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SUBJECT

Report of Test

on

Potore, Indicator, Navy Type

by

FR-1579

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NAVY RESEARCH REPORT

WALTON, D. C.

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NRL Report No. B-1579

NAVY DEPARTMENT

Report of Test

on

Motors, Indicator, Navy Type "N"

Bendix Aviation Corporation,

Manufacturer and Exhibitor

NAVAL RESEARCH LABORATORY

ANACOSTIA STATION

WASHINGTON, D. C.

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AUTHORIZATION FOR TEST

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

- Reference: (a) BuEng. ltr. S63-1/L5 (4-3-Ds) of 15 April 1939 to NRL.
(b) Specification - SGS (65)-42a of 15 February 1937.
(c) NRL Report B-1497 of 14 December 1938.
(d) Bendix Aviation Corporation Drawing - CAL 4400 of 1 February 1938.
(e) Bendix Aviation Corporation Drawing - CAL 3076 of 1 March 1934.
(f) BuEng. ltr. S63-1/L5 (4-3-Ds) of 15 April 1939 to Bendix Aviation Corporation.

OBJECT OF TEST

2. The object of this test was to determine conformance of the sample indicator-motors with the specifications, reference (b), and their suitability for Naval use in electrical telegraphs and indicating equipment.

ABSTRACT OF TEST

3. The sample indicator-motors were connected to a type "A" transmitter generator and set up at this laboratory in suitable test circuits where their performance was carefully observed for compliance with the requirements. Following a 500-hour endurance test, an inspection of the sample motors was made to determine compliance in the matter of materials, design, and workmanship. Several additional tests were made to determine the practicability of positioning one or two type "N" indicator-motors by one type "N" indicator-motor.

(c) On the basis of this test and the previous test, reference (c), it appears that an initial accuracy of 1% cannot be expected under the voltage and frequency variations given in the specifications. The low torque gradient renders the motor particularly susceptible to bearing troubles, and, if the effect of the endurance test is considered typical, it is doubtful that an accuracy of 1% can be maintained.

(d) The failure of three motors to withstand the distortion test indicates that some changes are necessary in the design.

(e) The motors check with the drawing, reference (d), but it should be noted that in marking the stator and rotor teeth, the manufacturer's notation is the reverse of the usual practice.

Conclusions

(a) The indicator-motors comply with the requirements of the specification, reference (b), as modified by reference (f), except in the following particulars:

- (1) The specification requirements for initial accuracy and accuracy following the endurance test have not been met by the sample type "N" indicator-motors when positioned by the type "A" generator furnished for use in connection with the test. The errors recorded herein are those which remained after the indicator-motor dial had stopped creeping following a change produced by displacing the generator.
- (2) Three of the motors failed under the dielectric test.
- (3) Appreciable burning of the slip rings occurred under the shock and vibration tests.
- (4) The bearings are not of dustproof construction as required by sub-paragraph E-3e.

(b) It is understood that there are service applications where the usual accuracy of $\pm 1^\circ$ is not actually required, and that these indicator-motors are being considered as substitutes for the type "M" indicator-motors in such applications. As this laboratory has had no experience in testing similar size motors of other types or manufacture, there are available no comparable data from which conclusions may be drawn regarding the probable service reliability of these motors as compared with other indicator-motors.

(c) On the basis of this test and the previous test, report reference (c), it appears that an initial accuracy of $\pm 1^\circ$ cannot be expected under the voltage and frequency variations given in the specifications. The low torque gradient renders the motors particularly susceptible to bearing troubles, and, if the effect of the endurance test is considered typical, it is doubtful that an accuracy of $\pm 2^\circ$ can be maintained.

(d) The failure of three motors to withstand the dielectric test indicates that some changes are necessary in the design.

(e) The motors check with the drawing, reference (d), but it should be noted that in marking the stator and rotor terminals, the manufacturer's notation is the reverse of the usual practice.

Recommendations

(a) It is recommended that these type "N" motors be not approved for Naval use, except in the case of specific applications where full compliance with the specification, reference (b), is not necessary.

5. Each type "N" motor is of the commutator type. The terminals S_1 and S_2 are connected to the rotor through brushes and brush contacts on a slip ring, while the other brushes are connected to the end of an insulating extension of the shaft. The brushes are housed in a separate chamber, formed by the cylindrical phenolic top ring insulator.

6. Five brass terminal blocks are secured to radial slots in the insulator. Two brushes are connected directly to terminals S_1 and S_2 . The brushes are flat springs, provided with anti-fused silver contacts. The slip ring and rotor end contact are also of silver. Flexible lead wires extend from the rotor winding to terminals S_1 , S_2 , and S_3 . A cloth-inserted phenolic disc is secured to the insulator and serves as a cover for the contact chamber.

7. The rotor is mounted on separable ball bearings. The rotor base of one bearing has a sliding fit in the removable end-hell and is provided with a forced spring to take up any play and keep the rotor in contact with the balls. The rotor also has a friction-mounted damping disc.

8. The rotor case is of brass and has two principal parts. By removing the end-hell, the rotor may be withdrawn. Photograph, Plate 1, shows two of the samples, one disassembled. Further details are given in the manufacturer's drawing, reference (c).

METHOD OF TEST

9. After the six motors and the generator had been set to electrical zero, the test dials were set to zero and the motors were tested for accuracy. They were connected in a single circuit to the generator and supplied with current from a source that could be maintained at 115 volts - 50 cycles, 107.5 volts - 50 cycles, or 115.5 volts - 50 cycles. The generator was rotated 360 degrees in each direction in 3-degree steps, and the errors for motor individualities were recorded. The test equipment used included 5-inch diameter standard dial equipment with verniers, making possible readings to 1/100th of a degree. The results are given as Table 1, and curves, Plates 2 to 7, inclusive.

10. The torque test was then conducted in the manner prescribed by the specifications. In addition, the maximum torque of each motor was measured. The arrangements were made with only one motor connected to the generator, but all six motors were tested. The results are given as Table 2.

DESCRIPTION OF MATERIAL UNDER TEST

4. Six sample type "N" indicator-motors, manufactured by Bendix Aviation Corporation, were submitted. One type "A" transmitter-generator was also furnished for use in connection with the test. In the remainder of this report they are referred to as motors and generators.

5. Each type "N" motor is of the movable field type. The terminals S_1 and S_2 are connected to the rotor through brushes. One brush contacts a slip ring, while the other presses against a contact in the end of an insulating extension of the shaft. The contacts are housed in a separate chamber, formed by the cylindrical phenolic terminal insulator.

6. Five brass terminal blocks are secured in radial slots in the insulator. Two brushes are connected directly to terminals S_1 and S_2 . The brushes are flat springs, provided with ball-faced silver contacts. The slip ring and rotor end contact are also of silver. Flexible lead wires extend from the stator winding to terminals R_1 , R_2 and R_3 . A cloth-inserted phenolic disc is secured to the insulator and serves 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 removable end-bell and is provided with a formed spring to take up end play and keep the races in contact with the balls. The rotor also has a friction-mounted damping disc.

8. The motor case is of brass and has two principal parts. By removing the end-bell, the rotor may be withdrawn. Photograph, Plate 1, shows two of the samples, one disassembled. Further details are given in the manufacturer's drawing, reference (d).

METHOD OF TEST

9. After the six motors and the generator had been set to electrical zero, the test dials were set to zero and the motors were tested for accuracy. They were connected in a single circuit to the generator and supplied with current from a source that could be maintained at 115 volts - 60 cycles, 103.5 volts - 65 cycles, or 126.5 volts - 55 cycles. The generator was rotated 360 degrees in each direction in 3-degree steps, and the errors in motor indications were recorded. The test equipment used included 6-inch diameter aluminum dials equipped with verniers, making possible readings to 3 minutes. The results are given as Table 1, and curves, Plates 2 to 7, inclusive.

10. The torque test was then conducted in the manner described by the specifications. In addition, the maximum torque of each motor was measured. The measurements were made with only one motor connected to the generator, but all six motors were tested. The results are given as Table 3.

11. The oscillation characteristics of the motors were determined by tests conducted in the manner described by the specifications, using the oscillographic method of timing. During this test, only one motor was connected to the generator at one time in accordance with information received from Bureau of Engineering personnel. The pointer used was a small needle type furnished by the manufacturer but balanced at this laboratory. The results of this test, made with motor shafts horizontal, are given as Table 4.

12. The motors and generator were then placed in a temperature controlled compartment having an ambient temperature of 65 degrees centigrade. The generator was rotated for 500 hours at 100 r.p.m., the direction of rotation being reversed every 24 hours. The temperature rises of the windings, as determined by resistance measurements during this test, are given as Table 5.

13. Following this, the motors were again tested for accuracy by the method previously described. The results of this test are given as Table 2 and curves, Plates 8 and 9. As the motor bearings had considerable friction, causing errors in indications, the motors were disassembled and the bearings cleaned and lubricated with light instrument oil. Following this, a portion of the accuracy test was repeated. The results of this test are given as Table 2A and curves, Plate 10.

14. The power consumption of the generator and motors was then measured with one to six motors in the circuit. The values obtained are given under test results, page 6.

15. At the request of Bureau of Engineering personnel, additional accuracy tests were made using one type "N" motor as a generator to position one and two type "N" motors. The results of these tests are given as Tables 6 and 7, and curves, Plates 11 and 12.

16. Employing the same motors and using one as a generator, torque gradient, maximum torque and oscillation tests were made in the manner previously outlined. The results of the torque gradient and maximum torque test are given as Table 8. The results of the oscillation test are given as Table 9.

17. Next, two of the type "N" motors were provided with the furnished dials and pointers and subjected to the specified shock and vibration tests. One was mounted with shaft perpendicular to bulkhead, the other with shaft parallel to bulkhead.

18. The test was concluded with dielectric strength and insulation resistance tests and an inspection to determine compliance with the requirements of the specification, concerning workmanship, materials, and dimensions. They were also checked against the manufacturer's drawing, reference (d).

RESULTS OF TESTS

19. The following test results were obtained when the sample motors were tested in the manner outlined by the specifications. Data obtained during the tests are given by the appended tables and curves. Table 10 gives a summary of the accuracy tests.

20. A study of the data shows that the initial accuracy of the motors, as recorded, was not in accordance with the 1° tolerance permitted by the specifications. Errors as high as $1^\circ-51'$ were observed. In the cases of three of the motors, however, the total variation in indications was less than 2° , indicating that these motors would have complied with the accuracy requirement had the zero of the dials been shifted to the center of error. Of the remaining three motors, one had a total variation of $2^\circ-9'$ and the others $2^\circ-21'$ and $2^\circ-42'$.

21. With the exception of one motor (No. 5) which showed little change, the motors were less accurate following the endurance tests. Errors as high as $2^\circ 6'$ were recorded. In most cases the errors were negative, indicating a lag behind the proper position due to friction in the bearings. Such errors are not subject to correction by zero shifting.

22. The accuracy of the motors, following this, but after cleaning and lubricating the bearings, was considerably better. The three motors checked, Nos. 2, 3 and 4, showed smaller maximum errors and total variations in indications than before the endurance test. Although the maximum errors ranged from $1^\circ-3'$ to $1^\circ-30'$ in two cases, the total variation in indications was less than 2° , giving the possibility of compliance by zero shifting.

23. The recorded average torque gradient of 0.062 inch-ounces per degree displacement is well above the required minimum of 0.05 established by reference (f). The average maximum torque, 4.65 inch-ounces at about 95° displacement, was also well above the 4.0 minimum specified by reference (b).

24. When a small needle type pointer was used as a load, the oscillation characteristics of the motors were satisfactory. The results are given in Table 4.

25. The type "A" generator developed bearing trouble after 342 hours of the endurance test at 65°C . Table 5 shows that the temperature of the windings exceeded the 35°C . rise permitted by the specifications before the generator was replaced. The replacement generator had a maximum temperature rise of approximately 35°C . and satisfactorily completed the endurance test.

26. The temperature rise and operation of the type "N" motors were satisfactory during the endurance test.

27. After cleaning and lubricating the bearings of the first generator, it was satisfactory for use in the remainder of the tests, although the bearings were still rough.

28. The results of the additional tests requested, where one type "N" motor is used as a generator to drive one or two motors, are given as Tables 6 to 9, inclusive. These tests were made immediately after those covered by paragraph 22. Due to lag from low torque values, nearly all of the errors are negative.

29. Table 6 shows the accuracy of one type "N" motor (No. 2) when positioned by another (No. 4). As the maximum errors, 1° - $45'$ for cw rotation, and 1° - $18'$ for ccw rotation, were negative, they could not be brought to compliance by zero shifting.

30. Table 7 shows that the accuracy of the system is further reduced when a second motor is connected in the circuit as an indicator. The maximum error of the No. 2 motor increased to 2° while the other motor (No. 3) had an error of 3° - $30'$. These errors were also negative.

31. Table 8 gives the torque gradient and maximum torque values obtained when using one type "N" motor as an indicator positioned by one type "N" motor as a generator. Table 9 gives oscillation values obtained under the same conditions.

32. The two type "N" motors subjected to the shock and vibration tests showed no signs of injury except that the slip rings had burned spots due to the lifting of the brushes causing arcing during these tests.

33. The insulation of the motors was satisfactory as measured with a 1000 volt "megger" but three failed under the dielectric test of 1500 volts, alternating potential, applied for one minute between current carrying parts and ground. Two failures were between the rotor winding ($S_1 - S_2$) and ground, and the other between the stator (R_1, R_2, R_3) and ground. The exact points of breakdown were not determined.

34. All motors complied with the dimensional tolerances of the specifications. The weight of one motor is 1 lb., 13 oz.

35. An inspection of the motors disclosed no defects other than those previously covered herein.

36. The following data give the power requirements of the indicator equipment at 115 volts, 60 cycles.

Type "A" transmitter-generator and type "N" indicator-motors.

Equipment	Motors Free to Indicate		One Motor Rotor Locked 180° Out of Position	
	Amperes	Watts	Amperes	Watts
1 Gen. and 6 motors	1.15	30.0	1.18	75.0
1 Gen. and 5 motors	1.01	27.0	1.09	71.0
1 Gen. and 4 motors	.92	23.0	.99	68.0
1 Gen. and 3 motors	.81	19.0	.90	66.0
1 Gen. and 2 motors	.69	16.0	.81	63.0
1 Gen. and 1 motor	.59	12.5	.72	60.0
1 Gen. alone	.48	9.0	--	--
3 Type "N" motors (1 as transmitter)	.35	12.2	.40	31.0
2 Type "N" motors (1 as transmitter)	.22	7.5	.28	30.0

(d) The bearings are not of standard configuration as required by sub-paragraph 2-3a.

38. It is understood that these are service applications where the usual accuracy of 2% is not actually required and that the indicator-motors are being considered as substitutes for the use of indicator-motors in such applications. In this laboratory work and experience in testing similar wire rotors of other types of rotors, there are available no comparable data from which confidence can be drawn regarding the probable service reliability of these rotors or compared with other indicator-motors.

39. On the basis of test work and the previous test report, reference (a), it appears that an initial accuracy of 2% cannot be expected under the voltage and frequency variations given in the specifications. The low torque gradient renders the motor particularly susceptible to bearing friction. If the effect of the bearings and is considered typical, it is doubtful that an accuracy of 2% can be maintained.

40. The failure of these rotors to withstand the above test conditions indicates that some changes are required in the design.

41. The rotors check with the drawing, reference (a), but it should be noted that in securing the rotor and rotor terminals, the manufacturer's solution is the cause of the usual problem.

CONCLUSIONS

37. The indicator-motors comply with the requirements of the specification, reference (b), as modified by reference (f), except in the following particulars:

- (a) The specification requirements for initial accuracy and accuracy following the endurance test have not been met by the sample type "N" indicator-motors when positioned by the type "A" generator furnished for use in connection with the test. The errors recorded herein are those which remained after the indicator motor dial had stopped creeping following a change produced by displacing the generator.
- (b) Three of the motors failed under the dielectric test.
- (c) Appreciable burning of the slip rings occurred under the shock and vibration tests.
- (d) The bearings are not of dustproof construction as required by sub-paragraph E-3e.

38. It is understood that there are service applications where the usual accuracy of $\pm 1^\circ$ is not actually required and that these indicator-motors are being considered as substitutes for the type "M" indicator-motors in such applications. As this laboratory has had no experience in testing similar size motors of other types or manufacture, there are available no comparable data from which conclusions may be drawn regarding the probable service reliability of these motors as compared with other indicator-motors.

39. On the basis of this test and the previous test, report, reference (c), it appears that an initial accuracy of $\pm 1^\circ$ cannot be expected under the voltage and frequency variations given in the specifications. The low torque gradient renders the motors particularly susceptible to bearing troubles and, if the effect of the endurance test is considered typical, it is doubtful that an accuracy of $\pm 2^\circ$ can be maintained.

40. The failure of three motors to withstand the dielectric test indicates that some changes are necessary in the design.

41. The motors check with the drawing, reference (d), but it should be noted that in marking the stator and rotor terminals, the manufacturer's notation is the reverse of the usual practice.

TABLE 1

Results of Accuracy Tests before Endurance

Errors in Minutes

Type "A" transmitter-generator connected to 6 type "N" indicator motors. Motors and generator set to electrical zero before test. Errors marked (+) lead the direction of rotation, those marked (-) lag. Thus a (+) error in the cw direction indicates the same geometrical position as a corresponding (-) error in the ccw direction.

Generator Setting in Degrees	Motor No. 1						Motor No. 2					
	115Volts		103.5Volts		126.5Volts		115Volts		103.5Volts		126.5Volts	
	60Cycles		65Cycles		55 Cycles		60Cycles		65 Cycles		55 Cycles	
	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw
3	+18	-48	+30	-48	+21	-30	+27	-60	+30	-75	+30	-51
6	+12	-45	+24	-48	+12	-27	+21	-60	+27	-72	+15	-39
9	+15	-45	+30	-57	+15	-30	+21	-54	+30	-75	+9	-42
12	+12	-30	+12	-42	+9	-24	+24	-69	+48	-78	+27	-51
15	0	-24	+3	-33	+6	-21	+24	-66	+30	-84	+39	-63
18	+15	-45	+15	-51	+15	-30	+30	-69	+21	-72	+30	-51
21	+18	-42	+18	-45	+15	-30	+12	-51	+18	-60	+12	-42
24	+12	-30	+9	-30	+9	-27	+15	-48	+24	-69	+9	-45
27	-6	-30	+12	-24	+6	-21	+27	-51	+3	-63	+18	-39
30	-3	-21	0	-24	-3	-15	0	-45	-3	-45	+3	-21
33	-3	-21	+3	-18	-3	-15	-6	-39	0	-30	-9	-9
36	-9	-9	-9	-12	-12	-3	-9	-24	+6	-51	-9	-18
39	-27	+6	-30	+3	-21	+6	+15	-24	-3	-60	+15	-30
42	-12	-3	-15	-12	-12	-3	+3	-39	-6	-42	0	-21
45	-15	-9	-12	-12	-9	0	-6	-42	+3	-39	-3	-18
48	-9	-12	-15	-12	-6	-9	+6	-33	+18	-48	+12	-24
51	-3	-12	-12	-9	-6	-12	+24	-51	+15	-60	+27	-45
54	-15	-9	-15	-9	-9	-12	+12	-48	+6	-54	+21	-45
57	+3	-15	-3	-21	+3	-12	+6	-42	+15	-48	+3	-39
60	-9	-9	-12	-9	-9	-3	+12	-30	+27	-51	+15	-30
63	-18	+3	-18	-6	-30	-3	+27	-48	+15	-69	+18	-48
66	-6	-12	-6	-33	-9	+6	+12	-51	+15	-66	+15	-45
69	+6	-24	+9	-30	+9	-3	+6	-42	+27	-51	+6	-36
72	+9	-30	+9	-30	+9	-15	+12	-39	+30	-60	+9	-30
75	+9	-21	+3	-30	+12	-21	+30	-60	+30	-78	+30	-45
78	-15	-12	0	-21	0	-18	+30	-57	+15	-75	+30	-51
81	+15	-21	-3	-21	+3	-12	+24	-60	+30	-60	+21	-51
84	+15	-9	-9	-15	-9	-15	+21	-21	+30	-56	+18	-45
87	-24	-12	-12	-18	-9	-3	+24	-18	+12	-60	+27	-48
90	-6	-24	+9	-30	+6	-3	+12	-48	-3	-48	+12	-45
93	+3	-27	+6	-30	+12	-21	+3	-30	+36	-45	+3	-21
96	-6	-15	-3	-21	+3	-18	0	-36	+3	-30	-6	-24
99	-3	-21	+3	-21	+3	-12	+3	-30	+9	-45	+9	-21
102	-9	-9	-9	-30	-30	-12	+6	-30	+3	-39	+3	-36
105	0	-54	-9	-30	+9	0	-6	-30	-9	-30	0	-30

TABLE 1 (CONTINUED)

Results of Accuracy Tests before Endurance

Errors in Minutes

Generator Setting in Degrees	Motor No. 1						Motor No. 2					
	115Volts		103.5Volts		126.5Volts		115Volts		103.5Volts		126.5Volts	
	60Cycles		65 Cycles		55 Cycles		60Cycles		65 Cycles		55 Cycles	
	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw
108	- 6	-18	-12	-42	* 3	-30	- 6	-24	- 6	-21	0	-15
111	- 6	-18	- 3	-30	+ 3	-12	*21	-24	0	-39	*12	-36
114	*12	-39	*15	-51	*15	-15	* 3	-45	* 3	-39	* 9	-42
117	*18	-45	*21	-54	+18	-30	*12	-39	0	-30	* 6	-27
120	*12	-42	*24	-51	*15	-30	*21	-42	* 3	-56	*12	-45
123	+21	-45	*24	-54	+21	-30	*30	-57	*30	-63	+36	-63
126	*21	-51	+30	-60	*21	-45	*32	-63	*30	-66	+30	-54
129	*30	-54	*48	-63	*27	-42	*33	-60	*30	-69	*30	-48
132	*24	-48	*33	-54	*21	-54	*24	-60	*18	-66	+24	-48
135	+21	-48	*30	-63	*21	-42	*45	-69	+51	-84	+45	-75
138	*30	-60	+42	-72	*42	-45	+45	-75	+36	-81	*45	-60
141	+30	-63	+48	-66	*30	-60	+33	-60	+30	-72	+42	-60
144	*21	-60	*36	-66	*30	-51	+45	-60	+51	-72	+48	-63
147	*18	-57	+42	-63	+24	-51	+45	-69	*30	-69	*45	-69
150	*30	-54	*39	-63	+24	-51	+30	-60	+24	-72	+33	-51
153	+30	-57	+42	-69	*45	-54	+15	-57	*12	-51	*12	-30
156	*15	-48	*33	-48	+18	-45	+12	-45	*12	-45	*15	-30
159	+18	-45	+18	-54	*12	-42	*30	-45	*24	-60	+24	-51
162	+21	-51	+30	-57	+21	-42	+26	-51	*21	-51	*24	-42
165	*15	-45	+18	-51	*15	-39	*18	-36	+ 6	-51	* 9	-39
168	*15	-42	*18	-51	+15	-39	+51	-64	*27	-81	*45	-69
171	+15	-48	*24	-57	*27	-48	*48	-78	*42	-78	*42	-66
174	+30	-57	+27	-60	+24	-60	*39	-69	*36	-69	*42	-63
177	+45	-72	0	-75	*51	-66	*24	-60	+18	-60	+18	-36
180	+30	-57	*45	-72	+30	-54	*15	-42	+15	-45	+12	-27
183	*24	-57	+39	-75	+24	-51	+27	-45	*21	-63	*30	-45
186	*27	-54	*42	-75	+30	-54	+18	-51	+12	-60	+12	-42
189	*24	-60	*48	-18	*21	-51	+21	-45	+21	-60	+12	-39
192	+24	-57	+39	-75	*24	-54	*45	-69	*48	-78	*30	-63
195	+27	-54	*42	-69	+45	-51	+45	-60	*42	-75	+45	-60
198	*27	-60	+45	-63	+30	-51	+33	-51	+51	-51	*30	-51
201	*48	-63	+54	-69	*48	-60	+ 9	-45	+ 3	-48	* 3	-27
204	+33	-45	+30	-48	*30	-30	0	-24	0	-30	* 3	-21
207	* 9	-30	+12	-42	+12	-18	* 6	-39	- 6	-30	*12	-27
210	*12	-39	*18	-48	* 9	-15	- 9	- 9	-12	-18	-12	-15

TABLE 1 (CONTINUED)

Results of Accuracy Tests before Endurance

Errors in Minutes

Generator Setting in Degrees	Motor No. 1						Motor No. 2					
	115Volts		103.5Volts		126.5Volts		115Volts		103.5Volts		126.5Volts	
	60Cycles		65Cycles		55 Cycles		60Cycles		65 Cycles		55 Cycles	
	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw
213	+12	-36	+21	-42	+12	-15	-15	- 9	+30	-12	-18	- 6
216	+ 6	-15	+15	-30	+ 3	- 9	+ 6	-21	+30	-33	0	-18
219	+ 6	-27	+15	-39	+ 9	-15	+ 6	-30	+ 9	-48	+ 9	-27
222	+15	-21	+ 9	-30	+ 3	-15	+ 3	-18	-15	-30	+12	-21
225	+12	-27	+15	-30	+ 9	-21	- 6	-15	-15	-21	- 3	-12
228	+ 6	-15	+12	-36	0	-12	- 6	-18	-15	-18	+ 3	-12
231	- 9	- 9	- 6	-18	0	+ 3	+ 9	-48	- 6	-42	+15	-45
234	- 6	-15	+ 6	-27	- 3	- 9	+ 6	-36	- 6	-30	+ 9	-33
237	+ 3	-18	+ 9	-27	+ 6	-15	+ 3	-33	0	-30	+ 6	-33
240	0	-15	+ 9	-33	+ 3	- 9	+ 9	-48	+ 6	-60	+ 9	-45
243	+ 3	-21	+12	-30	+ 3	-15	+30	-57	- 6	-60	+30	-51
246	+ 9	-30	+18	-30	- 6	-18	+15	-45	+ 9	-45	+15	-30
249	+24	-54	+42	-51	+15	-30	+ 3	-36	+ 6	-51	+ 6	-24
252	+ 9	-27	+18	-51	+ 6	-21	+ 6	-30	- 6	-45	- 6	-12
255	- 9	-18	+ 6	-30	+ 3	-12	+15	-56	+12	-60	+24	-45
258	+ 6	-18	+15	-30	+ 6	-12	+21	-51	+15	-60	+24	-48
261	- 3	-15	+ 9	-27	0	-12	+18	-42	+ 9	-45	+18	-36
264	0	-18	+ 9	-30	0	- 9	+30	-60	+24	-60	+42	-60
267	+ 6	-30	+18	-30	+ 9	-33	+26	-54	+27	-60	+42	-51
270	+15	-30	+18	-30	+12	-33	+12	-45	+ 9	-30	+15	-21
273	+21	-30	+21	-45	+15	-27	- 6	-27	0	-39	0	-21
276	+ 3	- 9	+ 6	-21	- 3	- 9	- 9	-15	-15	-33	- 6	-12
279	-15	- 6	-30	- 6	- 9	- 6	0	-30	-15	-30	+ 3	-21
282	-12	-27	- 6	-21	- 9	- 6	+ 3	-17	-15	-30	0	-18
285	- 6	-15	- 3	-21	- 9	- 9	- 3	-18	-15	-21	- 3	-12
288	0	-15	+ 6	-21	0	-15	+ 6	-39	- 9	-42	+ 9	-33
291	+ 9	-24	+12	-39	+12	-33	+24	-45	+ 9	-48	+21	-30
294	+ 6	-30	+ 9	-45	+ 9	-39	+ 6	-39	- 9	-51	+ 9	-30
297	+18	-45	+21	-48	+18	-39	+ 3	-30	+ 3	-48	+ 3	-12
300	+12	-30	+ 9	-30	+ 6	-33	+ 3	-30	- 6	-45	0	-18
303	- 6	-33	+ 3	-30	- 3	-15	+18	-60	+15	-72	+26	-51
306	+12	-42	+21	-51	+ 6	-33	+24	-63	+21	-69	+26	-51
309	+12	-45	+21	-54	+ 9	-33	+21	-60	+21	-72	+18	-42
312	+15	-45	+24	-60	+15	-42	+45	-75	+30	-84	+39	-63
315	+21	-48	+30	-60	+21	-48	+51	-75	+45	-84	+48	-63
318	+24	-51	+26	-60	+21	-48	+42	-69	+30	-81	+39	-51
321	+30	-54	+30	-63	+30	-51	+27	-60	+21	-75	+39	-51
324	+12	-42	+18	-48	+15	-39	+24	-60	+24	0	+33	-45
327	+ 3	-24	+ 3	-45	+ 6	-33	+30	-63	+21	-66	+39	-39
330	+12	-45	+12	-39	+15	-36	+21	-56	+12	-63	+21	-42

Results of Accuracy Tests before Endurance

[illegible]

TABLE 1 (CONTINUED)

Results of Accuracy Tests before Endurance

Errors in Minutes

Type "A" transmitter-generator connected to 6 type "N" indicator motors. Motors and generator set to electrical zero before test. Errors marked (*) lead the direction of rotation, those marked (-) lag. Thus a (*) error in the cw direction indicates the same geometrical position as a corresponding (-) error in the ccw direction.

Generator Setting in Degrees	Motor No. 3						Motor No. 4					
	115Volts		103.5Volts		126.5Volts		115Volts		103.5Volts		126.5Volts	
	60Cycles		65 Cycles		55 Cycles		60Cycles		65 Cycles		55 Cycles	
	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw
3	* 3	-54	*12	-54	* 3	-45	* 3	- 6	- 9	-15	-12	- 3
6	+24	-69	+24	-21	+21	-60	-15	-15	-12	-30	-18	- 3
9	*24	-69	*27	-69	*15	-60	-18	-30	* 9	-42	- 3	-15
12	*18	-54	+21	-57	*12	-48	- 3	- 9	- 9	-21	-12	- 3
15	+12	-57	+12	-60	*12	-51	-15	-15	-15	-24	-12	- 3
18	+12	-51	*12	-57	*12	-39	-21	-12	-15	-18	-42	0
21	+15	-60	+12	-63	+ 9	-48	-18	-27	-15	-30	- 9	- 6
24	* 9	-54	+12	-54	*12	-48	-18	- 9	-18	-15	-12	- 3
27	+ 3	-51	* 6	-54	*12	-48	- 6	-12	-15	-21	- 9	- 9
30	*21	-66	*27	-72	+24	-51	-30	- 9	-30	-15	-30	* 6
33	+21	-60	*24	-63	*18	-51	-30	-15	-12	-21	-39	- 6
36	+ 3	-30	* 3	-45	* 3	-30	-30	* 6	-30	- 3	-27	+12
39	- 9	-27	-15	-36	+24	-21	-57	+ 9	-48	* 3	-45	*12
42	-15	-21	-15	-39	-12	-12	-66	- 9	-42	0	-39	+18
45	-15	-21	-18	-18	-15	-12	-66	* 6	-45	- 3	-42	*12
48	-15	-21	- 9	-24	- 6	-18	-72	- 6	-36	- 6	-18	0
51	-15	-18	-12	-24	- 3	-21	-51	* 6	-48	- 3	-27	+12
54	+ 9	-51	- 6	-51	*12	-45	-54	* 3	-36	- 3	-24	+ 9
57	*12	-51	*15	-54	*21	-48	-45	-15	- 6	-24	-15	- 6
60	0	-30	+ 3	-39	+ 9	-30	-48	- 6	-15	-21	-21	* 3
63	- 6	-39	0	-30	+ 3	-30	-57	-12	-15	-21	-21	0
66	- 9	-24	- 9	-24	+ 3	-15	-57	-21	- 9	-21	-21	0
69	-12	-33	-12	-24	- 9	- 6	-15	-12	-15	-30	-30	0
72	- 6	-30	- 9	-30	- 3	-21	-51	-15	- 9	-21	-18	- 6
75	- 9	-30	- 9	-30	0	-24	-66	-12	-36	-15	-12	* 3
78	+18	-56	+12	-60	+27	-54	-66	-18	-30	-21	-12	- 9
81	*21	-54	*15	-54	+24	-51	-51	-30	- 9	-30	- 6	-18
84	* 9	-39	0	-45	*12	-39	-66	-21	-15	-33	- 9	-12
87	0	-30	- 9	-39	* 6	-30	-90	-21	-15	-30	- 6	- 9
90	- 9	-12	-18	-15	- 9	- 9	-93	-15	-18	-24	-12	- 6
93	-12	-15	-27	-15	-18	- 3	-72	-18	-21	-21	-15	0
96	-15	-15	-18	- 3	-21	+ 3	-66	-12	-27	-15	-21	+ 6
99	-30	-24	-30	- 9	-12	0	-69	+ 3	-48	-12	-39	+ 9
102	-12	-24	-15	-33	0	-27	-90	- 9	-51	- 9	-36	+ 9
105	0	-30	0	-45	+ 3	-30	- 9	-24	-33	- 6	-12	- 6

TABLE 1 (CONTINUED)

Results of Accuracy Tests before Endurance

Errors in Minutes

Generator Setting in Degrees	Motor No. 3						Motor No. 4					
	115Volts		103.5Volts		126.5Volts		115Volts		103.5Volts		126.5Volts	
	60Cycles		65 Cycles		55 Cycles		60Cycles		65 Cycles		55 Cycles	
	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw
108	- 6	-30	-12	-27	+ 3	-24	- 9	-18	-21	-15	- 9	-12
111	- 6	-30	- 9	-39	+ 6	-30	- 6	-27	-21	-24	- 6	-15
114	- 9	-24	- 9	-39	- 6	-15	- 9	-30	-39	-30	- 9	- 9
117	- 6	-24	- 9	-72	- 3	-21	-12	-21	-18	-27	-12	- 9
120	- 6	-24	-12	-75	- 9	-21	- 9	-21	-15	-24	-12	- 6
123	-12	-27	-12	-72	- 9	-21	-30	-12	-30	-21	-30	- 3
126	+12	-54	+ 9	-96	+12	-51	-30	-24	-18	-18	-39	- 9
129	+21	-57	+21	-90	+18	-54	0	-51	0	-57	- 3	-30
132	+18	-66	+12	-84	+18	-60	0	-39	- 9	-48	- 6	-33
135	+24	-75	+12	-84	+21	-60	+ 3	-51	- 9	-60	- 6	-45
138	+21	-69	+ 9	-69	+21	-54	+ 6	-48	0	-51	+ 6	-42
141	+18	-60	+ 3	-66	+15	-54	0	-48	0	-51	- 6	-30
144	+15	-48	0	-54	+15	-48	-45	-30	+ 6	-51	+ 6	-27
147	+ 9	-30	0	-42	+ 6	-39	-21	-12	-30	-21	- 9	- 9
150	+18	-54	+ 9	-54	+12	-48	-15	-21	- 9	-39	-12	-18
153	+12	-51	+12	-54	+12	-45	-18	-27	- 3	-45	- 3	-21
156	+12	-42	+ 9	-45	+ 3	-30	-45	-21	-12	-36	-12	-12
159	+ 3	-45	+ 3	-51	+ 6	-42	-15	-21	-18	-42	-12	-21
162	+ 3	-30	- 3	-42	0	-30	- 9	-21	-15	-39	-12	-18
165	0	-48	0	-54	+ 6	-48	-12	-21	-15	-39	- 9	-21
168	+12	-42	+ 6	-51	+12	-48	- 6	-27	- 9	-42	+ 3	-27
171	+ 3	-39	- 6	-42	0	-36	-15	-21	-21	-33	-15	-18
174	+12	-54	+ 9	-54	+12	-51	-21	-24	-18	-39	-12	-21
177	+15	-51	+15	-54	+15	-45	+ 6	-54	0	-54	+ 6	-30
180	+ 6	-45	+ 3	-54	+ 6	-45	- 6	-30	0	-30	- 3	-18
183	+12	-54	+12	-51	+12	-51	-12	-30	-30	-69	- 6	-21
186	+12	-54	+ 9	-54	+12	-48	- 6	-24	-12	-24	- 6	-15
189	+24	-60	+30	-63	+21	-60	+ 6	-57	+12	-60	+ 6	-42
192	+24	-57	+18	-60	+18	-51	+ 6	-51	+12	-60	- 6	-42
195	+ 6	-45	+ 9	-48	+ 3	-39	0	-45	- 3	-51	- 9	-33
198	+24	-87	+15	-57	+15	-51	- 3	-42	- 3	-60	- 6	-36
201	+15	-81	+15	-60	+12	-48	+ 9	-48	+12	-60	+ 6	-48
204	+ 6	-75	+ 6	-51	+ 6	-45	- 9	-30	- 9	-42	- 9	-18
207	+ 9	-84	+ 9	-60	+18	-54	-30	-24	- 6	-30	-12	-15
210	+15	-72	+ 9	-57	+18	-48	-30	-18	-12	-30	-15	-12
213	+12	-60	+12	-60	+15	-51	-30	-21	- 9	-30	-12	-12
216	+12	-51	+12	-51	+12	-42	0	-24	- 6	-30	-12	- 9
219	- 9	-39	- 9	-30	- 6	-21	-30	-24	-15	-15	-12	- 6
222	- 6	-30	0	-45	0	-30	-30	-15	-15	-33	-15	- 3
225	- 6	-30	+ 3	-30	- 6	-21	- 9	-21	- 9	-30	- 3	-15

TABLE 1 (CONTINUED)

Results of Accuracy Tests before Endurance

Errors in Minutes

Generator Setting in Degrees	Motor No. 3						Motor No. 4					
	115Volts		103.5Volts		126.5Volts		115Volts		103.5Volts		126.5Volts	
	60Cycles		65 Cycles		55 Cycles		60Cycles		65 Cycles		55 Cycles	
	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw
228	-15	-18	- 6	-18	- 9	-15	-30	- 9	-18	-12	-15	- 6
231	- 3	-42	-12	-51	* 6	-45	-30	-18	-21	-18	-15	- 6
234	- 3	-45	* 9	-54	*12	-39	- 9	- 9	-18	-18	-12	- 9
237	*12	-30	* 3	-60	*15	-51	- 9	-30	-12	-42	* 3	-18
240	+15	-48	*15	-51	*12	-48	* 6	-30	+ 3	-48	* 6	-30
243	* 3	-21	* 9	-18	- 6	-18	- 6	-27	- 3	-45	0	-18
246	+ 3	-48	*27	-51	* 9	-39	- 6	-27	- 3	-51	- 6	-18
249	+ 3	-45	+ 9	-45	* 3	-27	* 3	-30	0	-51	+ 6	-21
252	- 6	-30	0	-30	-12	- 6	-12	-15	- 6	-30	- 9	- 9
255	*12	-51	0	-69	*12	-54	-15	-18	-15	-27	-12	-12
258	+18	-60	+24	-63	+21	-51	- 6	-24	- 9	-39	- 6	-12
261	+27	-69	*12	-69	*24	-60	* 3	-45	0	-54	- 9	-30
264	*21	-54	+27	-51	*30	-54	* 9	-45	+12	-51	-24	-51
267	* 3	-45	+ 9	-45	0	-30	+ 6	-42	+ 6	-39	+ 6	-24
270	+ 6	-45	+ 6	-45	+ 9	-27	- 6	-45	- 9	-51	0	-18
273	+ 3	-24	0	-39	0	-21	* 3	-27	+ 3	-30	+ 6	-18
276	-15	-12	- 6	-12	-15	- 9	-12	- 9	-15	-12	+48	* 3
279	-15	-18	-30	-36	-12	-15	-24	- 6	-30	- 9	+24	+ 9
282	- 6	-27	-15	-36	0	-24	-24	- 6	-30	-15	-30	+ 3
285	* 3	-27	- 6	-45	0	-30	- 9	-30	- 9	-39	- 9	-12
288	* 9	-48	+ 9	-45	+12	-45	+ 9	-48	0	-45	-18	-30
291	- 3	-39	- 6	-30	0	-24	0	-27	- 6	-45	+ 6	-18
294	+ 9	-12	+ 9	-51	+12	-45	- 6	-39	0	-42	0	-21
297	* 9	-35	+ 6	-45	*12	-30	* 9	-30	+ 9	-48	+ 9	-24
300	- 6	-30	- 3	-27	- 3	-18	-12	-12	-12	-15	-12	0
303	* 3	-111	* 3	-48	* 3	-39	-21	-12	-18	-18	-18	0
306	+12	-54	*12	-60	* 6	-45	-15	-15	-12	-18	-12	- 6
309	*24	-69	+30	-69	+24	-57	+ 6	-48	* 9	-54	0	-18
312	+30	-66	+24	-66	+24	-54	+15	-51	+51	-66	+30	-51
315	+18	-63	+15	-63	+21	*51	+ 9	-45	+12	-48	+ 9	-24
318	+30	-81	*30	-81	+30	-69	* 6	-51	+12	-51	+ 9	-27
321	*30	-69	+30	-72	+30	-60	+15	-48	+18	-45	+12	-24
324	*15	-54	+12	-72	+15	-48	- 6	-15	- 3	-18	- 6	- 6
327	*18	-54	+ 9	-54	*12	-45	-15	-12	-15	-12	-15	0
330	+15	-51	+ 3	-54	+ 9	-42	-15	-12	-18	-21	-15	0
333	+18	-57	+15	-51	*15	-48	- 9	-33	- 9	-27	- 6	-12
336	*15	-54	+12	-60	+ 9	-51	+ 9	-30	* 9	-42	+ 9	-21
339	0	-48	- 3	-54	+ 3	-24	-12	-12	-18	-18	-12	0
342	+15	-54	+12	-51	+ 9	- 9	-30	0	-42	-15	- 9	- 6
345	+15	-51	*12	-66	+15	-48	- 6	-21	- 3	-18	- 3	-12
348	* 9	-48	* 9	-60	* 9	-42	-15	- 6	-30	- 3	-15	0
351	* 3	-48	+ 3	-48	+ 6	-45	-30	0	-39	0	-30	+ 6
354	+ 6	-48	0	-51	* 3	-42	-30	- 6	-33	- 6	-30	* 3
357	* 6	-66	+12	-60	+12	-45	-12	-12	- 9	-18	- 6	- 9
360	+12	-51	+12	-54	+ 9	-45	- 3	-30	0	-30	- 9	-18

TABLE 1 (CONTINUED)

Results of Accuracy Tests before Endurance

Errors in Minutes

Type "A" transmitter-generator connected to 6 type "N" indicator motors. Motors and generator set to electrical zero before test. Errors marked (+) lead the direction of rotation, those marked (-) lag. Thus a (+) error in the cw direction indicates the same geometrical position as a corresponding (-) error in the ccw direction.

Generator Setting in Degrees	Motor No. 5						Motor No. 6					
	115Volts		103.5Volts		126.5Volts		115Volts		103.5Volts		126.5Volts	
	60Cycles		65 Cycles		55 Cycles		60Cycles		65 Cycles		55 Cycles	
	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw
3	+30	-48	+30	-54	+39	-42	0	-12	+12	-39	-6	-12
6	+24	-42	+27	-54	+21	-27	-3	-12	-3	-21	-6	-3
9	+15	-30	+21	-51	+12	-21	+3	-21	0	-33	0	-15
12	+21	-30	+18	-51	+12	-24	-6	-12	+12	-30	-6	-6
15	+18	-45	+21	-51	+21	-30	-9	-15	0	-21	0	-12
18	+12	-27	+12	-45	+9	-18	0	-24	-3	-30	+12	-21
21	+3	-24	+6	-39	0	-12	+27	-51	+9	-42	+30	-51
24	+12	-27	+15	-30	+12	-21	+9	-24	+27	-54	+15	-24
27	+21	-30	+21	-45	+21	-36	-15	-3	+6	-30	-6	0
30	+12	-27	+12	-45	+12	-21	-24	-3	-9	-9	-9	+6
33	+3	-18	+6	-30	+3	-9	-15	-3	-15	-9	-12	+3
36	+3	-18	+3	-24	0	-12	-27	+15	-12	-9	-36	+15
39	+6	-21	+6	-24	+9	-21	-39	+15	-27	-6	-24	-39
42	-6	-9	-6	-24	0	+3	-12	-30	-39	+3	-9	0
45	-15	+3	-12	-15	-12	+6	+6	-21	-15	-9	+12	-21
48	-9	-9	-6	-3	+3	-3	-3	-9	0	-27	+3	-12
51	+3	-15	-3	-12	+9	-18	-21	+9	-9	-12	-15	+9
54	+3	-15	0	-18	+6	-12	-30	+12	-33	+6	-24	+15
57	0	-12	+3	-15	0	-12	-27	+6	+21	+9	-21	-9
60	+6	-21	+9	-27	+9	-15	-30	+9	-30	-3	-24	-12
63	+12	-27	+15	-30	+21	-27	-30	+3	-24	0	-21	+9
66	+3	-21	+6	-24	+6	-15	-6	-9	-18	-6	-6	-3
69	-3	-12	+3	-18	-3	-3	+12	-39	-9	-30	+15	-24
72	+3	-18	0	-24	+9	-12	+9	-21	+18	-51	+15	-15
75	+9	-24	+12	-24	+18	-21	-9	-3	+9	-30	-9	0
78	+6	-21	+6	-24	+9	-18	-15	0	-9	-12	-9	0
81	+3	-15	+3	-21	+6	-12	-9	-9	-12	-9	-9	-3
84	+9	-21	+3	-21	+12	-18	-30	+3	-6	-12	-15	+6
87	+15	-30	+12	-30	+21	-30	-12	+3	-27	-3	-15	0
90	+3	-18	+3	-21	+9	-12	-6	-9	-27	-6	-6	+6
93	-9	-9	-9	-9	-6	0	+15	-21	-15	-12	+9	-27
96	-12	-3	-12	-9	-6	-3	-3	-12	+3	-30	0	-6
99	-6	-12	-6	-15	+3	-12	-51	+6	-6	-12	-15	+6
102	-9	-6	-12	-6	0	-6	-30	+6	-24	+3	-21	+9
105	-6	-6	-12	-6	-6	-6	-9	0	-42	+6	-9	0
108	-3	-12	-9	-15	+3	-12	-30	+9	-30	0	-15	+9
111	+12	-27	0	+30	+15	-27	-30	+6	-30	-6	-30	-6

TABLE 1 (CONTINUED)

Results of Accuracy Tests before Endurance

Errors in Minutes

Generator Setting in Degrees	Motor No. 5						Motor No. 6					
	115Volts		103.5Volts		126.5Volts		115Volts		103.5Volts		126.5Volts	
	60Cycles		65 Cycles		55 Cycles		60Cycles		65 Cycles		55 Cycles	
	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw
114	+ 6	-21	- 6	+24	+ 9	-21	- 9	0	-39	+ 6	- 9	0
117	+ 3	-15	- 6	-36	+ 3	-12	- 3	-21	-30	- 9	+ 6	-18
120	+ 6	-27	+ 3	-30	0	-18	+ 3	-15	- 6	-24	+ 6	-12
123	+12	-27	+ 3	-39	+ 9	-21	- 9	- 6	- 9	-24	- 9	- 3
126	+ 3	-24	+ 3	-39	+ 6	-15	- 6	-12	-47	-15	-12	- 6
129	+ 3	-24	+ 6	-48	+ 3	-15	- 3	-24	-45	-18	- 6	- 6
132	+12	-30	+ 9	-60	+12	-24	-15	-12	-48	-24	-12	0
135	+30	-60	+27	-57	+30	-51	-18	-42	-51	-18	-12	-12
138	+42	-51	+24	-54	+27	-48	- 6	-54	-30	-42	0	-21
141	+39	-48	+18	-60	+21	-42	+15	-78	- 3	-54	+15	-51
144	+42	-51	+21	-54	+27	-54	+12	-63	+ 3	-69	+15	-45
147	+39	-51	+24	-30	+30	-51	+ 6	-54	- 6	0	+ 6	-15
150	+12	-30	+12	-30	+12	-36	+ 6	-48	+ 3	-51	+ 6	-15
153	+ 6	-24	+ 6	-30	+ 6	-30	+ 3	-27	+ 3	-51	+ 3	-12
156	+ 9	-24	+ 3	-60	+ 9	-24	-12	0	- 9	-36	-30	+ 6
159	+24	-48	+15	-51	+27	-48	-15	+ 6	-30	- 9	-30	+ 9
162	+33	-45	+15	-51	+24	-42	- 9	- 6	-15	0	- 9	- 3
165	+15	-42	+ 9	-51	+15	-36	+12	-27	+ 6	-15	+ 6	-21
168	+30	-51	+21	-51	+42	-48	+ 9	-24	+ 3	-45	+ 9	-18
171	+24	-48	+21	-45	+42	-48	+ 3	-12	- 6	-24	+ 3	-12
174	+15	-24	+ 9	-30	+18	-24	+ 6	-21	0	-30	+ 6	-18
177	+ 9	-21	+ 9	-48	+ 9	-12	+ 9	-21	+ 9	-30	+ 6	-15
180	+12	-27	+12	-60	+12	-36	-15	- 3	-12	- 9	-12	+ 3
183	+27	-51	+27	-51	+24	-45	-30	0	-30	- 6	-27	+ 6
186	+24	-48	+27	-60	+18	-42	- 9	- 6	- 9	-12	-15	+ 3
189	+21	-45	+30	-60	+15	-36	+ 9	-24	+15	-45	+ 3	-18
192	+30	-54	+48	-54	+45	-48	+12	-30	+12	-48	+ 9	-21
195	+39	-48	+39	-30	+30	-45	+12	-24	+ 9	-45	+ 6	-18
198	+15	-24	+18	-27	+15	-24	+15	-30	+12	-48	+12	-27
201	+ 9	-18	+12	-30	+ 9	-15	+12	-30	+15	-45	+12	-24
204	+ 9	-24	+15	-51	+ 9	-18	- 9	- 6	+12	- 9	-12	+ 3
207	+21	-30	+21	-30	+21	-27	-21	+ 9	-12	+ 3	-39	+12
210	+18	-27	+18	-30	+15	-21	-24	+ 6	-30	0	-39	+12
213	+15	-24	+12	-51	+12	-18	- 6	-12	- 3	-18	- 9	- 3
216	+24	-45	+24	-30	+24	-30	0	+12	- 6	-15	- 6	- 3
219	+21	-36	+21	-21	+24	-24	-15	- 3	-15	- 9	- 9	+ 3
222	+ 6	-12	+ 3	-12	+ 3	-12	- 9	- 9	- 9	-15	- 6	- 6
225	- 6	- 6	- 6	- 9	- 6	- 6	- 3	-12	- 6	-12	0	- 9
228	- 9	0	-12	-27	- 6	- 3	-33	+ 9	-39	+ 6	-30	+12
231	+ 9	-15	0	-24	+ 9	-15	-15	+21	-48	+15	-45	+21

TABLE 1 (CONTINUED)

Results of Accuracy Tests before Endurance

Errors in Minutes

Generator Setting in Degrees	Motor No. 5						Motor No. 6					
	115Volts		103.5Volts		126.5Volts		115Volts		103.5Volts		126.5Volts	
	60Cycles		65 Cycles		55 Cycles		60Cycles		65 Cycles		55 Cycles	
	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw	cw	ccw
234	+ 9	-15	0	-30	+ 9	-12	-39	+15	-48	+12	-42	+21
237	+ 9	-21	+ 6	-54	+ 9	-15	-15	- 6	-30	-15	-12	0
240	+45	-48	+27	-51	+27	-45	- 6	-12	- 3	-18	0	- 9
243	+36	-45	+27	-30	+24	-27	- 3	-12	- 6	-18	- 6	- 6
246	+15	-24	+21	-36	+ 6	-15	+ 3	-27	+ 6	-27	0	-12
249	+ 6	-15	+12	-30	+ 3	- 3	+ 6	-18	+ 6	-27	+ 3	-12
252	0	-15	+ 6	-48	- 6	- 6	-12	0	-15	- 6	-12	+ 9
255	+12	-24	+12	-30	+12	-21	-36	+ 6	-30	0	-36	+12
258	+12	-36	+15	-39	+15	-15	-21	+ 6	-27	- 3	-30	+ 6
261	+18	-30	+12	-54	+12	-15	0	-15	+ 3	-21	0	-12
264	+30	-45	+21	-48	+27	-42	+ 6	-15	+ 6	-21	+ 3	-15
267	+24	-30	+24	-30	+24	-24	0	-18	0	-21	0	- 9
270	+ 9	-15	+15	-18	+ 9	-12	+ 3	-15	0	-24	0	-12
273	0	- 9	+ 9	-18	- 6	0	- 3	-15	0	-24	+ 3	- 6
276	-15	- 3	- 6	- 9	-12	+ 9	-30	+ 9	-30	+ 3	-24	+12
279	- 6	- 6	- 9	-18	- 6	0	-39	+15	-42	+ 6	-39	+21
282	0	- 9	- 3	-12	- 3	- 6	-36	+15	-39	+ 3	-39	+18
285	- 6	- 6	- 3	-15	+ 6	0	-12	- 9	-12	-12	-12	0
288	+21	-39	+ 9	-27	+18	-27	- 6	- 9	- 9	- 9	- 6	- 3
291	+21	-39	+18	-39	+24	-27	-12	- 3	-15	- 9	- 6	0
294	+12	-30	+12	-33	+12	-21	0	-12	+ 3	-18	0	- 6
297	+ 9	-17	+12	-24	+ 6	- 9	+ 3	-15	-15	-21	- 3	- 6
300	- 3	-15	+ 3	-30	0	- 9	-15	0	-15	- 3	-12	+ 9
303	+12	-33	+ 6	-45	+ 9	-15	-12	+ 3	- 6	- 6	-21	+ 9
306	+ 9	-30	+18	-39	+ 6	-15	- 9	- 6	-21	-21	-15	+ 3
309	+12	-33	+15	-42	+ 9	-12	+21	-42	+18	-48	+12	-21
312	+30	-51	+30	-63	+30	-48	+18	-39	+18	-39	+15	-24
315	+45	-57	+45	-63	+48	-51	+12	-30	+15	-39	+15	-24
318	+42	-51	+30	-60	+39	-45	+24	-42	+21	-51	+18	-30
321	+27	-45	+27	-48	+33	-36	+24	-42	+24	-48	+27	-30
324	+24	-45	+24	-48	+33	-30	0	-15	0	-24	0	- 9
327	+27	-45	+30	-51	+39	-45	+ 3	-15	- 6	-24	- 3	-12
330	+21	-30	+18	-48	+21	-27	+ 6	-18	0	-30	+ 3	-15
333	+12	-24	+21	-39	+15	-21	+27	-48	+21	-48	+27	-39
336	+27	-42	+27	-51	+27	-36	+15	-27	+ 9	-36	+12	-21
339	+39	-51	+30	-54	+30	-51	+ 3	-12	- 6	-18	+ 3	-12
342	+27	-30	+21	-45	+24	-30	+ 3	-12	0	-24	0	- 9
345	+21	-27	+15	-30	+15	-27	+ 6	-21	0	-21	+ 6	-15
348	+18	-24	+12	-30	+18	-24	- 6	- 6	-6	- 9	- 3	- 3
351	+21	-30	+15	-45	+24	-30	- 6	- 6	-12	-12	- 6	- 3
354	+12	-21	+ 9	-24	+15	-21	+ 3	-15	- 3	-18	+ 3	-12
357	+12	-15	+ 9	-27	+ 9	-12	+21	-45	+18	-48	+24	-42
360	+24	-45	+24	-45	+24	-30	+15	-24	+12	-30	+12	-21

TABLE 2

Results of Accuracy Tests After Endurance.

Errors in Minutes

Type "A" transmitter-generator connected to 6 type "N" indicator-motors. Motors and generator set to electrical zero before test. Errors marked (+) lead the direction of rotation; those marked (-) lag. Thus a (+) error in the CW direction indicates the same geometrical position as a corresponding (-) error in the CCW direction. (115 volts, a.c., 60 cycle supply).

Generator Setting in Degrees	M O T O R S											
	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6	
	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW
3	- 9	-72	-12	-30	-30	-66	-39	-30	0	-21	-24	- 9
6	-15	-51	- 3	-15	-21	-105	-15	-27	- 9	-19	-39	- 9
9	-12	-63	-30	-24	- 9	-102	-30	-42	-12	+ 9	-30	-18
12	-15	-48	-12	-18	-12	-66	-30	-63	-18	- 3	-36	-12
15	-45	-57	-15	-21	-39	-72	-33	-66	-15	+12	-36	-21
18	- 9	-90	-30	-27	+ 9	-51	-39	-126	-30	+ 3	-33	-51
21	-12	-48	- 9	- 6	- 6	-90	-30	-90	-30	0	- 9	-60
24	- 9	-24	-18	-48	- 3	-63	-24	-30	-18	- 3	- 6	-27
27	-30	+ 3	- 9	- 3	-30	-60	-54	-75	- 6	-15	-39	+ 6
30	-42	+15	-45	+12	-39	-69	-60	-45	-12	+ 6	-51	- 3
33	-45	-51	-48	+15	-48	-54	-48	-54	-30	+ 6	-54	+ 6
36	-33	+ 3	-63	+ 9	-57	-57	-54	-42	-36	+ 6	-57	+18
39	-54	-18	-48	+ 6	-63	-45	-63	-21	-36	+ 3	-57	+15
42	-60	- 3	-42	+ 6	-66	-30	-51	- 6	-39	+ 6	-48	- 9
45	-54	-33	-48	-12	-75	-42	-45	-39	-51	+15	-30	-18
48	-51	- 6	-36	-18	-90	-27	-51	0	-48	+ 9	-36	- 3
51	-45	-51	-12	-18	-75	-21	-48	-21	-30	- 6	-57	+18
54	-39	-30	-33	+ 9	-90	-66	-48	- 9	-36	+ 3	-69	+ 6
57	-39	-36	-48	0	-57	-81	-51	-60	-33	+ 6	-66	+18
60	-45	-48	-45	0	-42	-69	-39	-30	-39	- 6	-63	+18
63	-60	-63	-36	- 9	-90	-60	-21	0	-15	-15	-63	+21
66	-51	-36	-36	-21	- 6	-51	-57	-21	-33	- 3	-51	- 3
69	-30	-27	-39	-18	-93	-57	- 9	-66	-39	0	-15	-18
72	-45	-84	-39	-21	-66	-33	-39	-39	-36	0	-15	-12
75	-15	-21	- 6	-27	-84	-54	-42	-39	-15	- 3	-48	+ 6
78	-60	-39	- 9	-24	-42	-66	-30	-27	-33	0	-51	+ 6
81	-51	-21	-33	-24	-48	-69	-45	-30	-36	0	-45	+ 3
84	-51	-15	-36	-18	- 6	-60	0	-54	-33	+ 6	-24	+ 9
87	-66	-45	-27	-27	-57	-57	-30	-18	-18	- 6	-63	0
90	-48	-81	-33	-15	-39	-51	-39	-24	-24	+ 3	-51	- 3
93	-48	-54	-45	0	-48	-30	-12	-72	-42	+ 9	-38	-30
96	-63	-42	+ 3	0	-69	-24	-48	-27	-48	+15	-36	+ 3
99	-60	-54	-63	- 6	-87	-18	-45	-21	-39	+ 9	-48	+ 9
102	-72	-30	-63	- 9	-54	-45	-51	- 9	-45	+ 9	-66	+18
105	-51	-48	-51	- 9	-75	-48	-39	-66	-51	+18	-57	+ 6
108	-57	-24	-57	+ 9	-75	-48	-15	-66	-45	+ 9	-69	+ 9

TABLE 2 (CONTINUED)

Generator Setting in Degrees	M O T O R S											
	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6	
	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW
111	-63	-18	-57	-18	-75	-57	- 6	- 6	-15	-12	-66	-27
114	-51	-24	-66	+ 3	-51	-51	-42	+ 3	-30	+ 3	-63	0
117	-36	-57	-48	-15	-72	-30	- 6	-42	-48	+ 6	-39	-15
120	-45	-36	-45	- 9	-63	-30	-30	-15	-36	+ 9	-36	-12
123	-36	-54	-30	-27	-60	-51	-42	-15	-30	0	-27	- 6
126	-48	-24	-15	-21	-105	-63	-30	-12	-36	+ 6	-45	- 9
129	-30	- 6	- 3	-48	-36	-69	-33	- 9	-36	0	-36	-21
132	-30	-30	- 9	-21	-42	-66	+15	-54	-30	- 9	-45	- 3
135	-36	-27	+12	-51	-54	-84	-12	-39	- 6	-30	-54	- 9
138	-18	-48	-24	-45	-33	-51	- 6	-42	- 6	-24	-42	-18
141	-12	-24	-36	-45	-15	-69	+ 3	-60	- 9	-21	- 9	-27
144	-18	-54	- 6	-51	-39	-51	-30	+21	-12	-27	- 6	-21
147	-15	-39	+ 9	-63	-51	-66	-33	-15	-15	-21	-21	-12
150	-36	-30	-15	-27	-33	-69	+ 3	- 3	-21	- 6	-42	-15
153	-30	-12	-18	-18	-36	-69	+ 6	-27	-36	-12	-39	-18
156	-39	-18	-45	-15	-51	-54	-30	-27	-33	- 9	-51	+ 6
159	-51	- 6	-36	-45	-51	-84	-36	+ 9	-15	-39	-63	+ 9
162	-45	- 6	-36	-30	-48	-15	-48	+24	-15	-21	-51	- 6
165	-33	- 6	-39	-27	-54	-54	-42	+12	-36	- 3	-39	-15
168	-54	- 9	-18	-51	-56	-51	-48	0	-42	- 6	-39	- 9
171	-36	- 9	-36	-21	-54	-51	-42	-12	-18	-12	-48	-12
174	-45	-15	-36	- 9	-66	-60	-54	+ 9	-39	0	-42	-24
177	- 6	-42	-60	-12	-66	-69	-57	- 9	-39	+ 6	-15	-21
180	- 9	-21	-39	- 9	-51	-57	- 9	-45	-18	- 6	-45	+ 3
183	-12	- 3	-39	-45	-63	-69	-45	+ 9	-15	-24	-57	+ 9
186	-36	- 9	-45	-27	-57	-69	-42	-39	-21	-21	-51	+ 3
189	-12	-15	-48	-63	-36	-69	-36	-18	-24	- 9	-36	-21
192	-39	-12	-30	-45	-36	-57	-42	- 6	- 9	-21	-33	-21
195	-15	-15	-15	-24	-60	-60	-69	-30	-12	-15	-39	-30
198	- 9	-18	-33	-12	-54	-75	-48	-39	-30	- 9	-30	-30
201	+ 6	-27	-54	- 6	-69	-66	-48	- 9	-36	- 3	-36	-21
204	-18	- 9	-63	+ 3	-66	-78	-12	0	-45	- 3	-48	+ 6
207	-39	+ 6	-45	-15	-57	-66	-42	- 3	-15	-18	-63	+15
210	-45	- 9	-63	0	-12	-54	-90	+ 9	-30	-12	-54	+15
213	-45	0	-90	0	+ 6	-42	-42	- 9	-36	- 6	-45	+ 3
216	-57	- 9	-69	- 9	-33	-48	-36	+12	-18	-12	-48	- 3
219	-60	- 6	-48	-12	-69	-69	-66	+24	-15	- 6	-48	- 6
222	-33	- 3	-42	+ 3	-69	-72	-54	+21	-39	+12	-45	- 9
225	-63	+ 6	-42	+ 3	-69	-18	-60	- 9	-48	+12	-39	- 9
228	-63	0	-39	+ 6	-81	-24	-66	- 6	-51	+15	-63	+15
231	-69	+12	-30	- 9	-69	-45	-66	-15	-45	0	-93	+21
234	-60	+ 9	-30	-12	-66	-51	-63	+27	-36	+ 3	-90	-24
237	-48	+ 3	-39	-12	-57	-72	-39	-42	-30	- 6	-60	+ 3
240	-48	+ 3	-36	-30	-42	-63	-12	-24	- 6	-15	-48	-12
243	-33	+ 3	- 6	-30	-54	-45	-69	0	- 3	-12	-39	- 3
246	-45	0	+ 9	-36	-33	-57	-45	- 9	-12	- 3	-42	-18
249	-12	-12	- 9	-18	-48	-39	-48	-15	-30	+12	-36	-15
252	-30	+ 3	-33	-12	-54	-30	-63	-12	-36	+ 9	-48	- 3
255	-45	+ 6	-48	-51	-66	-51	-63	- 3	-15	0	-66	+ 9
258	-39	+ 9	-30	-48	-69	-75	-60	-30	-18	0	-54	+ 9

TABLE 2 (CONTINUED)

Generator Setting in Degrees	M O T O R S											
	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6	
	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW
261	-48	+12	-9	-48	-57	-87	-63	-54	-15	0	-48	-21
264	-54	+9	-33	-57	-30	-66	-36	-39	0	-12	-42	-12
267	-36	+9	-12	-39	-60	-54	-66	-30	0	-15	-48	-15
270	-48	+3	-30	-54	-93	-87	-60	-15	-18	+3	-51	-18
273	-48	-3	-54	-21	-54	-51	-63	-48	-42	+9	-39	-12
276	-54	+6	-66	-3	-93	-24	-51	-21	-48	+21	-60	+3
279	-63	+21	-48	-12	-96	-15	-69	0	-45	+15	-93	+9
282	-66	+24	-60	-18	-66	-54	-75	+6	-27	+12	-69	-9
285	-48	-15	-63	+3	-66	-51	-39	+3	-39	+15	-57	-3
288	-54	-9	-57	-24	-48	-57	-63	-42	-9	-6	-42	-6
291	-36	-3	-54	-24	-66	-36	-63	-27	0	-6	-51	+3
294	-45	-3	-36	-30	-9	-60	-39	-27	-15	+3	-48	-9
297	-42	-3	-33	-27	-36	-54	-69	-30	-21	+9	-39	-15
300	-42	-6	-51	+3	-60	-24	-63	-30	-39	+21	-57	0
303	-51	+6	-39	-54	-66	-72	-66	-3	-30	+3	-66	0
306	-48	-9	-18	-39	-48	-108	-54	-18	-21	0	-63	-15
309	-48	-6	-33	-30	-33	-90	-39	-15	-9	0	-30	-30
312	-30	-15	-30	-24	-9	-63	-30	-68	-3	-24	-9	-24
315	-36	-21	-42	-24	-63	-66	-63	-78	+6	-27	-39	-24
318	-36	-21	-18	-51	-33	-102	-18	-54	-3	-18	-30	-36
321	-30	-24	-15	-45	-15	-90	-30	-48	-6	-6	-12	-51
324	-33	-21	-12	-24	-39	-54	-42	-9	-15	+3	-33	-15
327	-60	-12	-15	-18	-39	-75	-45	-18	-6	+6	-42	-9
330	-57	-21	-36	-21	-48	-66	-66	-54	-9	-6	-39	-24
333	-39	-9	-42	0	-6	-39	-42	-57	-15	+3	-15	-45
336	-45	-9	-30	-21	-15	-42	-60	-30	0	-12	-30	-24
339	-3	-9	-3	-45	-69	-30	-66	-39	0	-18	-36	-12
342	-48	-9	-30	-30	-72	-81	-78	-45	-9	+3	-45	-15
345	-30	-9	-42	-18	-57	-69	-90	-51	-15	+6	-36	-21
348	-33	+3	-33	-51	-66	-63	-60	-15	-30	+15	-42	-3
351	-42	-3	-9	-30	-66	-63	-78	-18	-18	+6	-54	-9
354	-39	+6	-30	-24	-48	-38	-75	-39	-18	+6	-39	0
357	-9	-6	-15	-18	-36	-66	-93	-30	-21	+9	-30	-27
360	-6	-12	-30	-15	-42	-60	-15	-27	-6	-3	-33	0

TABLE 2A

Results of Accuracy Tests After Endurance.

Errors in Minutes

Conditions same as for Table 2, except that all motors were cleaned and lubricated before this test. The three motors showing the greatest errors under the previous test were chosen for observation and their errors logged while the remaining three were also in the circuit. (115 volts a.c., 60 cycle supply).

Generator							Generator						
Setting in							Setting in						
Degrees							Degrees						
M O T O R S							M O T O R S						
No. 2		No. 3		No. 4			No. 2		No. 3		No. 4		
CW	CCW	CW	CCW	CW	CCW		CW	CCW	CW	CCW	CW	CCW	
3	- 6	-57	-30	-12	-48	0	114	-36	- 3	-48	- 9	-63	-12
6	- 3	-51	- 6	-27	-63	- 3	117	-15	- 9	-45	-12	-66	- 6
9	-15	-54	- 6	-30	-39	-24	120	-12	-15	-39	- 6	-51	- 9
12	- 6	-57	-15	-18	-60	0	123	+ 6	-33	-45	- 9	-61	-45
15	- 6	-63	-21	-21	-51	0	126	- 3	-45	-15	-45	-66	+ 3
18	+ 3	-63	-18	-12	-66	- 6	129	- 6	-24	0	-45	-63	-24
21	+ 3	-60	-15	-27	-51	-21	132	- 6	-33	- 3	-45	-39	-18
24	-18	-63	-15	-27	-42	-18	135	+12	-51	- 3	-45	-45	-24
27	-42	-57	-21	-15	-60	+12	138	+ 9	-30	- 9	-30	-54	-18
30	-21	-15	-15	-45	-69	+12	141	0	-45	-15	-39	-42	-21
33	-51	0	-15	-27	-57	+ 3	144	+ 6	-30	- 6	-30	-48	-18
36	-48	+ 3	-36	- 9	-69	+27	147	+12	- 6	-15	-18	-48	- 6
39	-45	-57	-54	0	-90	+24	150	-18	-21	- 9	-30	-60	-12
42	-39	-24	-48	0	-78	+33	153	-15	-15	- 6	-42	-66	-30
45	-36	-30	-45	- 3	-81	+15	156	- 9	- 9	-15	-18	-42	- 9
48	-45	-42	-39	- 6	-72	+ 9	159	- 9	-30	-18	-18	-60	- 6
51	-36	-54	-45	- 6	-69	+30	162	- 9	-12	-12	-12	-60	- 6
54	-12	-48	-33	-24	-75	+24	165	- 6	-27	-24	-21	-60	-12
57	-18	-33	-12	-24	-66	0	168	+15	-57	-12	-18	-60	-12
60	-24	-30	-36	-15	-78	+ 9	171	+18	-45	-39	- 9	-54	-33
63	-39	-48	-36	-12	-90	+ 9	174	+ 6	-24	-18	-27	-63	-24
66	- 6	-30	-39	- 6	-66	- 3	177	0	-18	- 6	-27	-60	-30
69	-24	-18	-45	- 3	-69	0	180	- 3	0	-12	-21	-57	0
72	-39	-24	-30	- 9	-78	- 3	183	- 3	-36	-12	-30	-54	-15
75	- 9	-45	-33	-21	-66	+ 6	186	- 6	-24	- 9	-24	-48	-21
78	- 9	-30	-30	-45	-69	+ 6	189	-15	-24	- 6	-30	-36	-30
81	-18	-15	- 3	-45	-75	-21	192	+ 9	-51	- 6	-30	-39	-27
84	- 9	-24	-15	-18	-66	- 3	195	+15	-51	-15	-15	-51	-30
87	- 9	-27	-36	-15	-66	- 9	198	- 6	-18	- 9	-27	-54	-21
90	-12	-12	-45	0	-69	- 9	201	- 9	-15	- 9	-24	-27	-30
93	-24	-21	-48	- 6	-66	-12	204	-39	- 3	-15	-15	-48	-18
96	-39	- 3	-45	0	-72	+12	207	-36	+ 9	-15	-30	-57	-15
99	-42	- 9	-57	+ 6	-72	+ 9	210	-45	- 3	- 9	-27	-60	-12
102	-36	-12	-42	- 9	-69	+12	213	-54	+30	- 6	-27	-51	- 6
105	-45	0	-39	-18	-90	- 9	216	-33	0	- 9	-24	-51	- 6
108	-51	+12	-33	-12	-54	0	219	- 9	- 6	-27	- 6	-60	+12
111	-45	- 9	-42	- 9	-66	- 6	222	-30	+ 6	-21	-12	-60	+ 6

TABLE 2A (CONTINUED)

Generator Setting in Degrees	M O T O R S						Generator Setting in Degrees	M O T O R S					
	No. 2		No. 3		No. 4			No. 2		No. 3		No. 4	
	CW	CCW	CW	CCW	CW	CCW		CW	CCW	CW	CCW	CW	CCW
225	-36	0	-27	-9	-51	-9	294	-9	-3	-15	-15	-39	-15
228	-51	-9	-39	-3	-60	0	297	-9	-3	-12	-24	-33	-21
231	-15	-18	-39	-15	-66	+3	300	-15	+6	-24	-6	-36	-6
234	-18	-18	-15	-18	-60	0	303	-12	-30	-36	-9	-51	-9
237	-33	-6	-9	-27	-51	-6	306	-3	-21	-9	-24	-51	-12
240	-9	-36	-6	-18	-36	-15	309	-9	-30	+3	-48	-30	-45
243	+6	-45	-18	-12	-51	-3	312	+6	-45	+9	-48	0	-39
246	-6	-15	-18	-21	-60	0	315	+9	-54	+3	-30	-36	-9
249	-12	-18	-15	-15	-6	+24	318	+9	-30	+12	-51	-15	-45
252	-33	+3	-18	-9	-45	0	321	-6	-33	+3	-30	-12	-30
255	-12	-24	-15	-27	-63	-9	324	-9	-48	-6	-21	-24	-6
258	+3	-27	-9	-27	-51	-12	327	-6	-36	-15	-18	-66	-12
261	-6	-18	+18	-57	-48	-24	330	-6	-45	-15	-18	-60	-6
264	+9	-33	+6	-45	-30	-24	333	-36	-27	-9	-30	-33	-6
267	+12	-33	-18	-12	-48	-18	336	-12	-15	-3	-24	-15	-24
270	0	-15	-12	-12	-48	-21	339	+3	-6	-21	-12	-42	-12
273	-12	+3	-30	-12	-48	-27	342	-12	-45	-12	-18	-51	+6
276	-39	+6	+6	+6	-48	-9	345	-9	-27	-9	-21	-48	-24
279	-33	+3	+15	+3	-66	+9	348	-3	-30	-21	-6	-54	+9
282	-15	-3	-33	-6	-60	+6	351	+3	-48	-30	-6	-66	+3
285	-42	+6	-30	-24	-63	-24	354	-6	-30	-18	-9	-66	0
288	-33	-6	-9	-21	-30	-21	357	-36	-30	-15	-12	-48	+3
291	+3	-15	-30	-9	-36	-6	360	-3	-24	-9	-21	-30	-9

TABLE 3

Torque and torque gradient in inch ounces -
Single indicators connected to type "A"
generator.

Displacement in degrees from electrical zero	No.1	No.2	No.3	No.4	No.5	No.6
CW						
1	.081	.097	.104	.029	.099	.083
2	.144	.166	.164	.099	.158	.146
3	.218	.228	.226	.162	.222	.206
4	.274	.296	.286	.229	.284	.263
5	.332	.362	.351	.290	.348	.334
6	.395	.428	.410	.353	.421	.389
7	.460	.489	.466	.421	.477	.459
8	.516	.554	.519	.488	.556	.514
9	.570	.615	.587	.548	.598	.567
10	.644	.682	.643	.612	.657	.636
CCW						
1	.032	.029	.025	.093	.037	.033
2	.059	.090	.092	.162	.099	.100
3	.152	.158	.146	.226	.166	.158
4	.216	.224	.205	.289	.231	.225
5	.283	.285	.275	.353	.294	.287
6	.329	.359	.336	.418	.357	.347
7	.394	.425	.391	.480	.424	.402
8	.454	.485	.457	.554	.480	.470
9	.525	.554	.510	.615	.548	.528
10	.577	.624	.564	.675	.608	.586
Torque Gradient	.0610	.0603	.0603	.0643	.0632	.0611
Max. torque CW	4.68	4.75	4.56	4.69	4.53	4.50
Max. torque CCW	4.63	4.83	4.62	4.90	4.65	4.52

TABLE 4

OSCILLATION TEST - time (in seconds) required
for "Standard" indicator pointer to come to
rest by oscillograph method.

<u>Motor No.</u>	<u>Degrees Displacement</u>	<u>Seconds. Time for pointer to come to rest.</u>
1	180	1.53
2	180	1.12
3	180	.75
4	180	.78
5	180	1.16
6	180	1.42
6	90	1.28
6	20	1.16
6	10	1.0
6	5	.38

TABLE 5

Maximum temperature rise of windings in degrees Centigrade during endurance test at 70°C Ambient.

Indicator No.	Windings Measured			
	Motor	S ₁ -S ₂	R ₁ -R ₂	R ₂ -R ₃
1		28.6	12.0	12.0
2		25.6	13.3	12.6
3		21.0	14.5	12.6
4		32.3	15.2	15.2
5		26.5	14.5	13.7
6		26.5	15.0	14.5

Transmitter
Generator

Sample furnished :
(removed after
342 hours)

Replacement

55.0	36.2	42.6	38.3
35.3	36.0	34.7	34.0

TABLE 6

Results of Accuracy Tests Using One Type "N" Indicator
Motor (No. 4) as a Transmitter Generator Connected to
One Type "N" Indicator-Motor (No. 2).

Errors in Minutes

Motor and generator set to electrical zero before test. Errors marked (+) lead the direction of rotation; those marked (-) lag. Thus a (+) error in the cw direction indicates the same geometrical position as a corresponding (-) error in the ccw direction (115 volt, a.c., 60 cycle supply).

Generator Setting in Degrees	Motor No. 2		Generator Setting in Degrees	Motor No. 2	
	cw	ccw		cw	ccw
3	- 6	-30	108	-60	-42
6	-45	- 9	111	-45	- 9
9	-57	+ 9	114	-51	-12
12	-45	+12	117	-63	-15
15	-42	- 9	120	-30	-21
18	-48	0	123	+30	-66
21	-66	+ 6	126	+24	-72
24	-54	+ 3	129	- 3	-63
27	-27	0	132	- 9	-66
30	-69	+30	135	+15	-63
33	-96	+51	138	+ 3	-48
36	-99	+54	141	-12	-48
39	-96	+12	144	- 3	-45
42	-90	-30	147	+12	-42
45	-99	+15	150	+ 3	-30
48	-66	-15	153	-24	- 9
51	-30	-24	156	-45	-12
54	-48	- 6	159	- 9	-45
57	-60	0	162	- 9	-54
60	-72	+18	165	-18	-27
63	-51	- 9	168	+ 9	-57
66	-66	0	171	+18	-60
69	-75	+ 9	174	+ 6	-30
72	-51	-45	177	-12	-21
75	- 6	-45	180	-21	- 6
78	-36	-48	183	- 3	-54
81	-48	-15	186	-15	-21
84	-48	0	189	-42	-12
87	-33	-24	192	-12	-60
90	-51	- 9	195	0	-45
93	-63	- 9	198	- 9	-24
96	-51	- 6	201	-39	0
99	-15	-30	204	-57	0
102	-30	-12	207	-48	-27
105	-54	- 6	210	-60	- 9

(Continued)

Table 6 (Continued)

Generator Setting in Degrees	Motor No. 2	
	CW	CCW
213	- 66	+ 9
216	-105	-15
219	- 9	-24
222	- 48	-12
225	- 45	- 9
228	- 33	-18
231	+ 6	-63
234	0	-54
237	- 39	-51
240	- 12	-60
243	+ 9	-60
246	- 6	-60
249	- 9	-15
252	- 18	-24
255	+ 24	-72
258	+ 15	-69
261	+ 3	-57
264	0	-66
267	- 3	-78
270	- 39	-63
273	- 42	-51
276	- 36	-21
279	- 33	-63
282	- 15	-48
285	- 36	- 9
288	- 30	-45
291	+ 6	-51
294	- 30	-27
297	- 36	-24
300	- 51	-15
303	+ 3	-69
306	+ 12	-60
309	0	-57
312	- 6	-78
315	+ 9	-69
318	- 6	-57
321	- 39	-24
324	- 48	-21
327	- 9	-51
330	- 36	-24
333	- 39	-15
336	- 39	-12
339	+ 6	-48
342	- 30	-21
345	- 15	-30
348	+ 12	-18
351	- 6	-45
354	- 30	-30
357	- 33	- 3
360	- 45	-15

(Continued)

TABLE 7

Results of Accuracy Tests Using One Type "N" Indicator-Motor (No. 4) as a Transmitter Generator Connected to Two Type "N" Indicator-Motors (Numbers 2 and 3).

Errors in Minutes

Motors and generators set to electrical zero before test. Errors marked (+) lead the direction of rotation; those marked (-) lag. Thus a (+) error in the cw direction indicates the same geometrical position as a corresponding (-) error in the ccw direction (115 volt, a.c., 60 cycle supply).

Generator Setting in Degrees	Motor No. 2		Motor No. 3		Generator Setting in Degrees	Motor No. 2		Motor No. 3	
	cw	ccw	cw	ccw		cw	ccw	cw	ccw
3	+15	- 60	+48	-168	111	-120	-54	+ 3	-165
6	-24	- 54	+63	-144	114	- 57	-45	+ 6	- 69
9	-48	- 27	+60	-135	117	- 73	-30	- 9	- 87
12	-69	- 48	+30	-129	120	- 45	-30	+15	-120
15	0	- 57	+51	-129	123	- 30	-54	+15	-126
18	-27	- 18	+18	-126	126	- 3	-90	+69	-171
21	-39	- 12	+21	-129	129	- 6	-66	+54	-135
24	-51	- 18	+45	-129	132	- 24	-72	+51	-138
27	-39	- 45	+30	-150	135	- 12	-84	+69	-135
30	- 9	- 15	+66	-162	138	- 30	-66	+ 6	-123
33	-18	- 9	+57	-129	141	- 54	-57	+21	-126
36	-60	0	+15	-105	144	- 6	-42	+48	-111
39	-90	- 9	+27	-129	147	- 18	-51	+12	-114
42	-63	+ 3	+ 6	- 90	150	- 18	-63	+51	-129
45	-69	0	+ 3	-114	153	- 18	-54	+51	- 81
48	-78	- 18	+15	-123	156	- 21	-48	+15	-120
51	-45	- 63	+12	-147	159	+ 3	-81	+ 6	-129
54	-30	- 27	+69	-150	162	- 9	-72	+27	-129
57	-30	- 24	+51	-132	165	- 12	-69	+30	-138
60	-45	- 21	+48	-108	168	+ 9	-78	+54	-135
63	-63	- 60	+30	-117	171	+ 12	-72	+24	-135
66	-66	- 42	+12	- 84	174	- 3	-69	+57	-138
69	-66	- 9	0	- 99	177	- 3	-57	+51	-126
72	-48	- 51	+12	-111	180	- 33	-66	+27	-129
75	- 6	- 66	+24	-150	183	- 30	-75	+63	-159
78	0	- 72	+66	-147	186	- 30	-72	+24	-168
81	-39	- 60	+54	-129	189	- 33	-72	+66	-171
84	-54	- 54	+42	-111	192	+ 9	-84	+72	-156
87	-39	- 57	+21	-120	195	- 3	-84	+30	-144
90	-51	- 27	- 3	- 81	198	- 3	-72	+72	-144
93	-72	- 9	- 3	- 84	201	- 33	-48	+48	-129
96	-66	- 27	+15	- 78	204	- 18	-51	+45	-150
99	-54	- 54	+ 9	-114	207	- 3	-57	+60	-168
102	-57	- 51	+30	-129	210	- 48	-48	+69	-171
105	-51	- 30	+27	-111	213	- 45	-27	+69	-159
108	-69	- 24	+12	-102	216	- 12	-72	+69	-138

(Continued)

Table 7 (Continued)

Generator Setting in Degrees	Motor No. 2		Motor No. 3	
	CW	CCW	CW	CCW
219	- 9	-57	+51	-135
222	-30	-66	+60	-135
225	-18	-12	+51	- 78
228	-30	-48	+33	-114
231	+18	-31	+87	-150
234	+ 9	-63	+78	-186
237	- 3	-69	+90	-210
240	+48	-81	+84	-174
243	+18	-72	+66	-144
246	+12	-69	+69	-117
249	- 6	-42	+42	-129
252	-36	-24	+21	-111
255	- 6	-90	+60	- 99
258	+ 9	-75	+75	-150
261	- 6	-37	+72	-177
264	+24	-111	+84	-174
267	+12	-66	+57	-132
270	- 9	-81	+57	-120
273	-42	-51	+18	-141
276	-69	-27	+24	-111
279	-54	-72	+ 6	-102
282	-51	-54	+54	-138
285	-51	-30	+57	-129
288	-45	-57	+57	-129
291	-18	-27	+69	-123
294	-42	-69	+54	-123
297	-48	-24	+51	-126
300	-66	- 6	+ 6	-111
303	-45	-87	+51	- 78
306	-45	-84	+48	-129
309	- 9	-69	+69	-141
312	0	-78	+69	-141
315	+ 9	-90	+54	-138
318	-30	-75	+69	-165
321	-36	-57	+48	-117
324	-48	-48	+ 6	-114
327	-60	-30	+15	-165
330	-54	-48	+ 9	-132
333	-51	-54	+24	-138
336	-39	-81	+51	-126
339	-18	-54	+39	-132
342	-27	-51	+30	-141
345	-48	-51	+51	-150
348	-33	-57	+39	-117
351	-48	-69	+42	-123
354	-36	-54	+15	-120
357	-45	-54	+24	-132
360	-48	-54	+27	-114

TABLE 8

Torque and Torque Gradient in Inch-Ounces.
Type "N" (No. 4) indicator as transmitter, connected to
Type "N" (No. 3).
(115 Volt, a.c., 60 Cycle Supply.)

Displacement in Degrees from Electrical Zero	CW	CCW
	Torque in Inch Ounces	Torque in Inch Ounces
1	.08	.039
2	.116	.065
3	.153	.102
4	.19	.137
5	.21	.169
6	.248	.197
7	.289	.234
8	.314	.264
9	.352	.307
10	.372	.337
Maximum torque	2.01	2.1
Torque gradient	0.0354	

TABLE 9

Results of Oscillation Tests, Numbers 3 and 4 Motors,
No. 3 as Transmitter.

Displacement in Degrees from Electrical Zero	Seconds to Return to Zero
180	0.784
90	0.633

TABLE 10

SUMMARY OF ACCURACY RESULTS FROM TABLES 1, 2 and 2A.

Condition	Range of errors and maximum errors - in minutes.											
	Motor No.1		Motor No.2		Motor No.3		Motor No.4		Motor No.5		Motor No.6	
(Table 1) Before endurance	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW
115 volts, 60 cycles	+48-27	+6-72	+51-9	-9-78	+30-30	-12-111	+15-93	+9-57	+45-15	+3-60	+27-51	+21-78
103.5 volts, 60 cycles	+54-30	+3-75	+51-15	0-84	+30-30	-3-96	+51-51	0-69	+48-12	+30-63	+27-51	+15-69
126.5 volts, 55 cycles	+51-30	+30-66	+51-18	-9-75	+30-21	+3-69	+48-45	+18-51	+48-12	+9-54	+30-45	+21-51
Maximum error	-75		-84		-111		-93		-63		-78	
Total variation in indications	105		102		141		162		93		129	
Maximum error at 115 volts, 60 cycles	-72		-78		-111		-93		-60		-78	
Total variation at 115 volts, 60 cycles	99		87		141		150		75		129	

(Continued)

TABLE 10 (Continued)

SUMMARY OF ACCURACY RESULTS FROM TABLES 1, 2 and 2A (Continued)

Condition	Range of errors and maximum errors - in minutes.											
	<u>Motor No.1</u>		<u>Motor No.2</u>		<u>Motor No.3</u>		<u>Motor No.4</u>		<u>Motor No.5</u>		<u>Motor No.6</u>	
(Table 2) After endurance	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW
115 volts, 60 cycles	+6-72	+24-90	+12-90	+15-63	+9-105	-15-108	+15-93	+27-126	+6-51	+21-39	-6-93	+21-60
Maximum error	-90		-90		-108		-126		-51		-93	
Total variation in indications	162		153		213		219		90		153	
(Table 2A) After endurance and cleaning and lubricating	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW	CW	CCW
115 volts, 60 cycles	-	-	+18-54	+30-63	+18-57	+6-57	-6-90	+33-45	-	-	-	-
Maximum error	-		-63		-57		-90		-		-	
Total variations in indications	-		117		114		135		-		-	

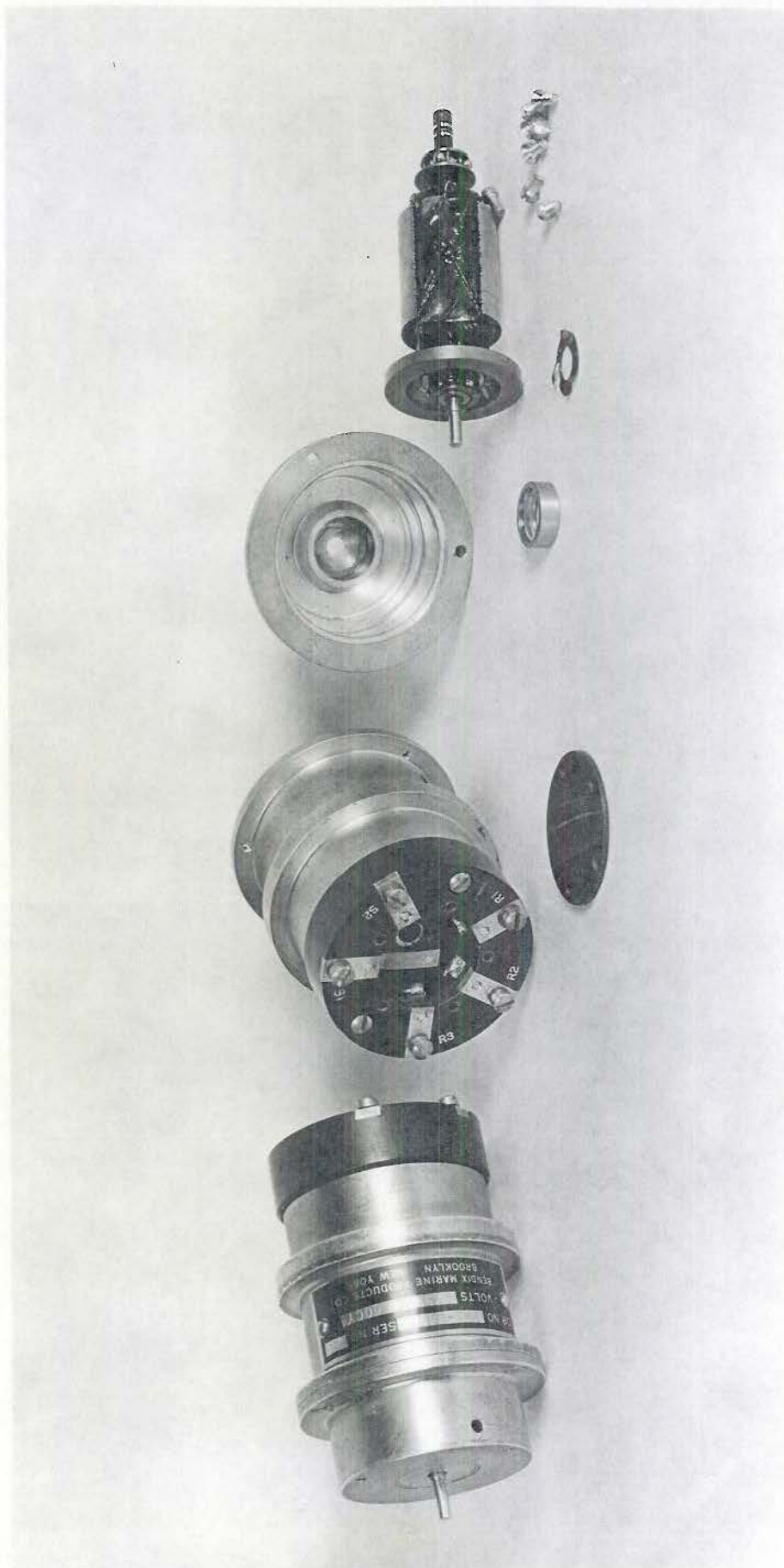


Plate 1

RECORDED ERROR

126.5 V. - 55 Ω

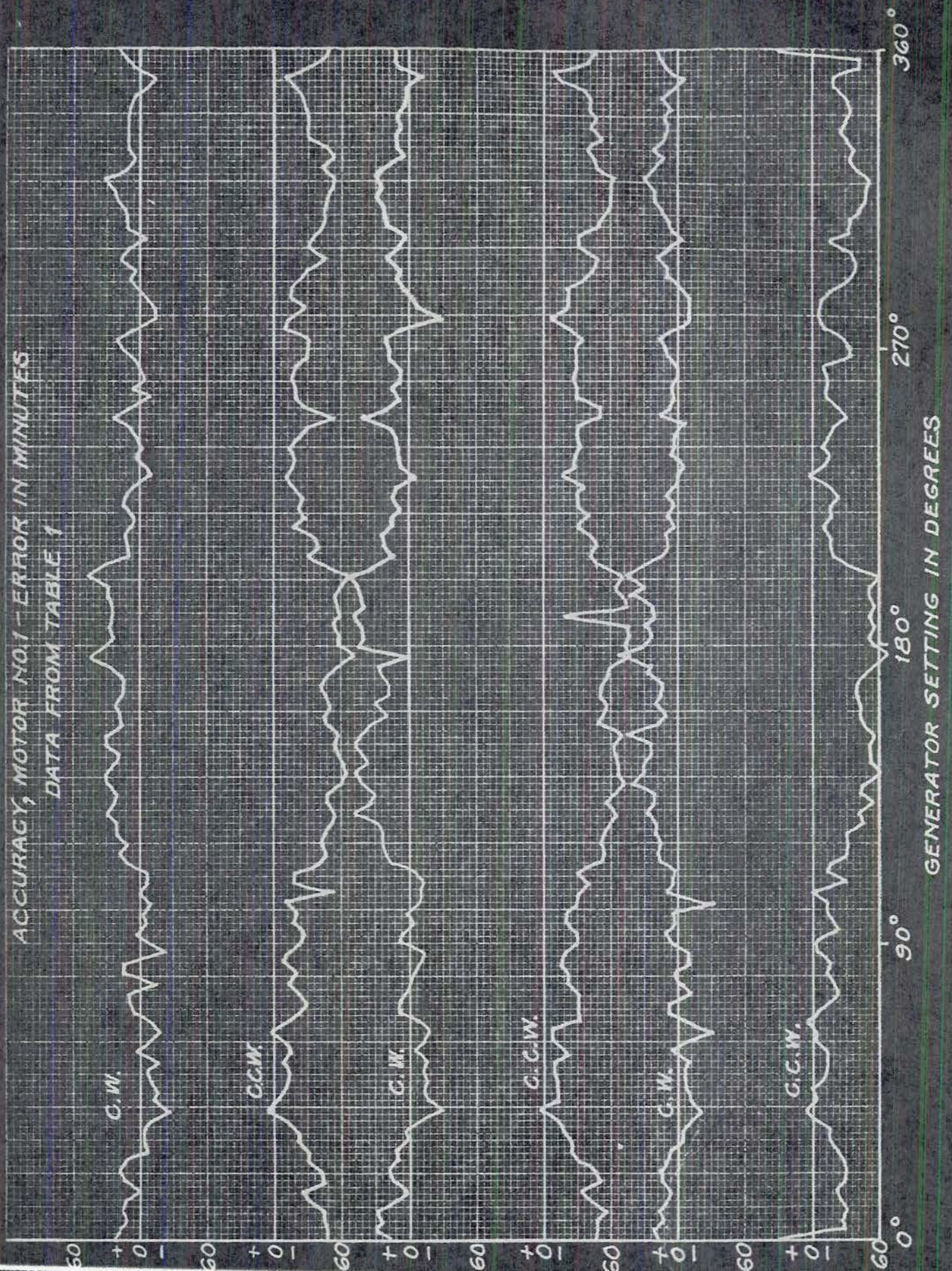
103.5 V. 65 Ω

115.0 V. - 60 Ω

SUPPLY

SUPPLY

SUPPLY



RECORDED ERROR

115.0 V - 60 2

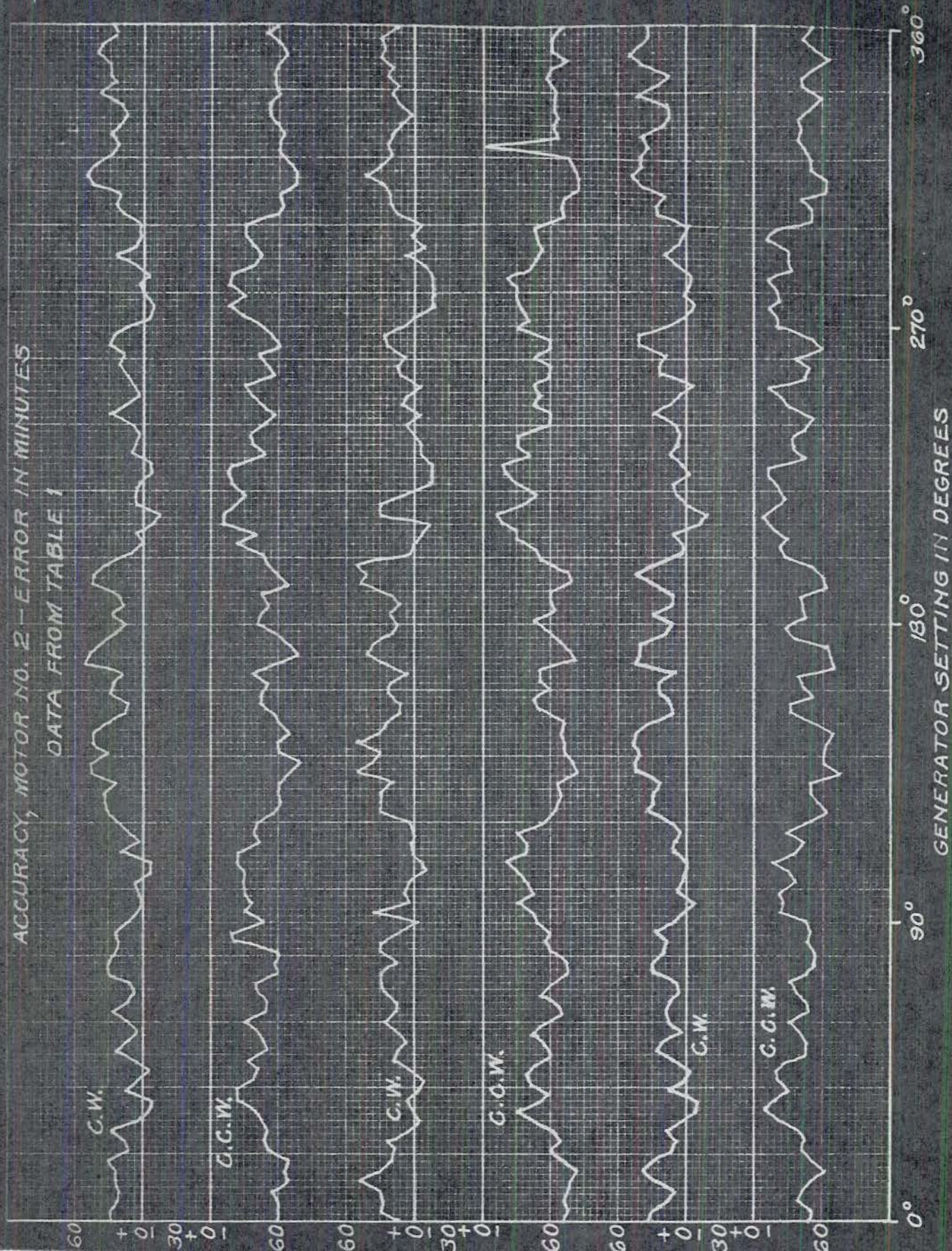
103.5 V - 65 2

126.5 V - 55 2

SUPPLY

SUPPLY

SUPPLY



ACCURACY, MOTOR NO. 3 - ERROR IN MINUTES.
DATA FROM TABLE 1



115.0 V. - 60 W
SUPPLY

RECORDED ERROR
103.5 V. - 65 W
SUPPLY

126.5 V. - 65 W
SUPPLY

RECORDED ERROR
126.5 V.-55 Ω
103.5 V.-65 Ω
115.0 V.-60 Ω
SUPPLY



ACCURACY, MOTOR NO. 4 - ERROR IN MINUTES
DATA FROM TABLE 1

C. C. W.

RECORDED ERROR

126.5 V. - 55 2
103.5 V. - 65 2
115.0 V. - 60 2
SUPPLY



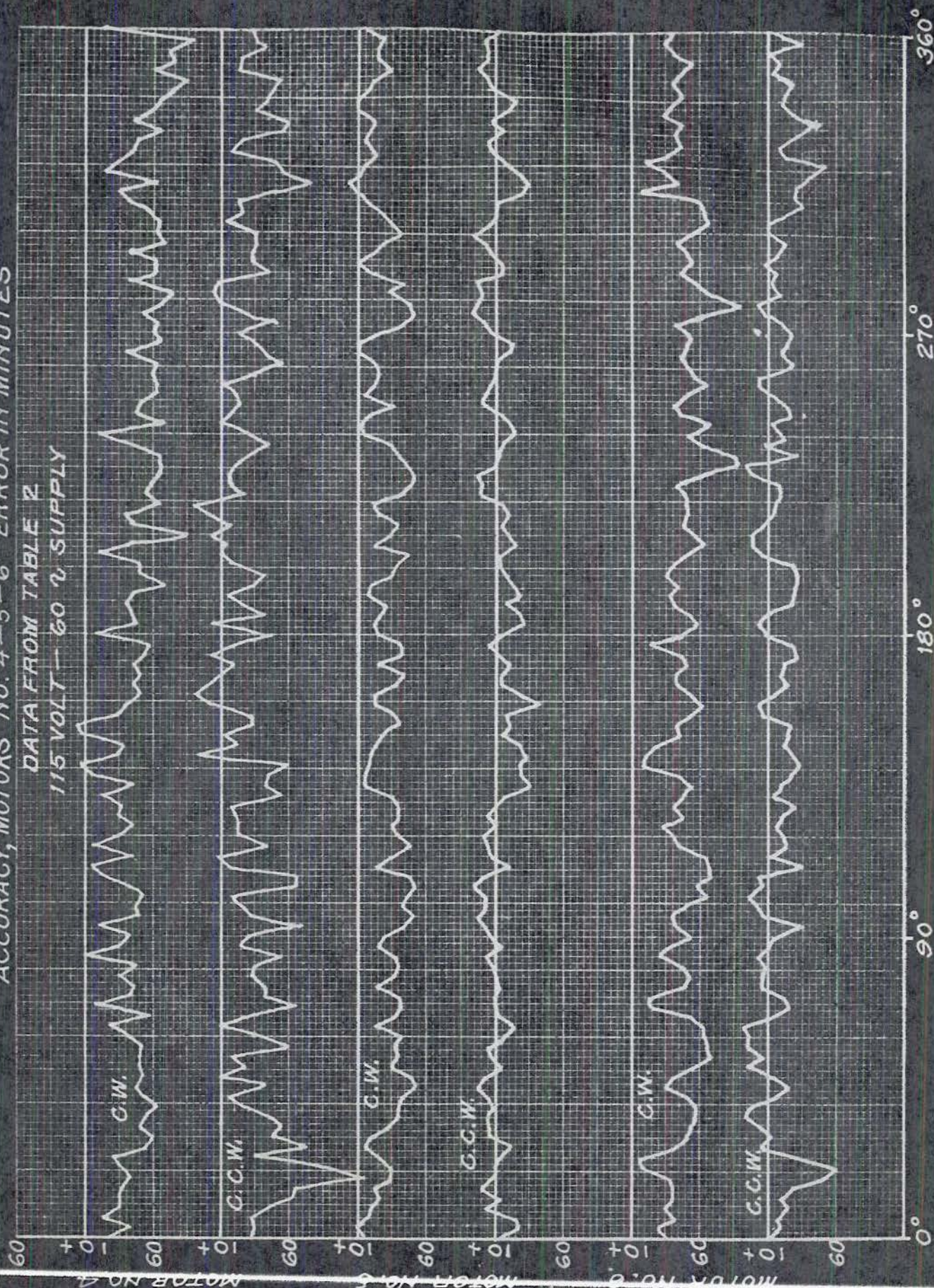
ACCURACY, MOTORS NO. 1-2-3 - ERROR IN MINUTES

DATA FROM TABLE 2
115 VOLTS - 60 Hz SUPPLY



ACCURACY, MOTORS NO. 4-5-6-ERROR IN MINUTES

DATA FROM TABLE 2
115 VOLT-60 Hz SUPPLY



RECORDED ERROR

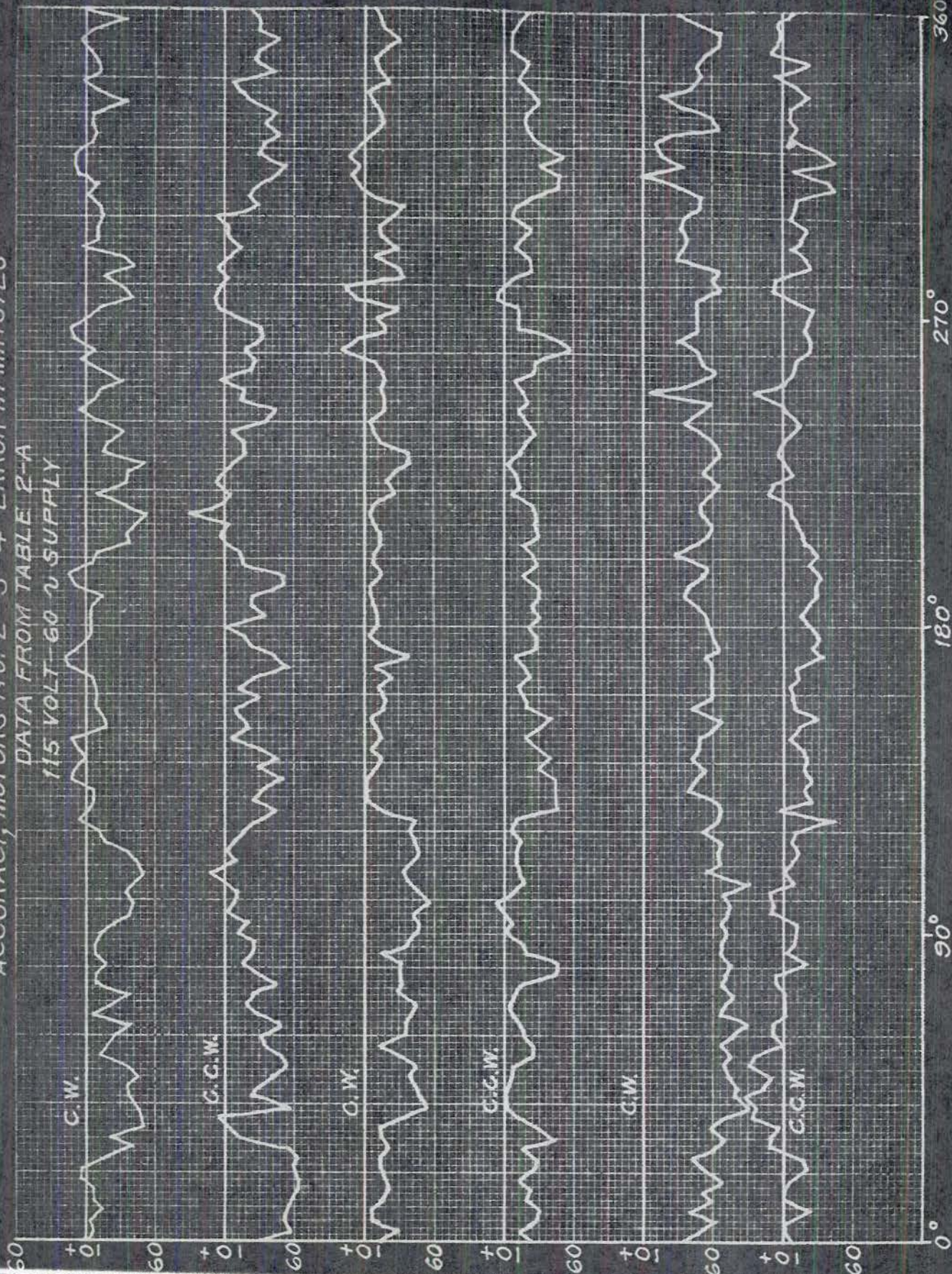
MOTOR NO. 4

MOTOR NO. 5

MOTOR NO. 6

ACCURACY, MOTORS NO. 2-3-4-ERROR IN MINUTES

DATA FROM TABLE 2-A
115 VOLT-60 $\sim$ SUPPLY



GENERATOR SETTING IN DEGREES

ACCURACY, MOTOR NO. 2 - ERROR IN MINUTES

DATA FROM TABLE 6

MOTOR NO. 2 POSITIONED BY NO. 4.

115 VOLT - 60 $\sim$ SUPPLY

