	Counted Miles	Indicator Knots	Counted Miles	Indicator Knots	Counted Miles	Indi Kn
16 Knots										
	8.01	15.9 16.1	8.01	15.9 16.1	8.005	15.8 16.1	7.94	15.8 16.0	8.06	16.0
Error %	+.125	±.625	+.125	±.625	+.062	±.937	-.75	-.625	+.75	+
2% Allowable error at 16 knots.										
30 Knots										
	15.01	29.9 30.1	14.99	30.0 30.2	15.05	29.8 30.1	14.95	29.9 30.1	15.05	30.0
Error %	+.066	±.33	-.066	±.33	+.33	±.50	-.33	±.33	+.33	+
1% Allowable error at 30 knots.										
39 Knots										
	19.55	38.9 39.1	19.55	39.0 39.2	19.54	38.9 39.1	19.55	38.9 39.1	19.58	39.
Error %	+.256	±.256	+.256	+.256	+.205	±.256	+.256	±.256	+.410	
1% Allowable error at 39 knots.										

NOTE: During this test the centrifugal pump motor was energized at rated voltage (115 V. d.c.) and 115 V. a.c. regulated 60 cycle supplied to circuits 8K-8KK and 1Y-1YY.

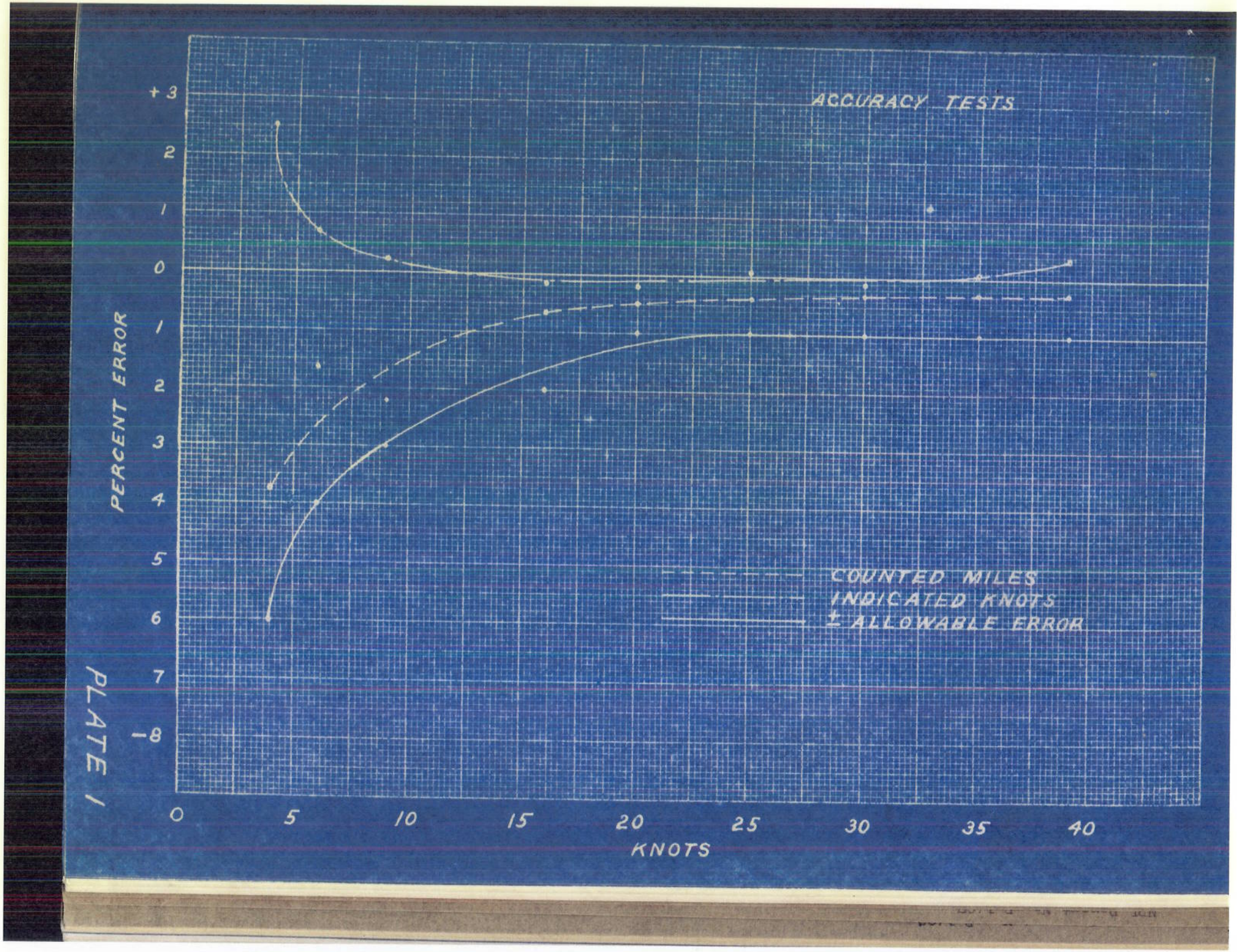
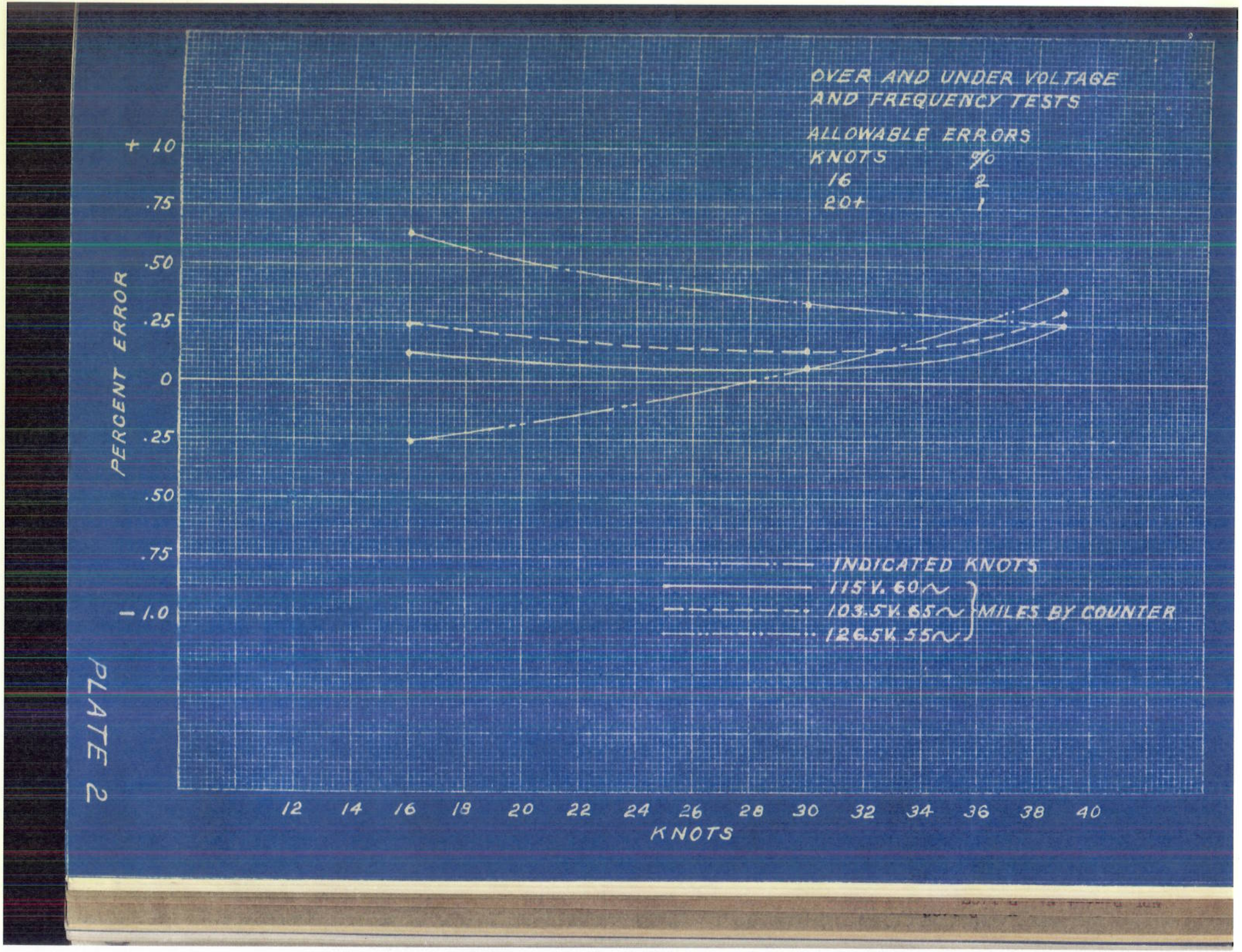

ACCURACY TESTS
PERCENT ERROR
+3
2
1
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35
40
KNOTS
COUNTED MILES
INDICATED KNOTS
± ALLOWABLE ERROR

PLATE 1


OVER AND UNDER VOLTAGE
AND FREQUENCY TESTS
ALLOWABLE ERRORS
KNOTS %
16 2
20+ 1
+ 1.0
.75
.50
.25
0
.25
.50
.75
- 1.0
PERCENT ERROR
INDICATED KNOTS
115 V. 60~
103.5 V. 65~
126.5 V. 55~
MILES BY COUNTER
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
KNOTS
PLATE 2

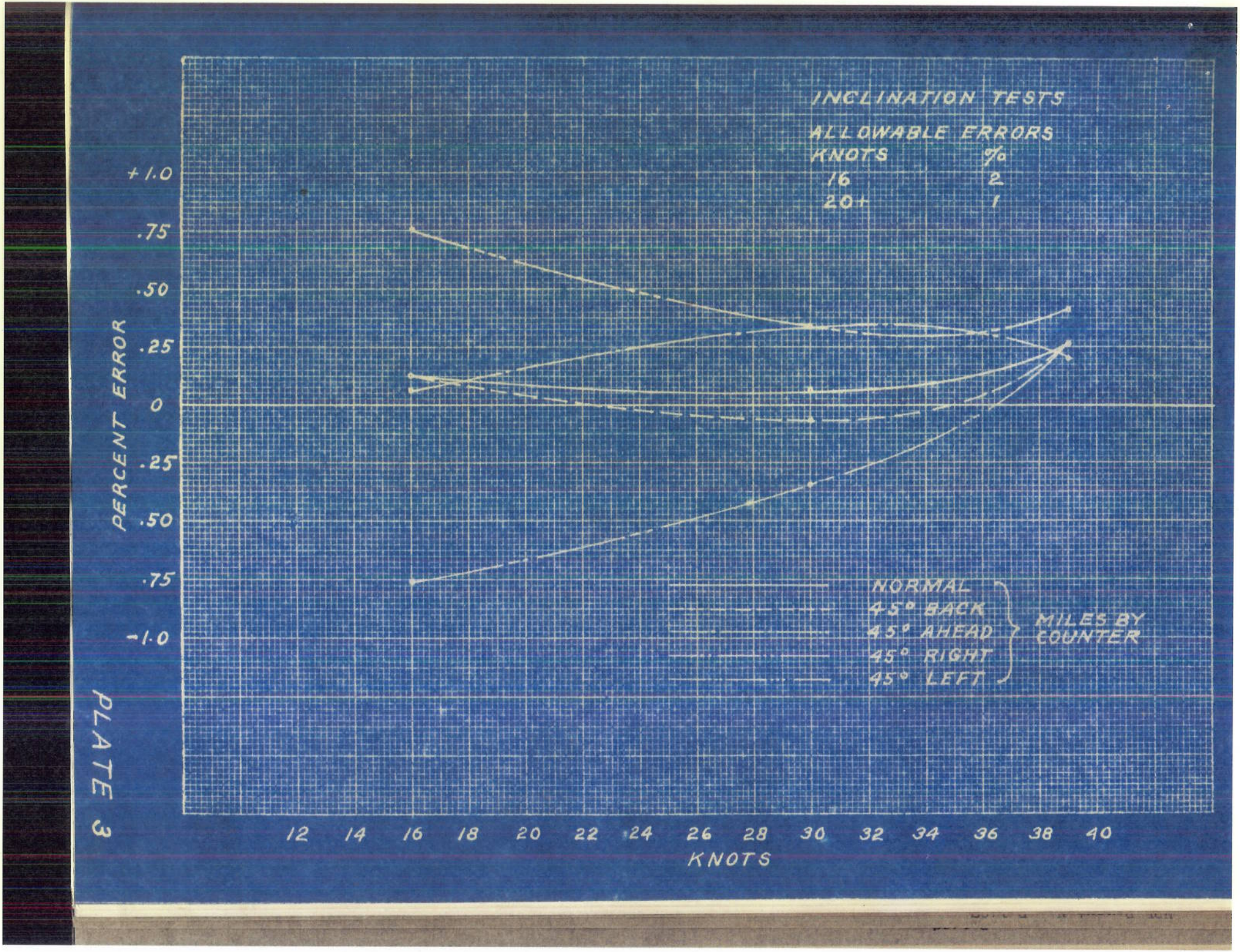
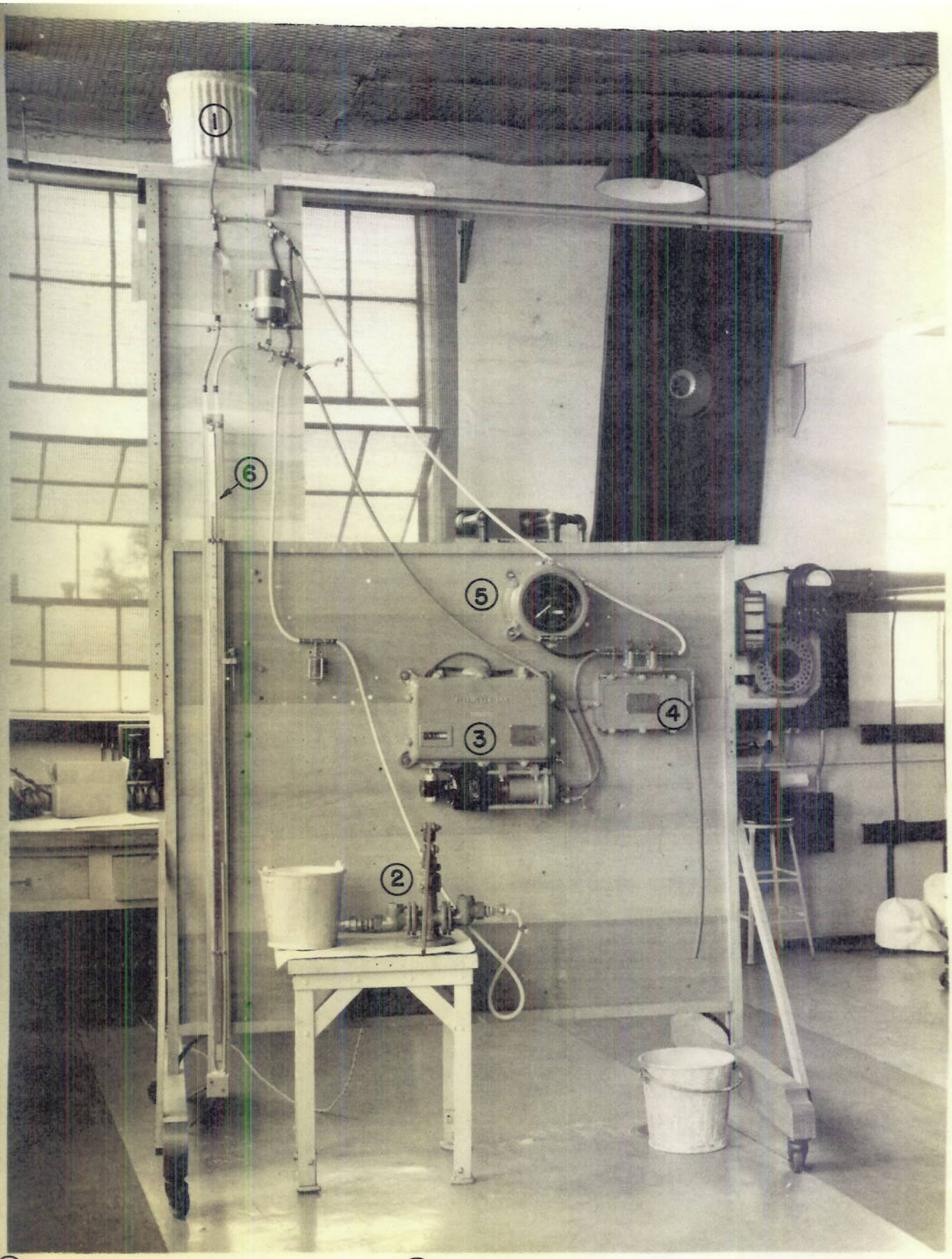

INCLINATION TESTS
ALLOWABLE ERRORS
KNOTS %
16 2
20+ 1
+1.0
.75
.50
.25
0
.25
.50
.75
-1.0
PERCENT ERROR
NORMAL
45° BACK
45° AHEAD
45° RIGHT
45° LEFT
MILES BY COUNTER
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
KNOTS

PLATE 3



1-STATIC PRESSURE
2-DYNAMIC PRESSURE
3-ROTARY TRANSMITTER
4-CONTROL UNIT
5-SPEED INDICATOR
6-MANOMETER

PLATE 4

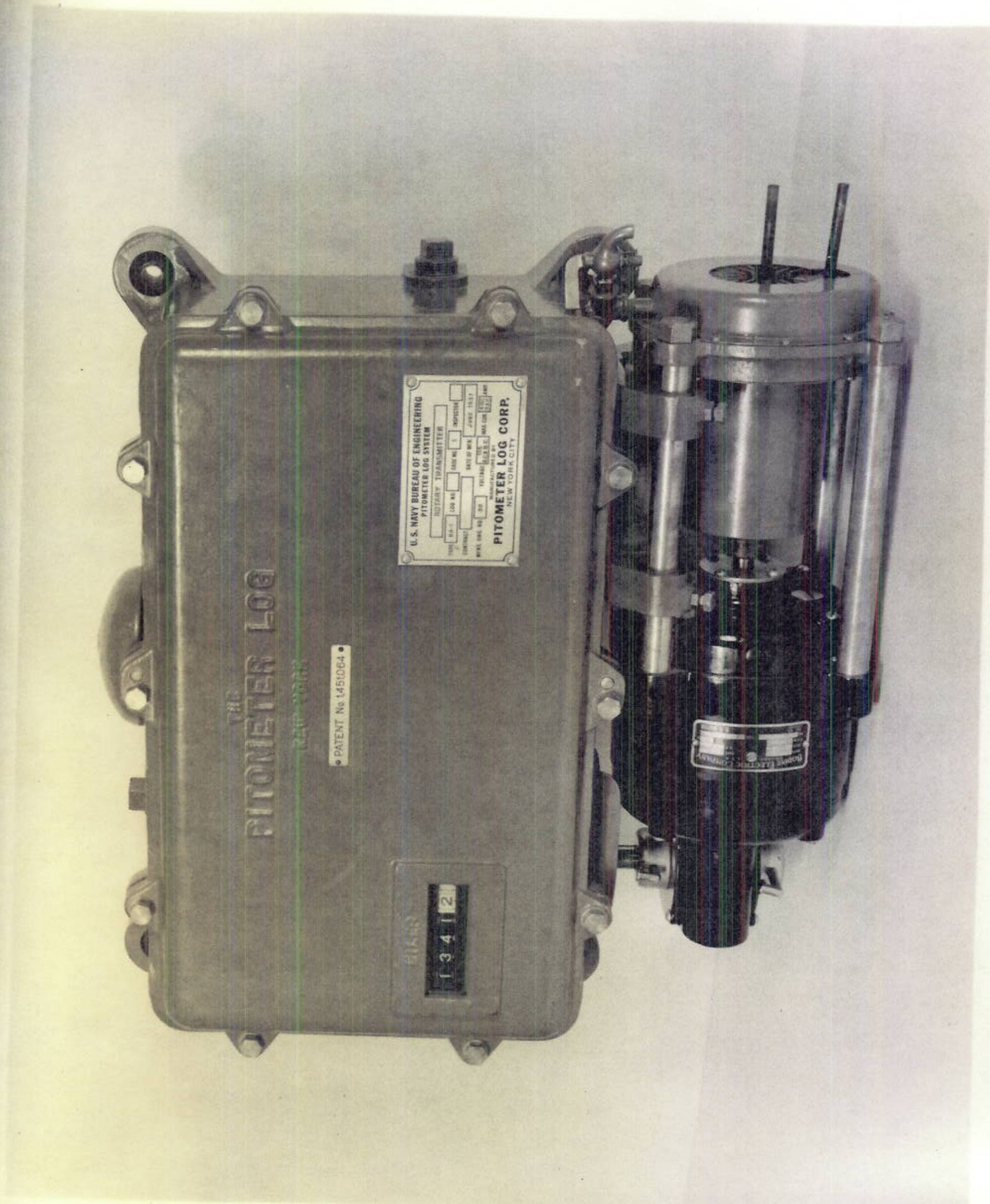

THE PITOMETER LOG
NEW YORK
PATENT No 1451064
U.S. NAVY BUREAU OF ENGINEERING
PITOMETER LOG SYSTEM
ROTARY TRANSMITTER
PITOMETER LOG CORP.
NEW YORK CITY

PLATE 5

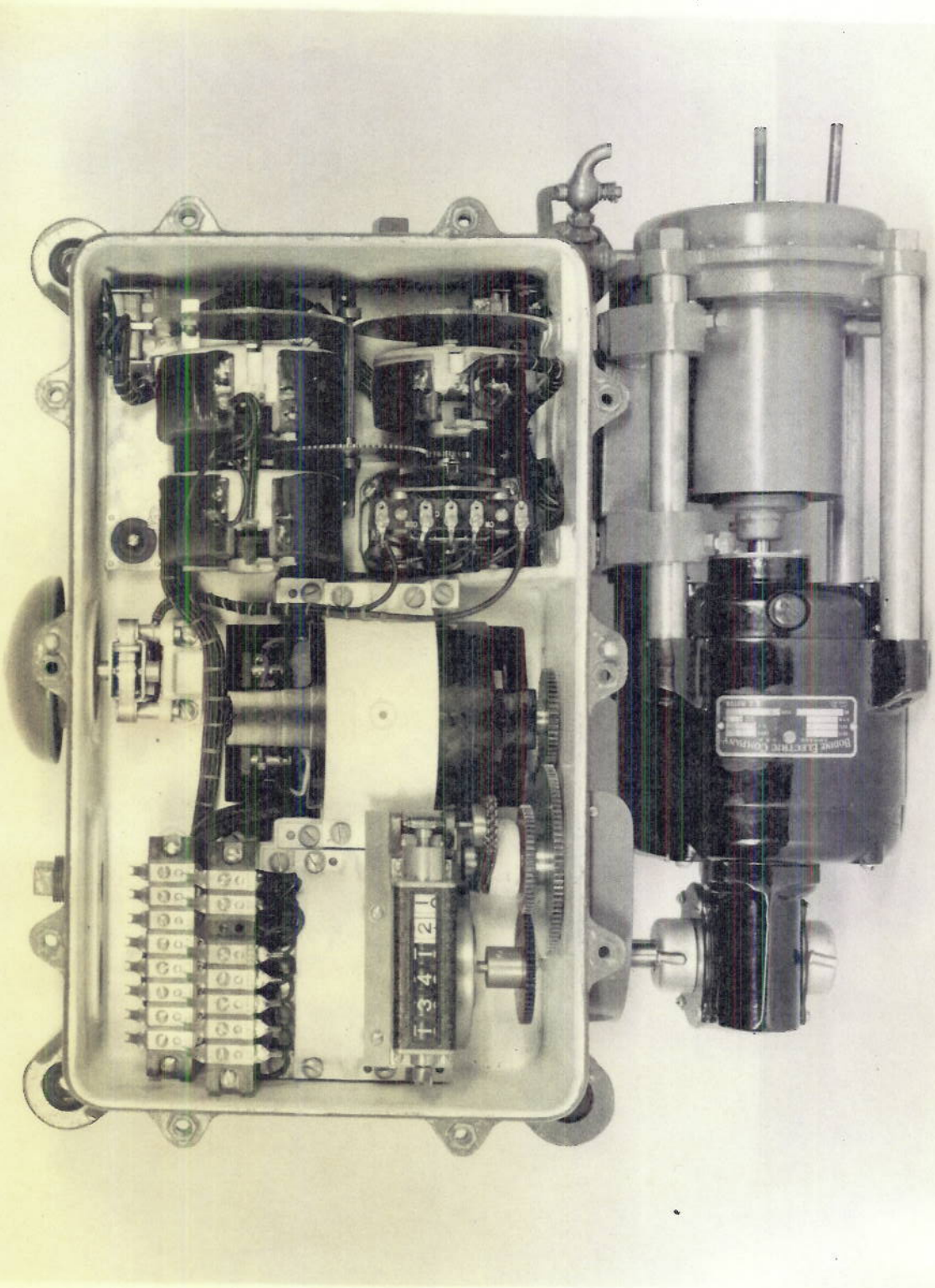


PLATE 6

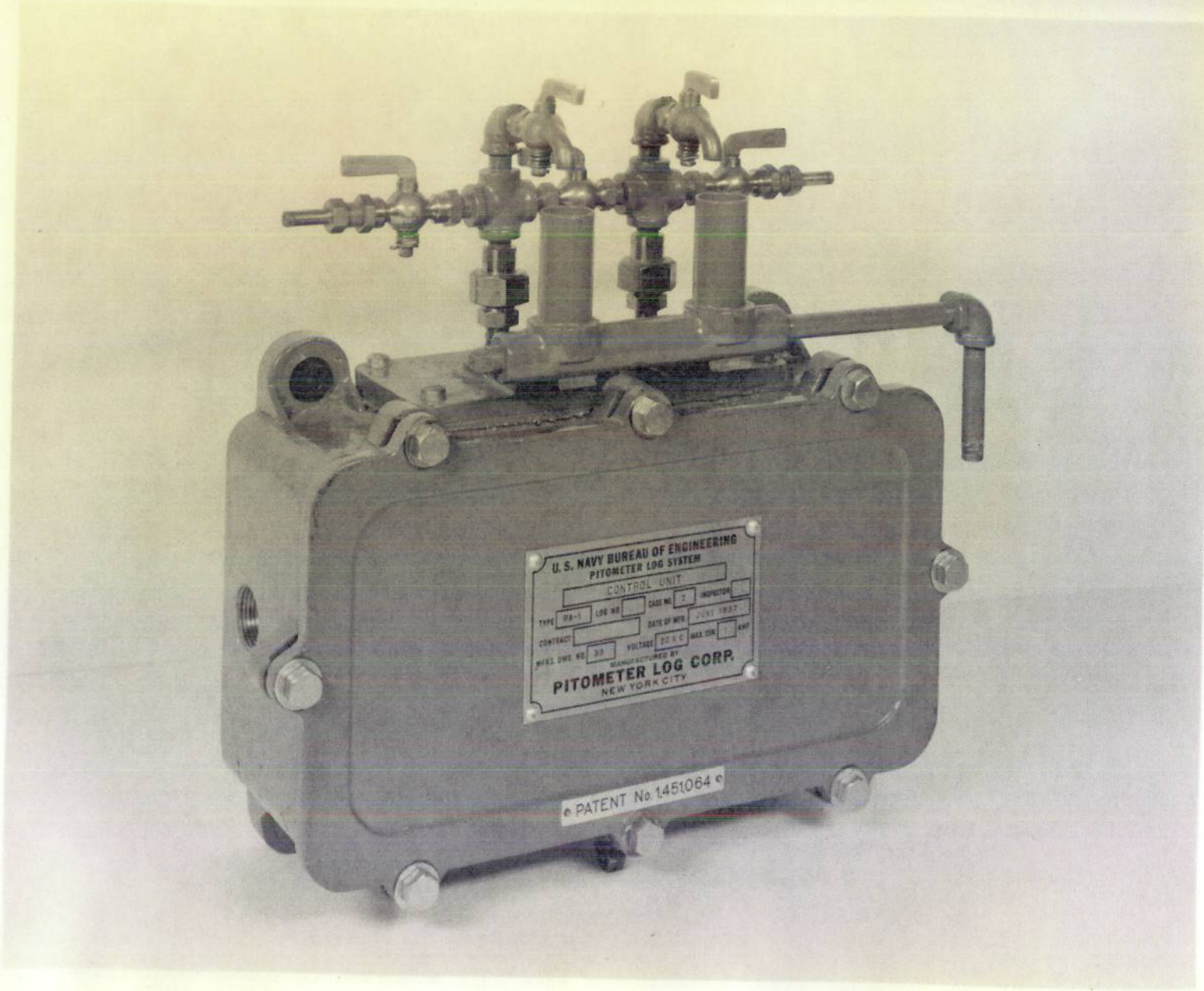

U. S. NAVY BUREAU OF ENGINEERING
PITOMETER LOG SYSTEM
CONTROL UNIT
PITOMETER LOG CORP.
NEW YORK CITY
PATENT No. 1,451,064

PLATE 7

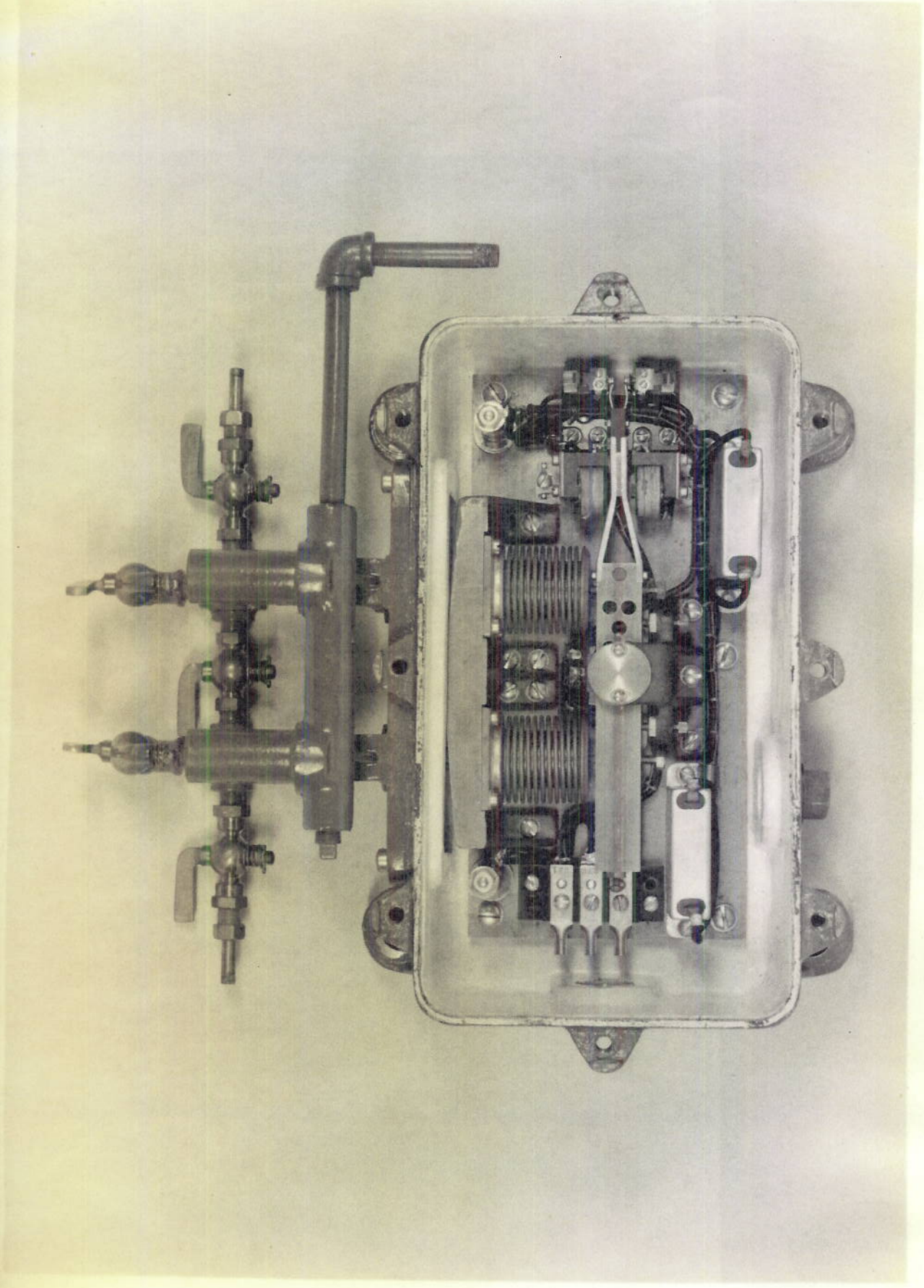


PLATE 8


MADE BY
PITOMETER LOG CORP
NEW YORK
KNOTS
MILES
0 2 6 5 3 1 6
5
10
15
20
25
30
35
PITOMETER LOG CORP

PLATE 9

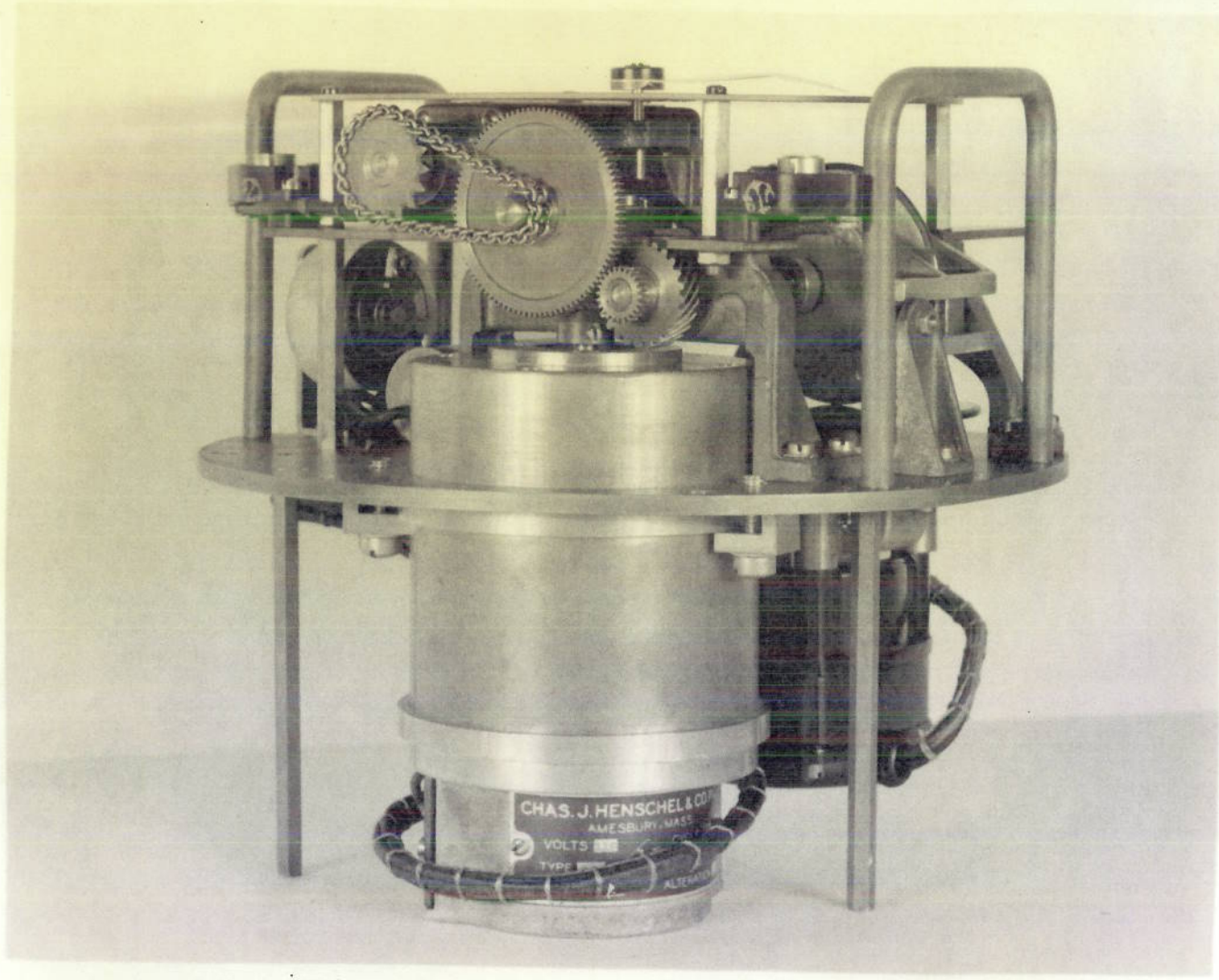


PLATE 10

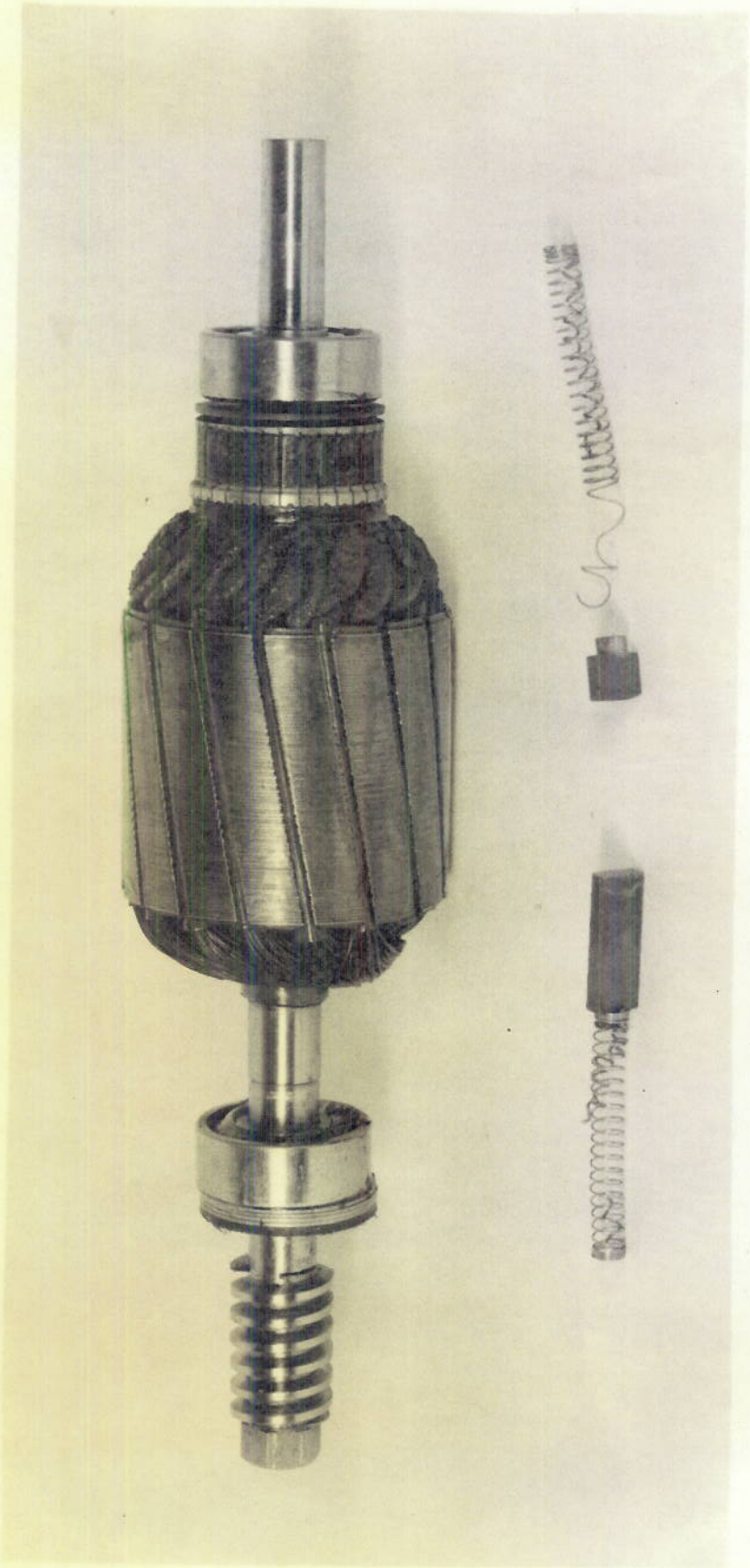


PLATE II