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NAVY DEPARTMENT
BUREAU OF ENGINEERING

Report of Test

on

Motors, Indicator, Navy Type "N"
Bendix Marine Products Corporation
Manufacturer and Exhibitor

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, DC

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Authorization: BuEng ltr. S63-1/L5(6-21-Ds) of 6 July 1938.
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Distribution:

Bueng (5)

bms

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AUTHORIZATION FOR TEST

1. This problem was authorized by reference (a) and another reference pertinent to this problem is listed as reference (b).

Reference: (a) Bueng. ltr. S63-1/L5(6-21-Ds) of 6 July 1938.
(b) Specifications SGS(65)-42a of 15 February 1937.

OBJECT OF TEST

2. The object of this test was to determine conformance of the sample motors with the specifications, reference (b), and their suitability for Naval use.

ABSTRACT OF TEST

3. The sample motors were set up at this Laboratory in suitable test circuits where their performance was carefully observed for compliance with the specifications. An inspection of the motors to determine compliance with the requirements in the matter of materials, design and workmanship, concluded the test.

Conclusions

(a) The sample motors, manufactured and submitted as Navy type "N" by Bendix Marine Products Corporation, Brooklyn, New York, do not comply with the specifications. They were not in a good mechanical condition at the end of the test.

Recommendations

(a) Due to the many failures of the motors to comply with the specifications, they are not recommended for Naval use as at present manufactured.

DESCRIPTION OF MATERIAL UNDER TEST

4. Six (6) sample type "N" indicator motors, manufactured by Bendix Marine Products Corporation were submitted for test. One type "A" transmitter generator was furnished for use in connection with the test.

5. The sample type "N" motors are of the moveable field type, the terminals S_1 and S_2 connecting to the rotor through brushes. One brush contacts a slip ring, the other presses against a contact in the end of an insulating extension of the shaft. The contacts are of silver and are housed in a separate chamber formed by the cylindrical terminal insulator.

6. Five (5) brass terminal blocks are secured in radial slots in this insulator. The two flat brushes are connected directly to the terminals S_1 and S_2 . The brushes are provided with silver contacts. The slip ring and shaft end contact are also of silver. Flexible lead wires extend from the stationary winding to R_1 , R_2 and R_3 . A cloth inserted phenolic disc is secured to the insulator and acts as a cover for the contact chamber.

7. The rotor is mounted on separable ball bearings. The outer race of one bearing has a sliding fit in the end bell and is provided with a formed spring to bring the race in contact with the balls. The rotor also has a friction mounted damping disc. The motor case is of BE composition and has two principal parts. By removing the end bell, the rotor may be withdrawn. Photograph, Plate 1, shows two (2) of the samples submitted, one (1) disassembled.

METHOD OF TEST

8. The six (6) sample type "N" motors were first tested for accuracy by the reflected light method. The equipment used for this purpose incorporates a shaft having a chuck on one end and a cylindrical housing on the other. This shaft is driven at 1 r.p.m. by a synchronous motor through reduction gears. The transmitter generator is rigidly held by a yoke which maintains alignment so that the extending generator shaft may be grasped by the chuck. The motor to be tested is mounted concentrically in the housing on the other end of the shaft. Thus, as the generator rotor is rotated, the motor stator is rotated in the same direction at the same rate.

9. The housing containing the motor is provided with slip rings and brushes so that the motor may remain connected in a circuit while rotating. This is done in the usual manner except that leads R_1 and R_3 of the generator are connected to R_3 and R_1 respectively of the motor.

10. With the circuit energized and the shaft rotating, the rotor of the motor under test remains stationary because its angular

velocity with respect to its stator (which is now rotating) is equal to the angular velocity of the rotating generator rotor with respect to its stator. Failure of this shaft to remain stationary indicates an error between the generator and motor.

11. By securing a very light galvanometer mirror to the motor shaft and projecting a beam of light to it, this inaccuracy may be measured by the position of a filament image on a scale.

12. For this test, a base distance was chosen so that a 1° variation produced a $1/2$ " deflection on the scale. To record the results of the tests, the deflected light beam was allowed to strike sensitive photographic paper on a revolving drum. The drum was driven by a synchronous motor.

13. Tests were made on each motor while the remaining 5 motors were connected in the circuit as a load. Separate records were made at 126.5 volts, 55 cycles, 115 volts, 60 cycles and 103.5 volts, 65 cycles. The motors were rotated both clockwise and counterclockwise for each photographic record in order to establish the limits of error. The zero error reference line was drawn on the records after development. These records are given by Plates 2 to 7 inclusive.

14. The torque test was next conducted in the usual manner as described by the specifications. In addition, the maximum torque of each motor was measured. All torque measurements were made with only the motor under test connected to the generator. The results are given by Tables 1 and 2.

15. The oscillation characteristics of the motors were determined by timing with a stop watch in the manner described by the specifications. During this test, all six test motors were connected to the generator. The shaft of the motor being observed was fitted with the standard Ordnance dial used for stiffness tests. This is the dial used on previous tests and it was chosen in the absence of a standard pointer. It is $3-1/2$ " in diameter and is of $1/64$ " aluminum.

16. The motors were tested for endurance by connecting them to the generator and placing them in a compartment having an ambient temperature of 65° C. The generator was rotated at 100 r.p.m. for 500 continuous hours. The direction of rotation was reversed every 24 hours. The resistances of the windings were frequently measured to determine their temperatures.

17. Following this, the motors were again tested for accuracy by the method previously described. These records are shown at the bottom of Plates 2 to 7 inclusive.

18. For additional information, motor No. 2 was connected as a generator to motor No. 3 and a similar accuracy test made. The result is shown by Plate 8.

19. Next, three (3) of these motors were subjected to the specified shock and vibration tests and examined for damage. The remaining motors were reserved for comparison.

20. The test was concluded with dielectric strength and insulation resistance tests and an inspection to determine compliance with the specifications in the matter of workmanship, materials, and dimensions.

RESULTS OF TESTS

21. The results of torque, oscillations, temperature rise, and accuracy tests, are given as Tables 1 to 5 inclusive. Comments as to the compliance of the motors with the specifications are as follows:

- (a) The torque gradient of all motors is below the required 0.1 inch ounces per degree. The average was 0.065 inch ounces per degree for the first 10 degrees displacement, clockwise and counterclockwise.
- (b) The average maximum torque was 4.83 inch ounces. This value was reached at approximately 95 degrees displacement and exceeds the required minimum of 4 inch ounces.
- (c) Under the oscillation test, the allowed maximum time of 3 seconds was exceeded in several instances. The greatest period required for the rotor to come to rest was 3.4 seconds.
- (d) The allowed temperature rise of the motors was not exceeded during the endurance tests at ambient temperature of 65° C. The temperature rise of the generator was one (1) degree above the allowed 35° C.
- (e) The accuracy requirement was met only by one motor during the initial accuracy test and by none following the endurance test. The greatest error recorded was three (3) degrees. The majority of the errors were negative.
- (f) All motors successfully completed the required 500 hour test for endurance.
- (g) During the shock and vibration tests, on motors numbers 2, 3, and 5, no erratic operation was noted, except in the case of number 2 motor. Under shock, its operation indicated the lifting of the brushes from the slip ring or end contact of the rotor.
- (h) All motors complied with the insulation test prior to the dielectric test.
- (i) All motors complied with the dielectric test of 1500 V.a.c.,

60 cycles, except motor number 5. A breakdown occurred between the damper and the stator winding.

- (j) The motors comply with the dimensions given in Table 1 of the specifications.

22. An inspection of the motors at the end of all tests disclosed the following deficiencies:

- (a) The ball bearings used do not appear to be dust proof.
- (b) The nameplates are not of approved material. Aluminum is used and is in contact with the BE composition case.
- (c) The damper disc assemblies on a majority of the motors were in bad condition.

CONCLUSIONS

23. The sample motors, manufactured and submitted as Navy type "N" by Bendix Marine Products Corporation, Brooklyn, New York, do not comply with the specifications. They were not in a good mechanical condition at the end of the test.

TABLE NO. 1

Torque, 0 to 10° Displacement
Single Indicators Connected to Type "A" Generator

Displacement in Degrees	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	Torque Gradient	
	Inch Ounces	Inch Ounces	Inch Ounces	Inch Ounces	Inch Ounces	Inch Ounces	Ind. No.	Inch Ounces
<u>CLOCKWISE</u>								
1	0.063	0.072	0.056	0.067	0.073	0.063	1	0.0638
2	0.133	0.134	0.116	0.131	0.134	0.133	2	0.0651
3	0.186	0.196	0.192	0.200	0.194	0.196	3	0.0639
4	0.266	0.263	0.254	0.267	0.261	0.262	4	0.0655
5	0.323	0.330	0.311	0.328	0.328	0.334	5	0.0665
6	0.386	0.398	0.379	0.399	0.402	0.394	6	0.0658
7	0.450	0.468	0.447	0.461	0.459	0.452		
8	0.518	0.527	0.500	0.532	0.520	0.525		
9	0.569	0.577	0.565	0.595	0.587	0.600		
10	0.632	0.663	0.637	0.667	0.648	0.655		
<u>COUNTERCLOCKWISE</u>								
1	0.063	0.067	0.064	0.064	0.064	0.074		
2	0.121	0.137	0.130	0.129	0.137	0.138		
3	0.190	0.208	0.195	0.192	0.206	0.200		
4	0.253	0.270	0.259	0.263	0.271	0.269		
5	0.322	0.335	0.329	0.328	0.335	0.331		
6	0.377	0.405	0.393	0.396	0.401	0.406		
7	0.451	0.481	0.466	0.460	0.459	0.473		
8	0.519	0.537	0.516	0.519	0.522	0.534		
9	0.578	0.610	0.582	0.582	0.597	0.597		
10	0.645	0.668	0.642	0.643	0.655	0.662		

TABLE NO. 2

MAXIMUM TORQUE

Single Indicators Connected to a
Type A "Autosyn" Generator

Supply 115 volts, 60 cycles

Indicator No.	Torque in Inch Ounces (CW)	Torque in Inch Ounces (CCW)
1	4.7	4.84
2	4.89	4.83
3	4.76	4.82
4	4.82	4.98
5	4.88	4.80
6	4.91	4.82

Note: Maximum at about 95° Displacement.

TABLE NO. 3

OSCILLATION TEST

Values Obtained with Stop Watch -
6 Indicators Connected to 1 Generator

Indicator No.	Seconds to come to rest when displaced				
	5°	10°	20°	90°	180°
1	1.3	1.7	2.2	3.2	3.4
2	.7	.7	.8	1.8	2.3
3	1.1	1.7	1.8	2.5	3.2
4	1.0	1.0	1.4	2.2	3.0
5	.8	1.0	1.2	1.7	2.3
6	.7	1.0	1.4	1.8	2.4

Note: A standard test dial was secured to the shaft of the motor under test.

TABLE NO. 4

TEMPERATURE RISE -

Maximum During 500 Hour Endurance Test

Indicators - 65°C. Ambient Temperature

Generator - 24°C. Ambient Temperature

Indicator No.	Windings Measured			
	S ₁ - S ₂	R ₁ - R ₂	R ₂ - R ₃	R ₃ - R ₁
1	32.0° C.	14.2° C.	15.0° C.	15.0° C.
2	31.0° C.	13.5° C.	13.5° C.	14.3° C.
3	29.2° C.	15.0° C.	14.3° C.	14.3° C.
4	31.5° C.	15.0° C.	15.0° C.	15.0° C.
5	34.0° C.	16.0° C.	16.0° C.	15.7° C.
6	28.5° C.	15.0° C.	15.0° C.	15.0° C.
Generator	36.0° C.	27.0° C.	27.0° C.	26.0° C.

TABLE NO. 5

MAXIMUM ERRORS RECORDED DURING TEST

Taken from Plates 2 to 8

Motor No.	BEFORE ENDURANCE			AFTER ENDURANCE
	55 Cycles 126.5 V.	65 Cycles 103.5 V.	60 Cycles 115 V.	60 Cycles 115 V.
1	.7°	1.0°	.75°	1.2°
2	1.2°	2.0°	1.7°	2.8°
3	1.2°	1.7°	1.7°	1.7°
4	1.3°	2.4°	1.8°	2.3°
5	1.25°	3.0°	2.4°	2.0°
6	1.1°	1.7°	1.5°	2.3°

Note: After endurance - No. 2 Motor as Generator Driving No. 3
 Motor - 115 V., 60 cycle supply
 Maximum error - 2.9°





NO.1 55 ~ 126.5V.

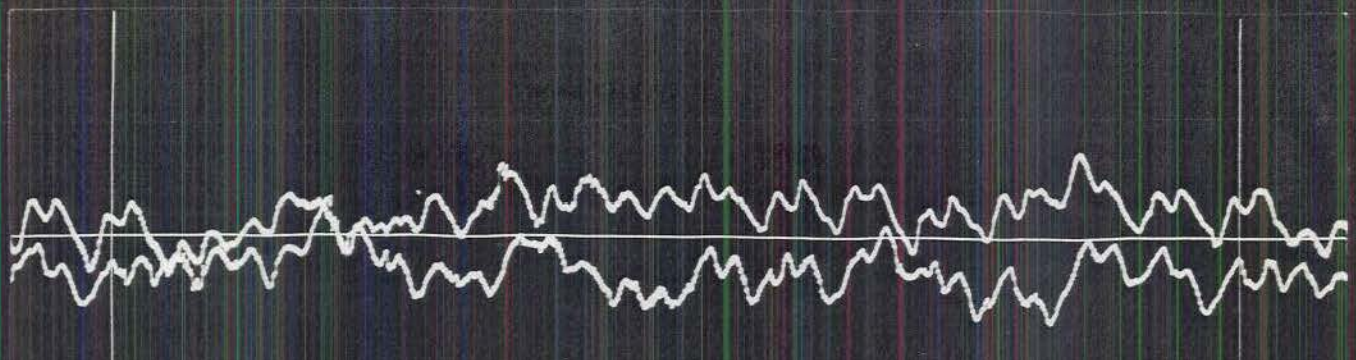


NO.1 60 ~ 115V.

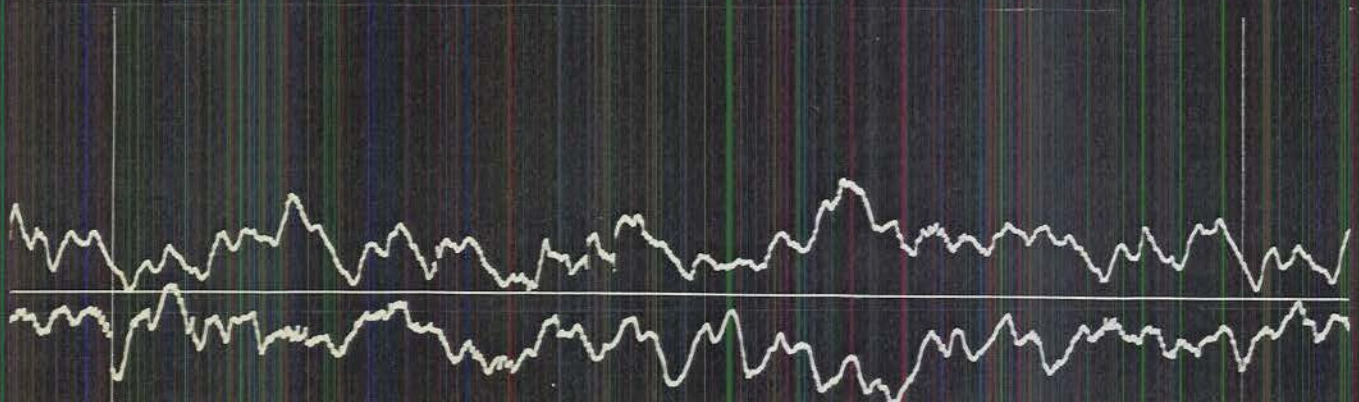


NO.1 65 ~ 103.5V.

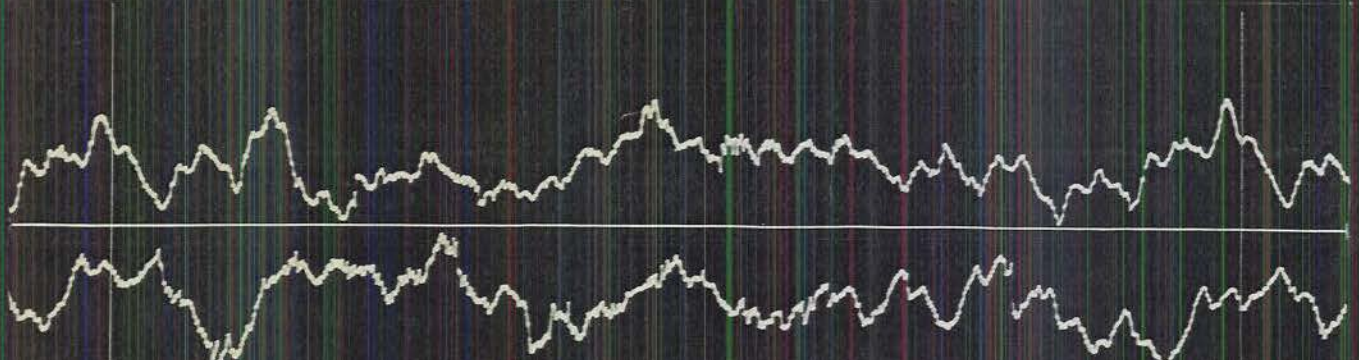




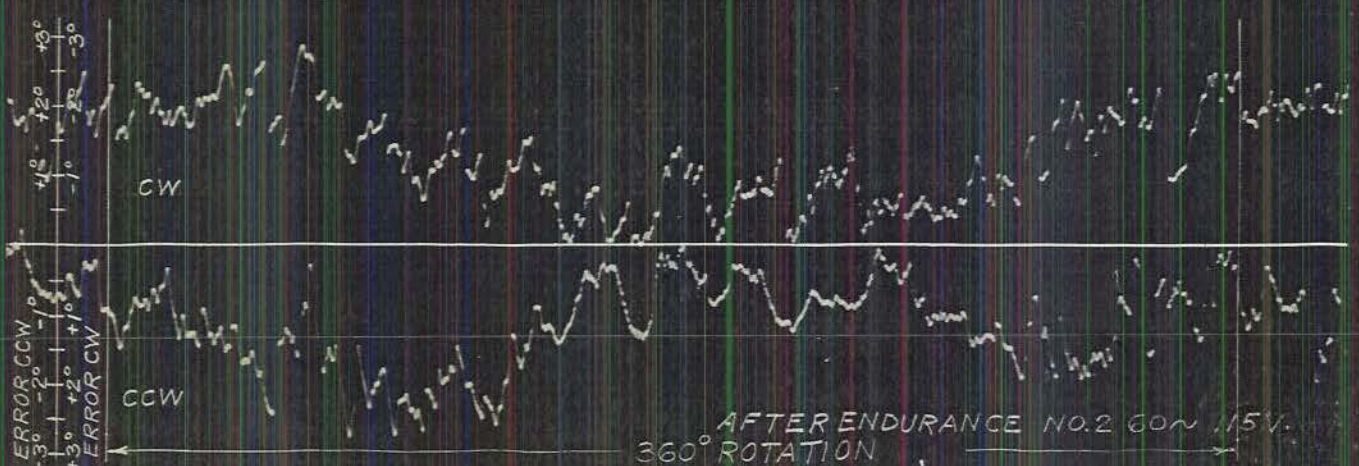
NO. 2 55 ~ 126.5 V.



NO. 2 60 ~ 115 V.



NO. 2 65 ~ 103.5 V.



+3°
+2°
+1°
0°
-1°
-2°
-3°

CW

CCW

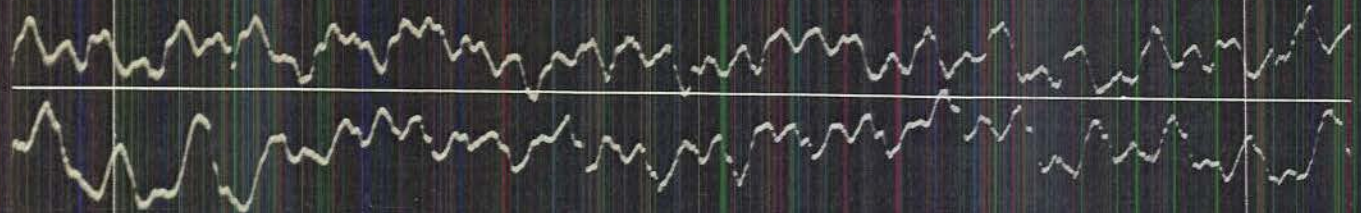
ERROR CCW

ERROR CW

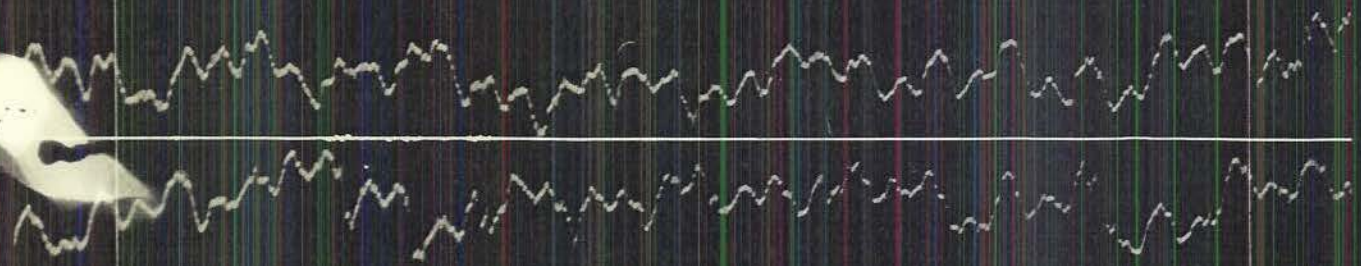
AFTER ENDURANCE NO. 2 60 ~ 115 V.
360° ROTATION



NO.3 55~126.5V.



NO.3 60~115V.



NO.3 65~103.5V.



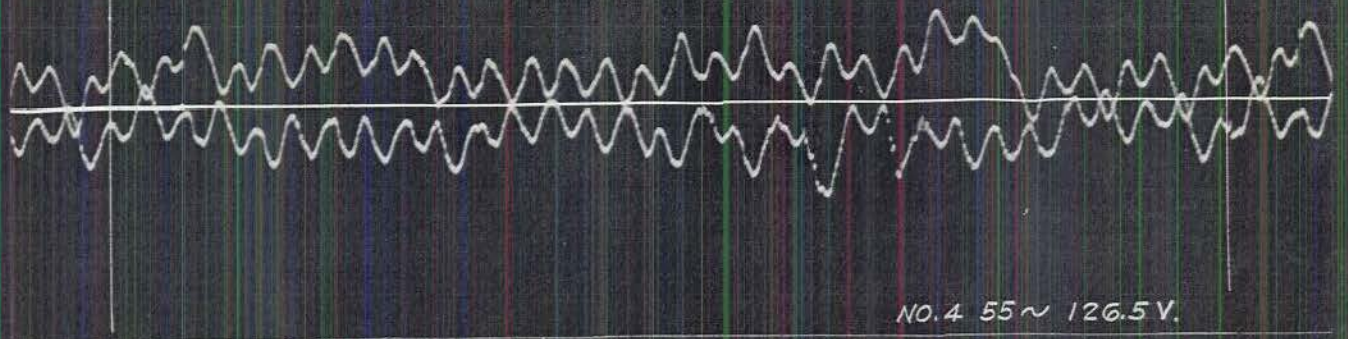
CW.



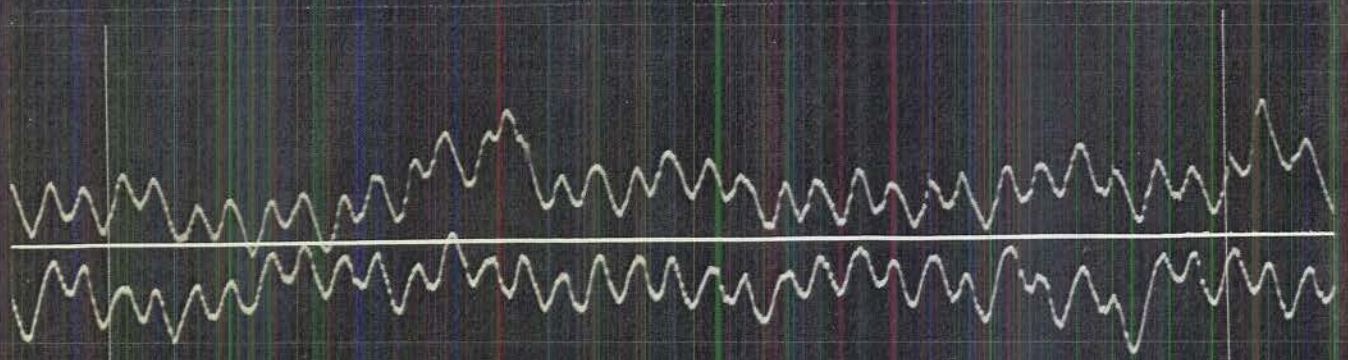
CCW.

360° ROTATION

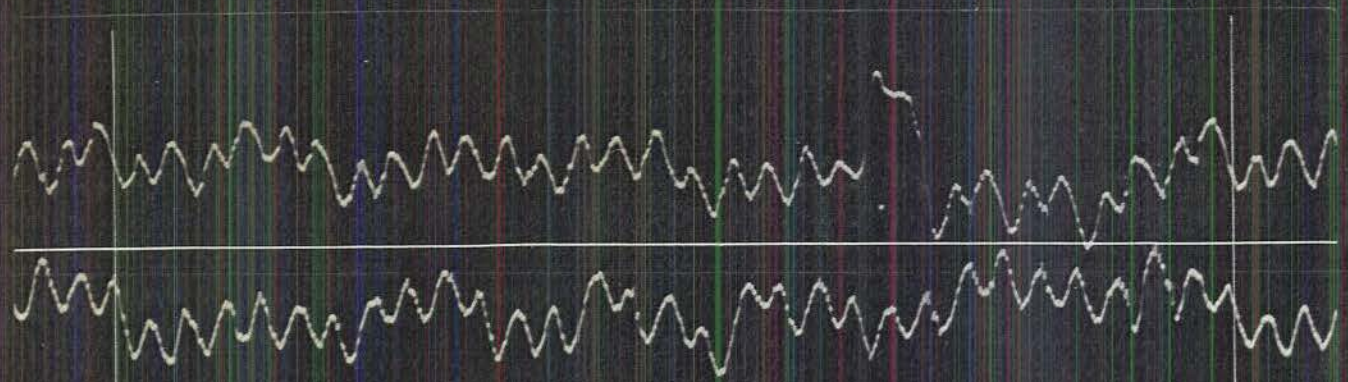
AFTER ENDURANCE NO.3 60~115V.



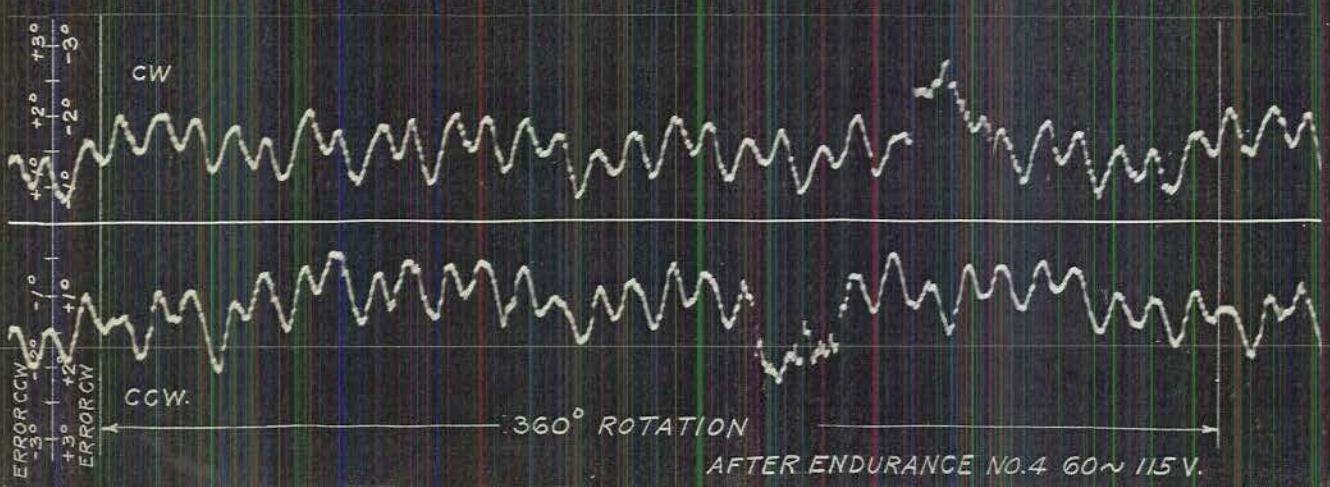
NO.4 55 ~ 126.5V.



NO.4 55 ~ 115V.



NO.4 65 ~ 103.5V.

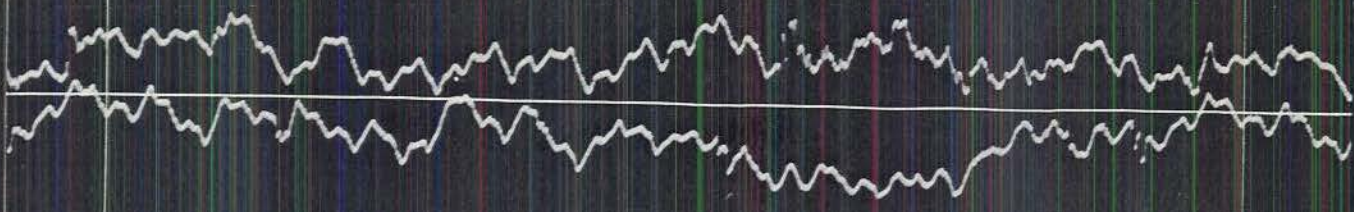


ERROR CW
+3°
+2°
+1°
0°
-1°
-2°
-3°

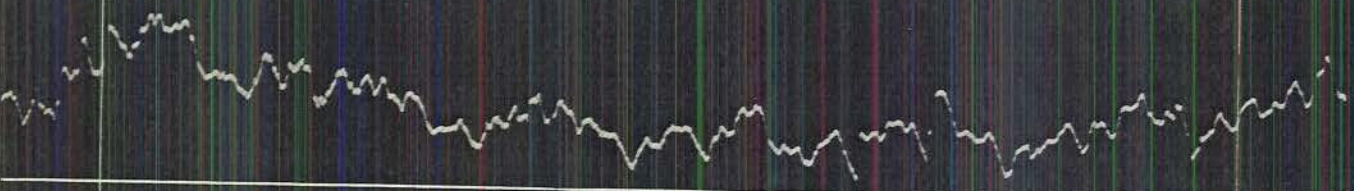
ERROR CCW
+3°
+2°
+1°
0°
-1°
-2°
-3°

360° ROTATION

AFTER ENDURANCE NO.4 60 ~ 115V.



NO.5 55N 126.5 V.



NO.5 60N 115 V.



NO.5 65N 103.5 V.



360° ROTATION
AFTER ENDURANCE NO.5 60N 115 V.



No. 6 55 ~ 126.5 V



No. 6 60 ~ 115 V

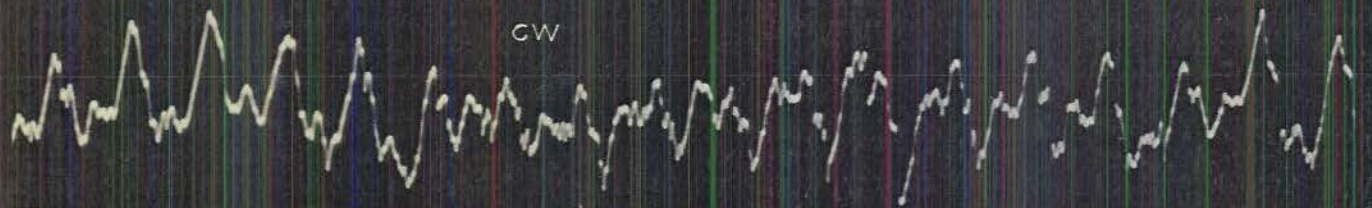


No. 6 65 ~ 103.5 V

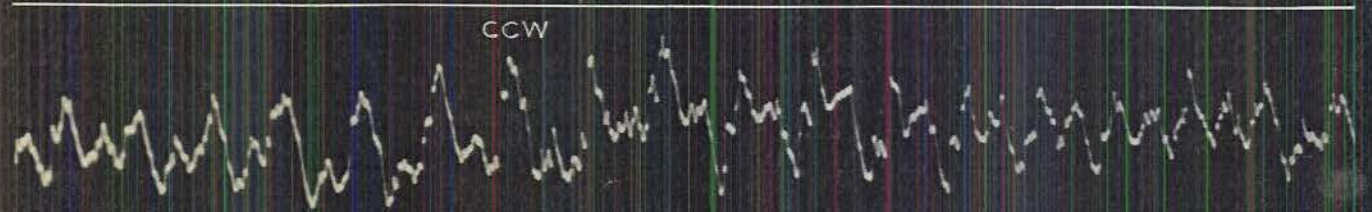


360° ROTATION

AFTER ENDURANCE No. 6 60 ~ 115 V



CW



CCW

NO. 2 & NO. 3 MOTORS

NO. 3 WITH MIRROR