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NAVY DEPARTMENT

Report of Test

on

SALINITY INDICATING EQUIPMENT

Submitted by

Blake Marine Instrument Co.
New York, New York

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1944 to NRL.

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AUTHORIZATION FOR TEST

1. This problem was authorized by reference (a). Other references pertinent to this problem are listed as references (b) to (f) inclusive.

- References:
- (a) BuShips Ltr. S65-5(335a) of 20 April 1944 to NRL.
 - (b) BuShips Ltr. S65-5(335a) of 12 May 1944 to NRL.
 - (c) Specification 17-I-19b of 1 April 1943.
 - (d) Specification 17-E-11 (INT) of 15 May 1943.
 - (e) Manufacturer's Plan No. 642700-A BuShips Plan No. S6505-74592, Alt. 0.
 - (f) Manufacturer's Plan No. 641951-A BuShips Plan No. S6505-74593, Alt. 0.

OBJECT OF TEST

2. This object of this test was to determine conformance of the sample salinity indicating equipment with specification, reference (c), except for the splashproof requirement. As directed by reference (b), the conditions of this requirement were modified to conform with those set forth in Paragraph F-lb(2), subparagraph (b), of specification, reference (d).

ABSTRACT OF TEST

3. The sample salinity indicating equipment was set up at this Laboratory in suitable test circuits where its performance was carefully observed for compliance with specification, reference (c). An inspection to determine compliance in the matter of materials, design, and workmanship, concluded the test on the indicator panel assembly.

4. Tests on the cell and valve assembly submitted with this equipment have not been completed. The test results will be forwarded in a supplementary report at the earliest possible date.

CONCLUSIONS

(a) The subject salinity indicating equipment, except cell and valve assembly, which has not yet been tested, complied with specification, reference (c), and the splashproof requirement set forth in Paragraph F-lb(2), subparagraph (b), of specification, reference (d).

(b) Although a sample cell test resistor assembly, part no. 76127, manufacturer's plan, reference (f), was not submitted for test, the test clips with which it is provided have previously proved unsatisfactory in this application. Approval of this accessory is therefore not recommended until a sample has been submitted to the Laboratory for test and examination.

(c) The internal circuit of the indicating meter as shown in the manufacturer's plan, reference (e), is incomplete and incorrect, and does not agree with the actual circuit of the meter. Plate 16 shows a schematic diagram of the elements of the actual circuit.

RECOMMENDATIONS

(a) That the subject salinity indicating equipment (exclusive of conductivity cell and valve assembly and cell test resistor assembly) be approved for Naval use.

(b) That the contractor's plan, reference (e), be corrected and completed with respect to the internal circuit of the indicating meter, as noted under "Conclusions".

DESCRIPTION OF MATERIAL

5. The equipment submitted for test consists of one indicator unit and two cell and valve assemblies. A sample of the cell test resistor assembly (part no. 76127, manufacturer's plan, reference (f)) was not submitted with this equipment. The indicator is designed to operate from a supply of 115 volts, 60 cycles. The purpose of the equipment is to indicate the saline content in the boiler feed, condenser, and other water lines.

6. The indicator unit consists of the following major parts:

- (a) A transformer, ratio 115/115 with a 69 volt tap
- (b) A power factor meter with a dial graduated in grains of sea salt per gallon, from 0 to 10 grains per gallon, with zones of the scale colored as follows:

| <u>Scale Reading</u> | <u>Indication</u> |
|----------------------|-------------------|
| 0 to 0.5 gr/gal | White |
| 0.5 to 1.0 gr/gal | Green |
| 1.0 to 10.0 gr/gal | Red |

- (c) A Navy type J rotary transfer switch, for connecting any one of seven salinity cells to the indicator circuit.
- (d) A rotary temperature compensator switch, with a dial graduated from 57.5°F to 200°F in steps of 7.5°F, by which resistance in the bridge circuit may be varied to compensate for the effect of temperature on the resistance of the condensate.
- (e) A checking resistor for checking the meter accuracy at 1.0 gr/gal with the temperature compensator set at 110°F.
- (f) A single pole double throw push button switch for checking the meter accuracy, by substituting a checking resistor for a salinity cell.
- (g) A pilot light, with a blue glass lens, to indicate that the secondary winding of the transformer is energized.
- (h) A pair of non-renewable fuses, each provided with a neon blown fuse indicator.
- (i) A terminal block in two parts with connections for seven salinity cells.

7. All the above parts except the terminal block, which is mounted on the back wall of the case, are mounted on the rear of the front panel. This front panel, hinged to swing to the left is provided with a yoke-like opening in the flanged edge on the right side. In closing, the jaws of this yoke pass around the fastening bolt which is tapped through the side of the case into a reinforcing boss. This 5/16#-18 bolt has a conical section immediately beneath the head, and on tightening, this section is drawn through and up against the edge of the yoke-like opening. Both the panel and the case are of steel and are finished with a gray paint. (Munsel #N.4.5).

DESCRIPTION OF MATERIAL (Cont'd)

8. Four Lord type rubber shock mountings, one assembled in each of the four rear corners, are provided for mounting the indicator on a bulkhead.

9. Further details of design and construction are shown in photographs, plates 1 and 2, and drawings, references (e) and (f).

OPERATION OF THE SYSTEM

10. The principal circuit elements of the salinity indicating equipment are the conductivity cell, the temperature compensating resistors, the indicating meter, and a transformer with 69 volt tap to the secondary winding.

11. The internal circuit elements of the indicating meter circuit consist of three fixed resistance units, two stationary coils, and two movable coils. The two stationary coils and one resistance unit are connected in series and energized from the 69 volt secondary winding of the transformer. On a common shaft are mounted the two movable coils wound at right angles to each other and free to rotate in the field set up by the two stationary coils.

12. One of the movable coils - henceforth referred to as the holding coil - is connected in series with a second resistance unit, across which is shunted the temperature compensator. In parallel with this portion of the circuit is the conductivity cell connected in series with the other movable coil - henceforth referred to as the deflecting coil. The third fixed resistance unit is connected in series with this series-parallel combination, and the entire circuit is also energized from the 69 volt secondary winding of the transformer.

13. When the system is energized, the deflection of the indicator pointer (mounted on the shaft supporting the two movable coils) is determined by the reaction of the resultant magnetic field of the two movable coils and the field of the two stationary coils; i.e., the indicator pointer position is a function of the ratio of the currents in the two movable coils. At a constant temperature, the resistance across the conductivity cell varies inversely as the salinity of the solution in which the cell is immersed, and correspondingly, the current through the deflecting coil (which is in series with the cell) varies directly with the salinity. The resultant magnetic field of the movable coils is therefore affected, and the indicator pointer position is accordingly a function of the salinity of the solution in which the conductivity cell is immersed.

14. With a solution of a particular salinity, the resistance across the conductivity cell varies inversely as the solution temperature, and correspondingly, the current in the deflecting coil varies directly with the temperature. This would in turn affect the resultant magnetic field of the movable coils and thus the indicator pointer position. Correction for this effect of solution temperature is made by proper selection of

OPERATION OF THE SYSTEM (Cont'd)

resistance values in the temperature compensator. This selection establishes the current in the holding coil at a value such that the ratio of currents in the movable coils, and thus their resultant magnetic field and the indicator pointer position, - is correct for that particular value of salinity, and the instrument is correctly compensated for that value of temperature.

METHOD OF TEST

15. The following tests were conducted in the order given:

- (a)¹ Preliminary accuracy - not specified
- (b) Endurance (50 hr.)
- (c) Shock
- (d) Vibration
- (e)¹ Accuracy
- (f) Endurance (450 hr.)
- (g) Inclination
- (h)¹ Final accuracy - not specified
- (i) Dielectric and Insulation
- (j) Splashproof (indicator meter only)
- (k) Material, Design, and Workmanship Inspection

NOTE: 1 - Accuracy of indication was checked at 115 volts, 60 cycles for the entire range of the temperature compensator at salinities of 0.1, 0.3, 0.5, 1.0, 2.0, and 5.0 gr/gal. In the preliminary accuracy test, this entire check was repeated at 108v, 55 cycles, and 122v, 65 cycles.

RESULTS OF TEST

16. The test results obtained were as follows:

| <u>Requirements</u> | <u>Test Values</u> |
|---|--|
| Accuracy: Para. F-2k and E-6 of spec., ref. (c). | Complied. (Variations \pm 0.5% are considered within the limits of experimental error) |
| Endurance: Para. F-2f of spec., ref. (c). | Complied. |
| Shock Integrity: Para. F-2h of spec., ref. (c). | Complied. |
| Vibration Integrity: Para. F-2i of spec., ref. (c). | Complied. |
| Inclination Integrity: Para. F-2g of spec., ref. (c). | Complied. |

RESULTS OF TEST (Cont'd)

| <u>Requirements</u> | <u>Test Values</u> |
|---|---|
| Indicator Pointer: Para. E-4c (11) of spec., ref. (c). | Complied. |
| Dielectric strength: Para. F-2n of spec., ref. (c). | Complied. |
| Insulation resistance: Para. F-2n of spec., ref. (c). | Complied. |
| Splashproof Integrity: Para. F-1b (2), subpara. (b) of spec., ref. (d). | Complied. (Meter enclosure contained less than 0.5cc of water following test) |
| Scale length: Para. E-4c (9) of spec., ref. (c). | Complied. |
| Selector switch: Para. E-4c(13) of spec., ref. (c). | Complied. |
| Temperature compensator: Para. E-4c(14) of spec., ref. (c). | Complied. |
| Pilot light: Para. E-4c(15) and E-7a of spec., ref. (c) | Complied. |
| Checking resistor: Para. E-4c (17) of spec., ref. (c). | Complied. |
| Nameplate: Para. E-4c(19)a of spec., ref. (c). | Complied. |
| Cell directory plate: Para. E-4c (19)b of spec., ref. (c). | Complied. |
| Weight and Dimensions: Para. E-4c (26) of spec., ref (c). | Complied. |

Height 21 inches
Width 12 inches
Depth 8½ inches
Weight 47-¾ lbs.

CONCLUSIONS

(a) The subject salinity indicating equipment, except cell and valve assembly which has not yet been tested, complied with specification, reference (c), and the splashproof requirement set forth in Paragraph F-1b(2), subparagraph (b), of specification, reference (d).

(b) The internal circuit of the indicating meter as shown in the manufacturer's plan, reference (e), is incomplete and incorrect, and does not agree with the actual circuit of the meter. Plate 16 shows a schematic diagram of the elements of the actual circuit.

TABLE 1

Initial Accuracy Test
(115 volts, 60 cycles)

| Compen- ator Setting °F | Temp. (°F) for values of resist- ances taken from curves | Errors in percent of full scale linear distance | | | | | |
|----------------------------------|--|---|----------------|----------------|----------------|----------------|----------------|
| | | 0.1 gr/ gal | 0.3 gr/ gal | 0.5 gr/ gal | 1.0 gr/ gal | 2.0 gr/ gal | 5.0 gr/ gal |
| 50 | 46.25 | +1.5 | -1.0 | -0.5 | -1.5 | +0.5 | +0.5 |
| 50 | 53.75 | +2.5 | +2.5 | +2.5 | +2.5 | +2.0 | +1.5 |
| 57.5 | 53.75 | +1.5 | 0 | -0.5 | -0.5 | +0.5 | 0 |
| 57.5 | 61.25 | +2.0 | +2.5 | +2.0 | +2.5 | +2.0 | +1.0 |
| 65 | 61.25 | +1.0 | 0 | -0.5 | -1.0 | +0.5 | 0 |
| 65 | 68.75 | +2.0 | +2.0 | +2.0 | +2.5 | +2.0 | +1.0 |
| 72.5 | 68.75 | +0.5 | 0 | -0.5 | -1.0 | +0.5 | 0 |
| 72.5 | 76.25 | +1.5 | +2.0 | +2.0 | +2.5 | +2.0 | +1.0 |
| 80 | 76.25 | +0.5 | 0 | 0 | -1.0 | 0 | 0 |
| 80 | 83.75 | +1.5 | +2.0 | +2.0 | +2.0 | +1.5 | +1.0 |
| 87.5 | 83.75 | 0 | 0 | 0 | -1.0 | 0 | 0 |
| 87.5 | 91.25 | +1.0 | +1.5 | +2.0 | +2.0 | +1.5 | +1.0 |
| 95 | 91.25 | 0 | -0.5 | -0.5 | -1.0 | 0 | 0 |
| 95 | 98.75 | +1.0 | +1.0 | +2.0 | +2.0 | +1.5 | +0.5 |
| 102.5 | 98.75 | 0 | -1.0 | -0.5 | -1.0 | 0 | -0.5 |
| 102.5 | 106.25 | +1.0 | +1.0 | +1.5 | +1.5 | +1.5 | +0.5 |
| 110 | 106.25 | -0.5 | -1.0 | -0.5 | -1.0 | 0 | -0.5 |
| 110 | 113.75 | +0.5 | +1.0 | +1.5 | +1.5 | +1.0 | +0.5 |
| 117.5 | 113.75 | -0.5 | -1.0 | -0.5 | -1.0 | -0.5 | -0.5 |
| 117.5 | 121.25 | 0 | +1.0 | +1.5 | +1.0 | +1.0 | 0 |
| 125 | 121.25 | -0.5 | -1.0 | -0.5 | -1.0 | -0.5 | -1.0 |
| 125 | 128.75 | +0.5 | +1.0 | +1.0 | +1.0 | +1.0 | 0 |
| 132.5 | 128.75 | -0.5 | -1.0 | -0.5 | -1.0 | -0.5 | -1.0 |
| 132.5 | 136.25 | +0.5 | +1.0 | +1.5 | +1.0 | +0.5 | -0.5 |
| 140 | 136.25 | -0.5 | -0.5 | -0.5 | -1.0 | -1.0 | -1.5 |
| 140 | 143.75 | 0 | +1.0 | +1.5 | +1.0 | +0.5 | -0.5 |
| 147.5 | 143.75 | -0.5 | -0.5 | 0 | -0.5 | -1.0 | -1.5 |
| 147.5 | 151.25 | 0 | +1.0 | +1.5 | +1.5 | +0.5 | -0.5 |
| 155 | 151.25 | -0.5 | -0.5 | 0 | -0.5 | -1.0 | -1.5 |
| 155 | 158.75 | 0 | +1.0 | +1.5 | +1.0 | 0 | -1.0 |
| 162.5 | 158.75 | -0.5 | -0.5 | 0 | -0.5 | -1.0 | -1.5 |
| 162.5 | 166.25 | 0 | +1.0 | +1.5 | +1.5 | 0 | -1.0 |
| 170 | 166.25 | -0.5 | -0.5 | 0 | -0.5 | -1.0 | -2.0 |
| 170 | 173.75 | 0 | +1.0 | +1.0 | +1.0 | 0 | -1.5 |
| 177.5 | 173.75 | -0.5 | 0 | 0 | -0.5 | -1.0 | -2.0 |
| 177.5 | 181.25 | 0 | +1.0 | +1.0 | +1.0 | 0 | -1.5 |
| 185 | 181.25 | -0.5 | 0 | 0 | -0.5 | -1.5 | -2.0 |
| 185 | 188.75 | 0 | +1.0 | +1.5 | +1.0 | 0 | -1.5 |
| 192.5 | 188.75 | -0.5 | 0 | +0.5 | -0.5 | -1.5 | -2.0 |
| 192.5 | 196.25 | 0 | +1.0 | +1.5 | 0 | -0.5 | -1.5 |
| 200 | 196.25 | -0.5 | +0.5 | +0.5 | -1.0 | -1.5 | -2.0 |
| 200 | 203.75 | 0 | +1.0 | +1.5 | -0.5 | -0.5 | -2.0 |

TABLE 2

Initial Accuracy Test
(108 volts, 55 cycles)

| Compen- ator setting °F | Temp.(°F) for values of resist- ances taken from curves | Errors in percent of full scale linear distance | | | | | |
|----------------------------------|---|---|----------------|----------------|----------------|----------------|----------------|
| | | 0.1 gr/ gal | 0.3 gr/ gal | 0.5 gr/ gal | 1.0 gr/ gal | 2.0 gr/ gal | 5.0 gr/ gal |
| 50 | 46.25 | +1.0 | -0.5 | -0.5 | -1.5 | 0 | 0 |
| 50 | 53.75 | +2.5 | +3.0 | +2.5 | +2.5 | +2.0 | +1.0 |
| 57.5 | 53.75 | +1.5 | +0.5 | 0 | -0.5 | +0.5 | 0 |
| 57.5 | 61.25 | +2.0 | +2.5 | +2.5 | +2.5 | +2.0 | +1.0 |
| 65 | 61.25 | +1.0 | +0.5 | 0 | -1.0 | 0 | 0 |
| 65 | 68.75 | +2.0 | +2.0 | +2.0 | +2.0 | +2.0 | +1.0 |
| 72.5 | 68.75 | +1.0 | 0 | 0 | -1.0 | 0 | 0 |
| 72.5 | 76.25 | +2.0 | +2.0 | +2.5 | +2.0 | +2.0 | +1.0 |
| 80 | 76.25 | +1.0 | 0 | 0 | -0.5 | 0 | 0 |
| 80 | 83.75 | +2.0 | +2.0 | +2.5 | +2.0 | +2.0 | +1.0 |
| 87.5 | 83.75 | +0.5 | 0 | 0 | -0.5 | 0 | 0 |
| 87.5 | 91.25 | +1.5 | +1.5 | +2.5 | +2.0 | +1.5 | +1.0 |
| 95 | 91.25 | +0.5 | -0.5 | 0 | -0.5 | 0 | 0 |
| 95 | 98.75 | +1.0 | +1.5 | +2.0 | +1.5 | +1.5 | +0.5 |
| 102.5 | 98.75 | 0 | -0.5 | -0.5 | -1.0 | 0 | -0.5 |
| 102.5 | 106.25 | +1.0 | +1.5 | +2.0 | +1.5 | +1.5 | +0.5 |
| 110 | 106.25 | 0 | -0.5 | -0.5 | -1.0 | 0 | -0.5 |
| 110 | 113.75 | +1.0 | +1.0 | +1.5 | +1.5 | +1.0 | 0 |
| 117.5 | 113.75 | -0.5 | -1.0 | -0.5 | -1.0 | -0.5 | -1.0 |
| 117.5 | 121.25 | +0.5 | +1.0 | +1.5 | +1.0 | +1.0 | 0 |
| 125 | 121.25 | -0.5 | -0.5 | -0.5 | -1.0 | -0.5 | -1.0 |
| 125 | 128.75 | +0.5 | +1.0 | +1.5 | +1.0 | +1.0 | -0.5 |
| 132.5 | 128.75 | -0.5 | -0.5 | -0.5 | -1.0 | -0.5 | -1.0 |
| 132.5 | 136.25 | +0.5 | +1.0 | +1.5 | +1.0 | +0.5 | -0.5 |
| 140 | 136.25 | -0.5 | -0.5 | 0 | -0.5 | -0.5 | -1.0 |
| 140 | 143.75 | +0.5 | +1.0 | +1.5 | +1.5 | +0.5 | -0.5 |
| 147.5 | 143.75 | -0.5 | 0 | 0 | -0.5 | -0.5 | -1.5 |
| 147.5 | 151.25 | +0.5 | +1.0 | +1.5 | +1.5 | 0 | -0.5 |
| 155 | 151.25 | -0.5 | -0.5 | 0 | -0.5 | -1.0 | -1.5 |
| 155 | 158.75 | +0.5 | +1.0 | +1.5 | +1.5 | +0.5 | -1.0 |
| 162.5 | 158.75 | -0.5 | -0.5 | 0 | -0.5 | -1.0 | -1.5 |
| 162.5 | 166.25 | +0.5 | +1.0 | +1.5 | +1.5 | 0 | -1.0 |
| 170 | 166.25 | -0.5 | 0 | 0 | -0.5 | -1.0 | -2.0 |
| 170 | 173.75 | 0 | +1.0 | +1.5 | +1.0 | 0 | -1.5 |
| 177.5 | 173.75 | -0.5 | 0 | 0 | -0.5 | -1.0 | -2.0 |
| 177.5 | 181.25 | 0 | +1.0 | +1.5 | +1.0 | 0 | -1.5 |
| 185 | 181.25 | -0.5 | 0 | +0.5 | -0.5 | -1.0 | -2.0 |
| 185 | 188.75 | 0 | +1.0 | +1.5 | +1.0 | -0.5 | -2.0 |
| 192.5 | 188.75 | -0.5 | 0 | +0.5 | -0.5 | -1.5 | -2.0 |
| 192.5 | 196.25 | 0 | +1.5 | +1.5 | 0 | -0.5 | -2.0 |
| 100 | 196.25 | -0.5 | +0.5 | +0.5 | -1.0 | -1.5 | -2.5 |
| 100 | 203.75 | 0 | +1.5 | +1.5 | -0.5 | -0.5 | -2.0 |

TABLE 3

Initial Accuracy Test
(122 volts 65 cycles)

| Compen- sator Setting °F | Temp. (°F) for values of resist- ances taken from curves | Errors in percent of full scale linear distance | | | | | |
|-----------------------------------|--|---|----------------|----------------|----------------|----------------|----------------|
| | | 0.1 gr/ gal | 0.3 gr/ gal | 0.5 gr/ gal | 1.0 gr/ gal | 2.0 gr/ gal | 5.0 gr/ gal |
| 50 | 46.25 | +0.5 | -1.5 | -0.5 | -2.0 | +0.5 | 0 |
| 50 | 53.75 | +2.0 | +2.0 | +2.0 | +2.0 | +2.0 | +1.0 |
| 57.5 | 53.75 | +0.5 | 0 | -0.5 | -1.0 | +0.5 | 0 |
| 57.5 | 61.25 | +2.0 | +2.0 | +2.0 | +2.0 | +2.0 | +1.0 |
| 65 | 61.25 | 0 | 0 | -1.0 | -1.0 | +0.5 | 0 |
| 65 | 68.75 | +1.5 | +2.0 | +2.0 | +2.0 | +2.0 | +1.0 |
| 72.5 | 68.75 | 0 | -0.5 | -1.0 | -1.0 | 0 | 0 |
| 72.5 | 76.25 | +1.0 | +2.0 | +2.0 | +2.0 | +1.5 | +1.0 |
| 80 | 76.25 | 0 | -0.5 | -0.5 | -1.0 | 0 | 0 |
| 80 | 83.75 | +1.0 | +1.5 | +2.0 | +2.0 | +1.5 | +1.0 |
| 87.5 | 83.75 | 0 | -0.5 | -0.5 | -0.5 | 0 | 0 |
| 87.5 | 91.25 | +1.0 | +1.0 | +1.5 | +2.0 | +1.5 | +0.5 |
| 95 | 91.25 | 0 | -1.0 | -1.0 | -1.0 | 0 | 0 |
| 95 | 98.75 | +0.5 | +1.0 | +1.5 | +1.5 | +1.0 | +0.5 |
| 02.5 | 98.75 | -0.5 | -1.0 | -1.0 | -1.0 | 0 | -0.5 |
| 02.5 | 106.25 | +0.5 | +1.0 | +1.5 | +1.5 | +1.5 | +0.5 |
| 10 | 106.25 | -0.5 | -1.0 | -0.5 | -1.0 | 0 | -0.5 |
| 10 | 113.75 | +0.5 | +1.0 | +1.5 | +1.0 | +1.0 | 0 |
| 17.5 | 113.75 | -0.5 | -1.5 | -1.0 | -1.0 | -0.5 | -0.5 |
| 17.5 | 121.25 | 0 | +0.5 | +1.0 | +1.0 | +1.0 | 0 |
| 25 | 121.25 | -0.5 | -1.0 | -1.0 | -1.0 | -0.5 | -1.0 |
| 25 | 128.75 | 0 | +0.5 | +1.0 | +1.0 | +1.0 | 0 |
| 32.5 | 128.75 | -1.0 | -1.0 | -1.0 | -1.0 | -0.5 | -1.0 |
| 32.5 | 136.25 | 0 | +0.5 | +1.0 | +1.0 | +0.5 | -0.5 |
| 40 | 136.25 | -1.0 | -0.5 | -0.5 | -1.0 | -0.5 | -1.0 |
| 40 | 143.75 | 0 | +1.0 | +1.0 | +1.5 | +0.5 | -0.5 |
| 47.5 | 143.75 | -1.0 | -0.5 | -0.5 | -0.5 | -1.0 | -1.5 |
| 47.5 | 151.25 | 0 | +1.0 | +1.5 | +1.5 | +0.5 | -0.5 |
| 55 | 151.25 | -1.0 | -0.5 | -0.5 | -0.5 | -1.0 | -1.5 |
| 55 | 158.75 | 0 | +0.5 | +1.0 | +1.5 | +0.5 | -1.0 |
| 62.5 | 158.75 | -1.0 | -0.5 | -0.5 | -0.5 | -1.0 | -1.5 |
| 62.5 | 166.25 | 0 | +1.0 | +1.0 | +1.0 | 0 | -1.0 |
| 70 | 166.25 | -1.0 | -0.5 | -0.5 | -0.5 | -1.0 | -2.0 |
| 70 | 173.75 | -0.5 | +1.0 | +1.0 | +1.0 | 0 | -1.5 |
| 77.5 | 173.75 | -1.0 | -0.5 | -0.5 | -0.5 | -1.0 | -2.0 |
| 77.5 | 181.25 | -0.5 | +0.5 | +1.0 | +1.0 | -0.5 | -1.5 |
| 85 | 181.25 | -1.0 | -0.5 | 0 | -0.5 | -1.5 | -2.0 |
| 85 | 188.75 | -0.5 | +1.0 | +1.5 | +1.0 | -0.5 | -1.5 |
| 92.5 | 188.75 | -1.0 | 0 | 0 | -0.5 | -1.5 | -2.0 |
| 92.5 | 196.25 | -0.5 | +1.0 | +1.0 | 0 | -0.5 | -2.0 |
| 00 | 196.25 | -1.0 | 0 | +0.5 | -1.0 | -1.5 | -2.5 |
| 00 | 203.75 | -0.5 | +1.0 | +1.5 | -0.5 | -0.5 | -2.0 |

TABLE 4

Accuracy Test after Shock and Vibration
(115 volts, 60 cycles)

| Compen- sator Setting of | Temp.(OF) for values of resist- ances taken from curves | Errors in percent of full scale linear distance | | | | | |
|-----------------------------------|---|---|----------------|----------------|----------------|----------------|----------------|
| | | 0.1 gr/ gal | 0.3 gr/ gal | 0.5 gr/ gal | 1.0 gr/ gal | 2.0 gr/ gal | 5.0 gr/ gal |
| 50 | 46.25 | +0.5 | -2.0 | -2.0 | -2.0 | -1.0 | 0 |
| 50 | 53.75 | +1.5 | +1.0 | +1.5 | +0.5 | +1.5 | +1.0 |
| 57.5 | 53.75 | +0.5 | -0.5 | -2.0 | -1.5 | -0.5 | 0 |
| 57.5 | 61.25 | +1.5 | +1.0 | +1.5 | +0.5 | +1.0 | +1.0 |
| 65 | 61.25 | +0.5 | -0.5 | -2.0 | -1.5 | -0.5 | 0 |
| 65 | 68.75 | +1.5 | +1.0 | +1.0 | +0.5 | +1.0 | +0.5 |
| 72.5 | 68.75 | +0.5 | -0.5 | -2.0 | -1.0 | -0.5 | 0 |
| 72.5 | 76.25 | +1.5 | +1.0 | +1.5 | +1.0 | +1.0 | +0.5 |
| 80 | 76.25 | +0.5 | -0.5 | -1.5 | -1.0 | -0.5 | -0.5 |
| 80 | 83.75 | +1.0 | +1.0 | +1.5 | +1.5 | +1.0 | +0.5 |
| 87.5 | 83.75 | 0 | -0.5 | -1.5 | -0.5 | -0.5 | -0.5 |
| 87.5 | 91.25 | +1.0 | +1.0 | +1.0 | +1.5 | +1.0 | 0 |
| 95 | 91.25 | 0 | -1.0 | -1.5 | -0.5 | -0.5 | -0.5 |
| 95 | 98.75 | +1.0 | +0.5 | +1.0 | +1.0 | +1.0 | 0 |
| 102.5 | 98.75 | 0 | -1.0 | -1.5 | -0.5 | -0.5 | -1.0 |
| 102.5 | 106.25 | +1.0 | +0.5 | +1.0 | +1.5 | +1.0 | 0 |
| 110 | 106.25 | -0.5 | -1.0 | -1.5 | -1.0 | -0.5 | -1.0 |
| 110 | 113.75 | +0.5 | +0.5 | +1.0 | +1.0 | +1.0 | -0.5 |
| 117.5 | 113.75 | -0.5 | -1.0 | -1.5 | -1.0 | -1.0 | -1.0 |
| 117.5 | 121.25 | +0.5 | +0.5 | +1.0 | +1.0 | +0.5 | -0.5 |
| 125 | 121.25 | -0.5 | -1.0 | -1.5 | -1.0 | -1.0 | -1.5 |
| 125 | 128.75 | +0.5 | 0 | +1.0 | +0.5 | 0 | -1.0 |
| 132.5 | 128.75 | -0.5 | -1.0 | -1.5 | -1.0 | -1.0 | -1.5 |
| 132.5 | 136.25 | +0.5 | 0 | +1.0 | +0.5 | -0.5 | -1.0 |
| 140 | 136.25 | -0.5 | -1.0 | -1.0 | -1.0 | -1.5 | -1.5 |
| 140 | 143.75 | +0.5 | +0.5 | +1.0 | +1.0 | 0 | -1.0 |
| 147.5 | 143.75 | -0.5 | -0.5 | -1.0 | -0.5 | -1.5 | -2.0 |
| 147.5 | 151.25 | +0.5 | 0 | +1.0 | +1.0 | -0.5 | -1.0 |
| 155 | 151.25 | -0.5 | -0.5 | -1.0 | -0.5 | -1.5 | -2.0 |
| 155 | 158.75 | 0 | +0.5 | +1.0 | +1.0 | -0.5 | -1.5 |
| 162.5 | 158.75 | -0.5 | -0.5 | -1.0 | -0.5 | -1.5 | -2.0 |
| 162.5 | 166.25 | 0 | +0.5 | +1.0 | +1.0 | -0.5 | -1.5 |
| 170 | 166.25 | -0.5 | -0.5 | -1.0 | -0.5 | -1.5 | -2.0 |
| 170 | 173.75 | 0 | +0.5 | +1.0 | +1.0 | -0.5 | -2.0 |
| 177.5 | 173.75 | -0.5 | -0.5 | -1.0 | -0.5 | -2.0 | -2.5 |
| 177.5 | 181.25 | 0 | +0.5 | +1.0 | +1.0 | -1.0 | -2.0 |
| 185 | 181.25 | -0.5 | -0.5 | -0.5 | -0.5 | -2.0 | -2.5 |
| 185 | 188.75 | 0 | +0.5 | +1.0 | +1.0 | -1.0 | -2.0 |
| 192.5 | 188.75 | -0.5 | 0 | -0.5 | -0.5 | -2.0 | -2.5 |
| 192.5 | 196.25 | 0 | +1.0 | +1.0 | 0 | -1.0 | -2.5 |
| 200 | 196.25 | -0.5 | 0 | -0.5 | -1.0 | -2.0 | -3.0 |
| 200 | 203.75 | 0 | +1.0 | +1.0 | -0.5 | -1.0 | -2.5 |

TABLE 5

Final Accuracy Test
(115 volts, 60 cycles)

| Compen- sator Setting of | Temp. (°F) for values of resist- ances taken from curves | Errors in percent of full scale linear distance | | | | | |
|-----------------------------------|--|---|----------------|----------------|----------------|----------------|----------------|
| | | 0.1 gr/ gal | 0.3 gr/ gal | 0.5 gr/ gal | 1.0 gr/ gal | 2.0 gr/ gal | 5.0 gr/ gal |
| 50 | 46.25 | -0.5 | -2.5 | -2.0 | -2.5 | -1.0 | -1.0 |
| 50 | 53.75 | +1.0 | +1.0 | +1.0 | -0.5 | +1.0 | 0 |
| 57.5 | 53.75 | 0 | -1.0 | -2.0 | -1.0 | -1.0 | -1.0 |
| 57.5 | 61.25 | +1.0 | +1.0 | +1.0 | -0.5 | +1.0 | 0 |
| 65 | 61.25 | -0.5 | -1.0 | -2.0 | -1.5 | -1.0 | -1.0 |
| 65 | 68.75 | +1.0 | +1.0 | +1.0 | +0.5 | +1.0 | 0 |
| 72.5 | 68.75 | -0.5 | -1.5 | -2.0 | -1.0 | -1.0 | -1.0 |
| 72.5 | 76.25 | +1.0 | +1.0 | +1.0 | +1.0 | +1.0 | 0 |
| 80 | 76.25 | -0.5 | -1.5 | -1.5 | -1.0 | -1.0 | -1.0 |
| 80 | 83.75 | +1.0 | +1.0 | +1.0 | +1.0 | +1.0 | 0 |
| 87.5 | 83.75 | -0.5 | -1.0 | -1.5 | -1.0 | -1.0 | -1.0 |
| 87.5 | 91.25 | +0.5 | +0.5 | +0.5 | +1.0 | +1.0 | 0 |
| 95 | 91.25 | -0.5 | -1.5 | -1.5 | -1.0 | -1.0 | -1.0 |
| 95 | 98.75 | +0.5 | +0.5 | +1.0 | +1.0 | +0.5 | 0 |
| 102.5 | 98.75 | -1.0 | -1.5 | -1.5 | -0.5 | -1.5 | -1.0 |
| 102.5 | 106.25 | 0 | +0.5 | +1.0 | +1.5 | +0.5 | 0 |
| 110 | 106.25 | -1.0 | -1.5 | -1.0 | -1.0 | -1.0 | -1.0 |
| 110 | 113.75 | 0 | 0 | +1.0 | +1.0 | +0.5 | -0.5 |
| 117.5 | 113.75 | -1.0 | -1.5 | -1.5 | -1.0 | -1.5 | -1.5 |
| 117.5 | 121.25 | 0 | 0 | +1.0 | +1.0 | 0 | -1.0 |
| 125 | 121.25 | -1.0 | -1.5 | -2.0 | -2.0 | -2.0 | -1.5 |
| 125 | 128.75 | -0.5 | 0 | 0 | -1.0 | -0.5 | -0.5 |
| 132.5 | 128.75 | -1.0 | -1.5 | -1.5 | -1.5 | -1.5 | -1.5 |
| 132.5 | 136.25 | -0.5 | 0 | +1.0 | 0 | -0.5 | -1.0 |
| 140 | 136.25 | -1.0 | -1.0 | -1.0 | -1.0 | -1.5 | -1.5 |
| 140 | 143.75 | -0.5 | +0.5 | +1.0 | +0.5 | -0.5 | -1.0 |
| 147.5 | 143.75 | -1.0 | -1.0 | -1.0 | -0.5 | -1.5 | -2.0 |
| 147.5 | 151.25 | -0.5 | 0 | +1.0 | +0.5 | -0.5 | -1.0 |
| 155 | 151.25 | -1.0 | -1.0 | -1.0 | -0.5 | -1.5 | -2.0 |
| 155 | 158.75 | -0.5 | 0 | +1.0 | +0.5 | -0.5 | -1.5 |
| 162.5 | 158.75 | -1.0 | -1.0 | -1.0 | -0.5 | -1.5 | -2.0 |
| 162.5 | 166.25 | -0.5 | +0.5 | +1.0 | +1.0 | -0.5 | -1.5 |
| 170 | 166.25 | -1.0 | -1.0 | -1.0 | -0.5 | -1.5 | -2.0 |
| 170 | 173.75 | -0.5 | +0.5 | +0.5 | +1.0 | -1.0 | -1.5 |
| 177.5 | 173.75 | -1.0 | -1.0 | -1.0 | -0.5 | -2.0 | -2.0 |
| 177.5 | 181.25 | -0.5 | +0.5 | +1.0 | +1.0 | -1.0 | -1.5 |
| 185 | 181.25 | -1.0 | -1.0 | -0.5 | -0.5 | -2.0 | -2.5 |
| 185 | 188.75 | -0.5 | +0.5 | +1.0 | +1.0 | -1.0 | -2.0 |
| 192.5 | 188.75 | -1.0 | -1.0 | -0.5 | -0.5 | -2.0 | -2.5 |
| 192.5 | 196.25 | -0.5 | +0.5 | +1.0 | 0 | -1.5 | -2.0 |
| 200 | 196.25 | -1.0 | -0.5 | 0 | -1.0 | -2.0 | -2.5 |
| 200 | 203.75 | -0.5 | +1.0 | +1.0 | -0.5 | -1.5 | -2.0 |

TABLE 6

Table of Resistance of Solution in Ohms

Taken from Resistance Temperature Curves, Figure 1
of Reference (c)

| Solution Temp (°F) | 0.1 gr/ gal | 0.3 gr/ gal | 0.5 gr/ gal | 1.0 gr/ gal | 2.0 gr/ gal | 5.0 gr/ gal |
|-----------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 46.25 | 25,500 | 11,400 | 7,080 | 3,900 | 1,890 | 790 |
| 53.75 | 22,900 | 9,800 | 6,400 | 3,400 | 1,700 | 715 |
| 61.25 | 21,000 | 8,900 | 5,800 | 3,100 | 1,550 | 650 |
| 68.75 | 18,850 | 8,150 | 5,300 | 2,810 | 1,410 | 590 |
| 76.25 | 17,100 | 7,400 | 4,800 | 2,570 | 1,290 | 540 |
| 83.75 | 15,850 | 6,800 | 4,400 | 2,350 | 1,180 | 495 |
| 91.25 | 14,550 | 6,350 | 4,100 | 2,170 | 1,100 | 457 |
| 98.75 | 13,550 | 5,900 | 3,780 | 2,010 | 1,020 | 423 |
| 106.25 | 12,600 | 5,450 | 3,500 | 1,880 | 940 | 394 |
| 113.75 | 11,800 | 5,100 | 3,280 | 1,750 | 880 | 369 |
| 121.25 | 11,000 | 4,750 | 3,060 | 1,640 | 830 | 347 |
| 128.75 | 10,350 | 4,450 | 2,880 | 1,540 | 780 | 325 |
| 136.25 | 9,700 | 4,150 | 2,690 | 1,440 | 740 | 307 |
| 143.75 | 9,200 | 3,900 | 2,530 | 1,350 | 695 | 290 |
| 151.25 | 8,650 | 3,700 | 2,390 | 1,270 | 660 | 273 |
| 158.75 | 8,200 | 3,500 | 2,270 | 1,200 | 622 | 260 |
| 166.25 | 7,800 | 3,300 | 2,150 | 1,140 | 590 | 248 |
| 173.75 | 7,400 | 3,140 | 2,050 | 1,090 | 565 | 237 |
| 181.25 | 7,100 | 3,000 | 1,950 | 1,040 | 540 | 226 |
| 188.75 | 6,800 | 2,850 | 1,850 | 995 | 515 | 216 |
| 196.25 | 6,500 | 2,700 | 1,780 | 975 | 495 | 206 |
| 203.75 | 6,200 | 2,600 | 1,700 | 955 | 476 | 199 |

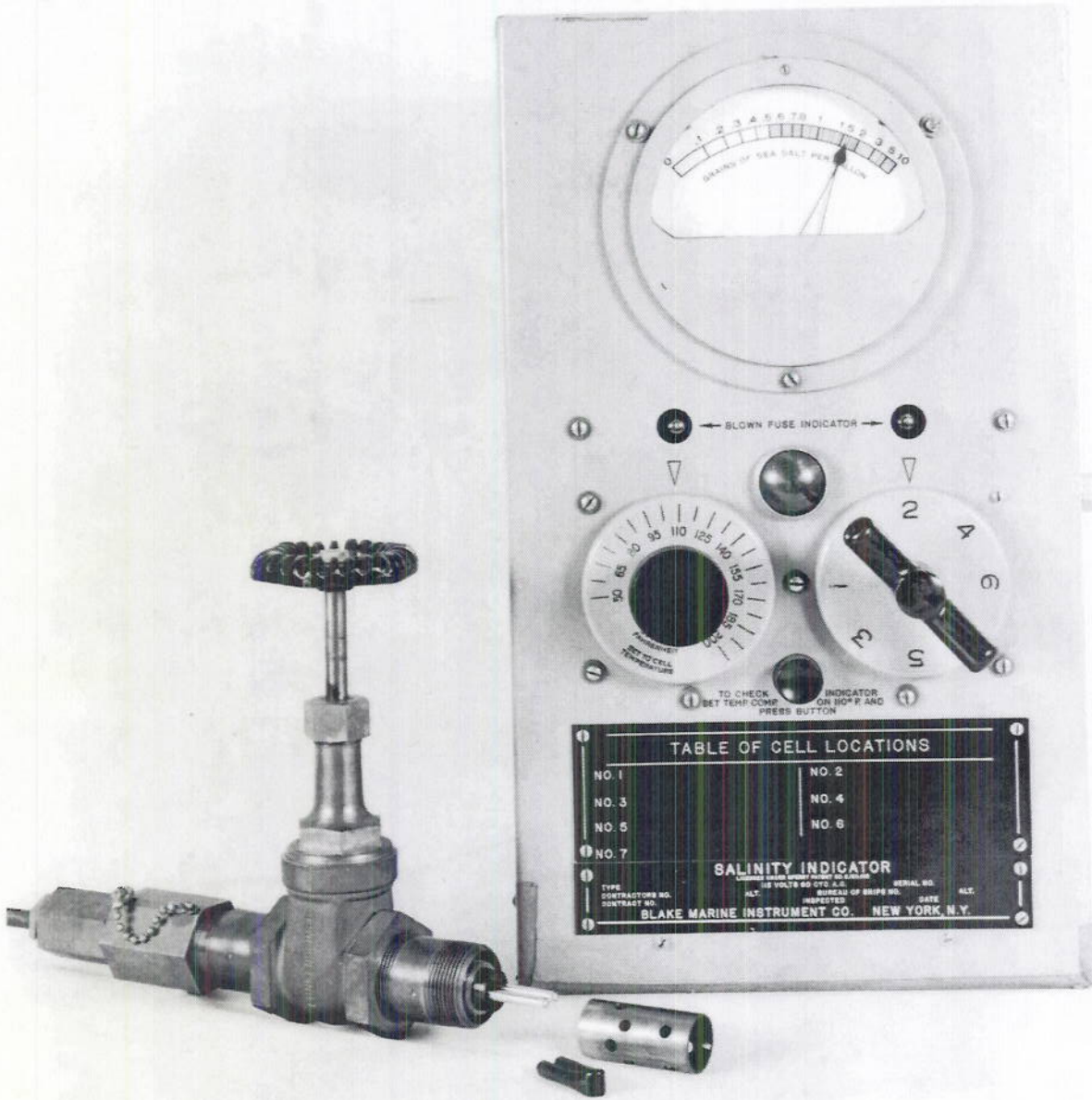


PLATE I

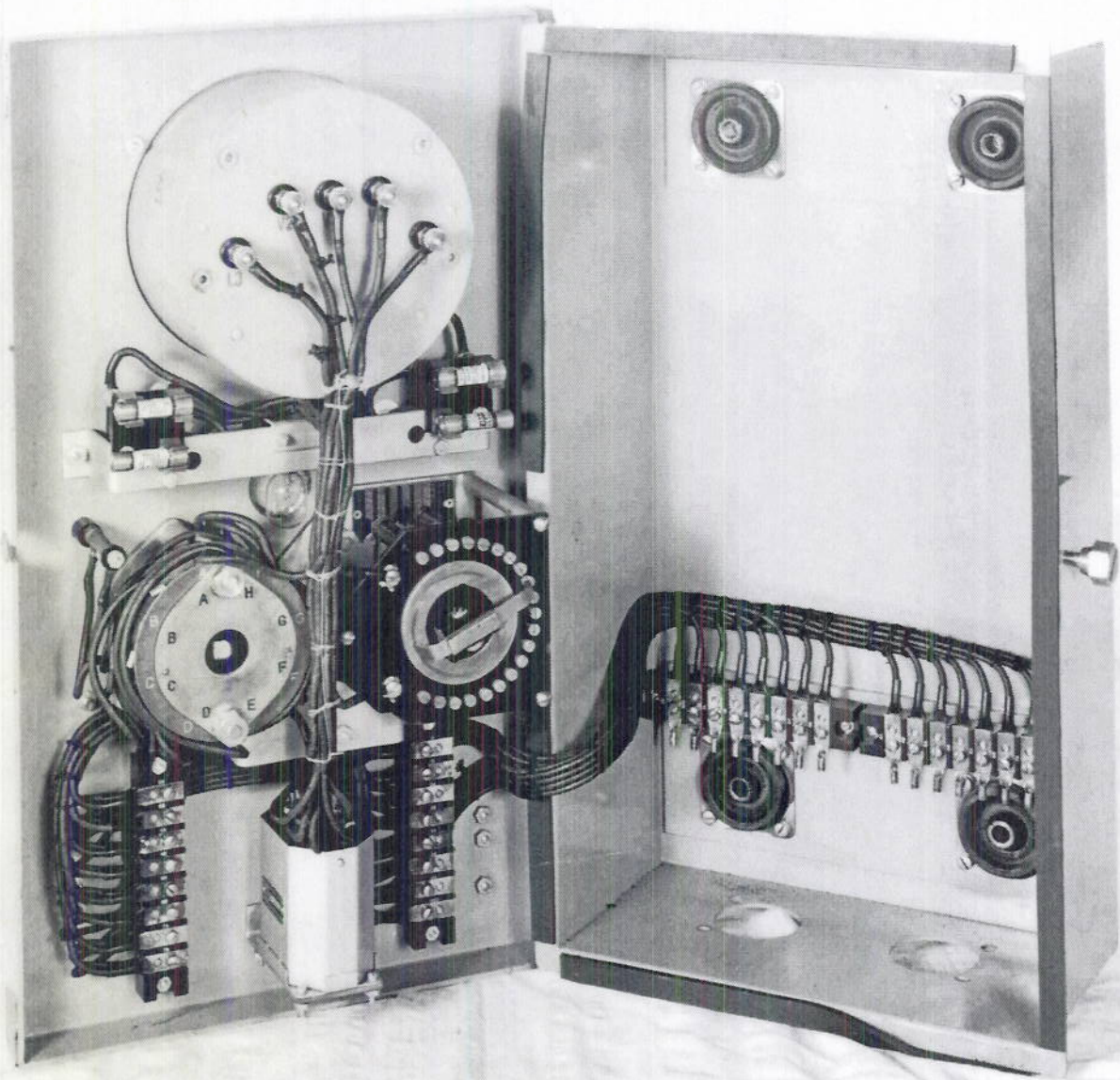
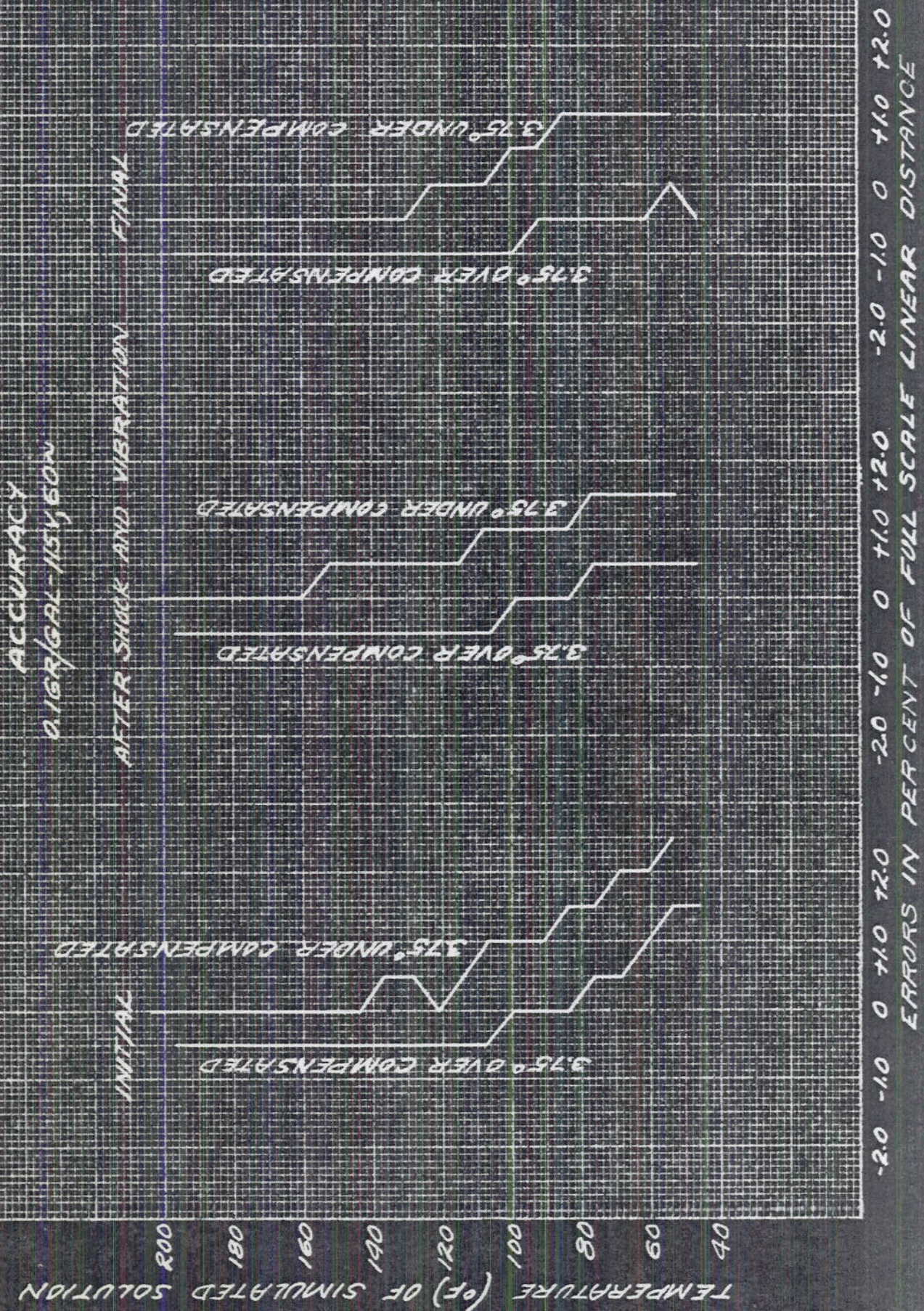
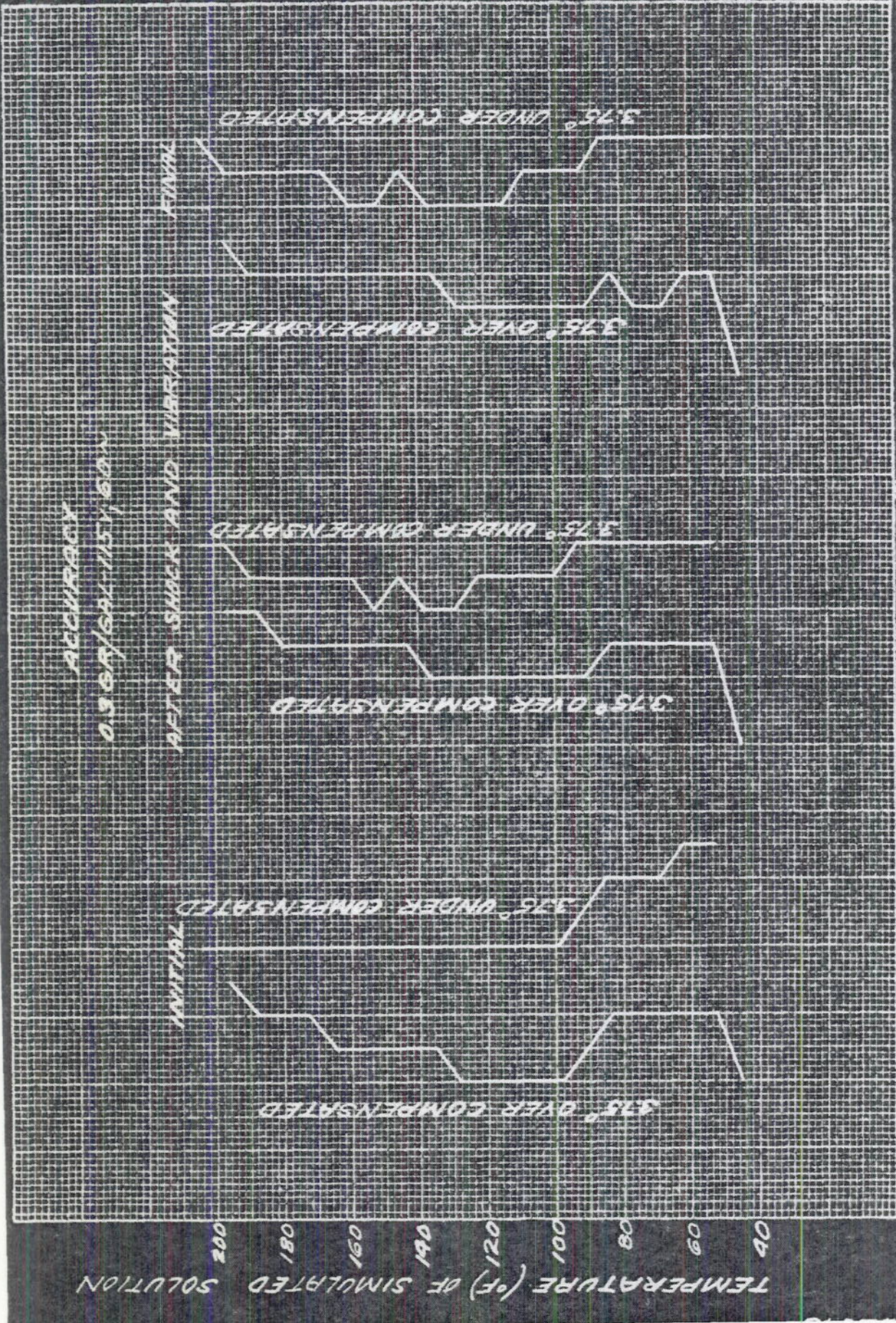


PLATE 2





-2.0 -1.0 0 +1.0 +2.0 -2.0 -1.0 0 +1.0 +2.0 -2.0 -1.0 0 +1.0 +2.0
ERRORS IN PER CENT OF FULL SCALE LINEAR DISTANCE

ACCURACY
0.5 GA/GAL - 115V, 60N

INITIAL AFTER SHOCK AND VIBRATION FINAL

3.75° OVER COMPENSATED

3.75° UNDER COMPENSATED

3.75° OVER COMPENSATED

3.75° UNDER COMPENSATED

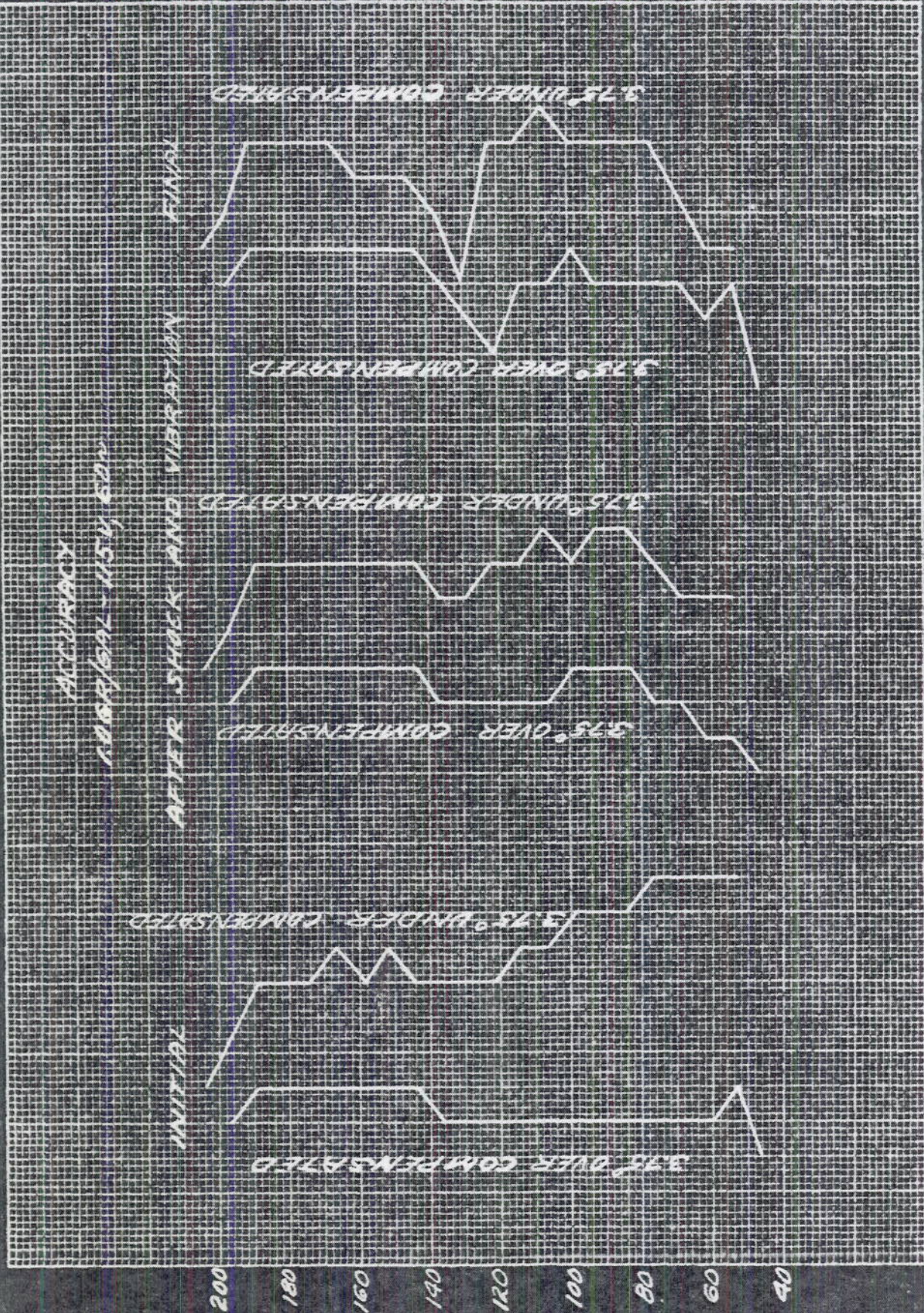
3.75° OVER COMPENSATED

3.75° UNDER COMPENSATED

TEMPERATURE (°F) OF MODULATED SOLUTION

-2.0 -1.0 0 +1.0 +2.0 -2.0 -1.0 0 +1.0 +2.0 -2.0 -1.0 0 +1.0 +2.0 -2.0 -1.0 0 +1.0 +2.0 -2.0 -1.0 0 +1.0 +2.0 -2.0 -1.0 0 +1.0 +2.0

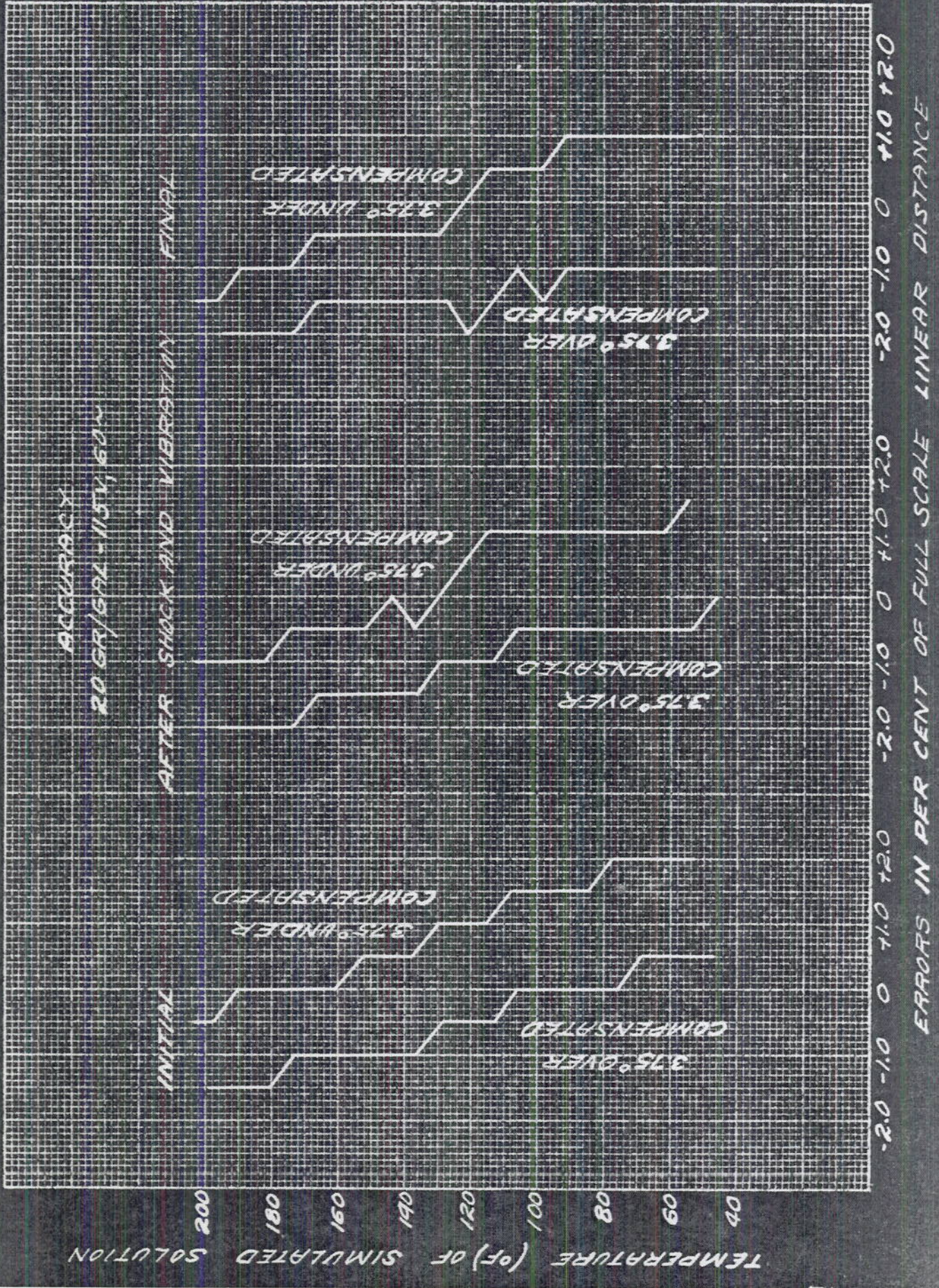
ERRORS IN PER CENT OF FULL SCALE LINEAR DISTANCE



INITIAL
 AFTER SUBJECTS AND VIBRATION
 FACTORS
 ADJUSTED 115%

TEMPERATURE (OF) OF SIMULATED SOLUTION

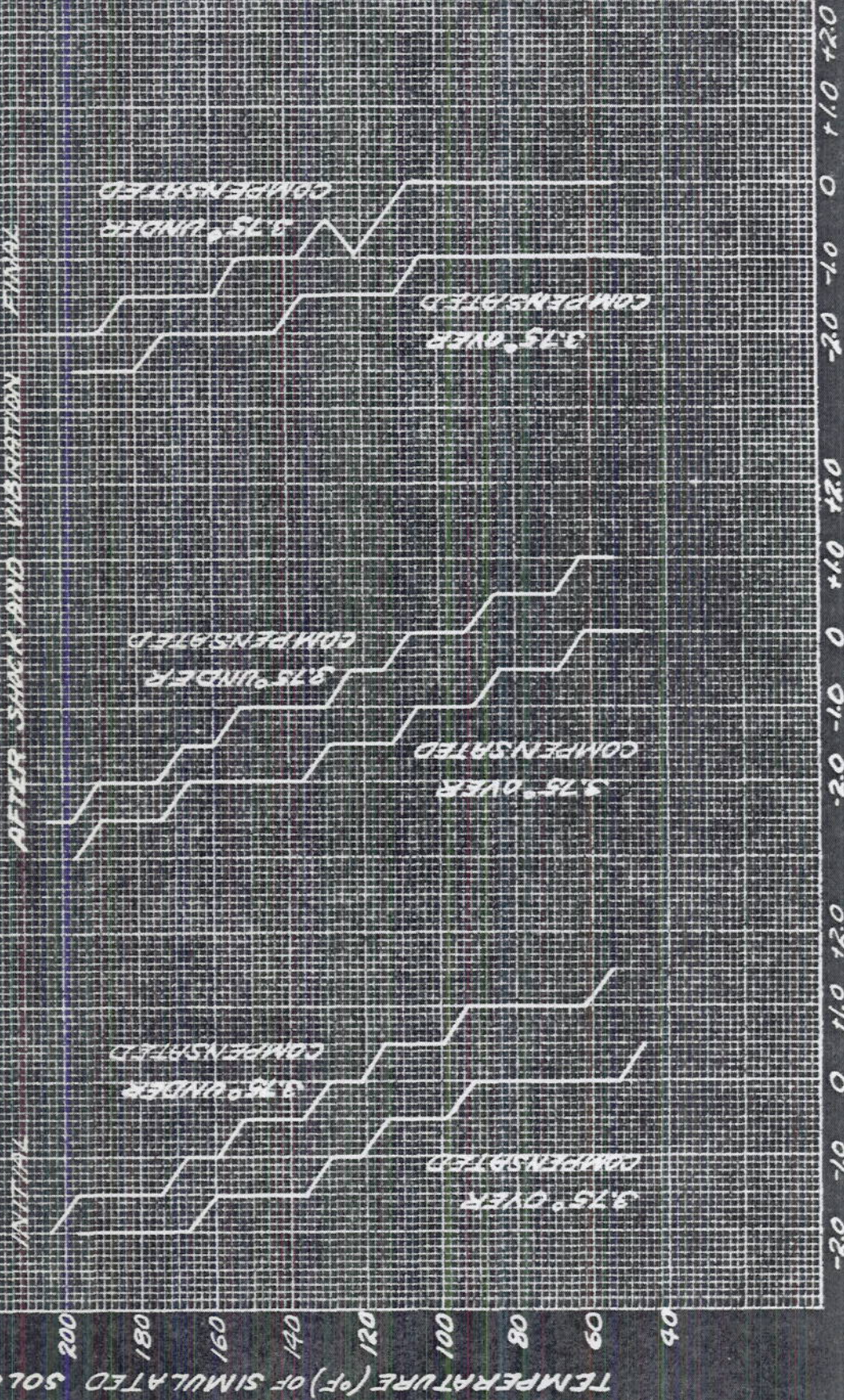
-2.0 -1.0 0 1.0 1.0 2.0 -2.0 -1.0 0 1.0 1.0 2.0 -2.0 -1.0 0 1.0 1.0 2.0
 ERRORS IN PER CENT OF FULL SCALE DISTANCE



ACCURACY

50 PER/SEN - 16/1/60

INITIAL AFTER SURGE AND RESTORATION TO MAX



ERRORS IN PER CENT OF FULL SCALE LINEAR DISTANCE

TEMPERATURE (°F) OF SIMULATED SOLUTION

INITIAL ACCURACY

0.1 GR/GAL

TEMPERATURE (°F) OF SIMULATED SOLUTION

128.465W

115.460W

105.460W

375° UNDER COMPENSATED

375° OVER COMPENSATED

375° UNDER COMPENSATED

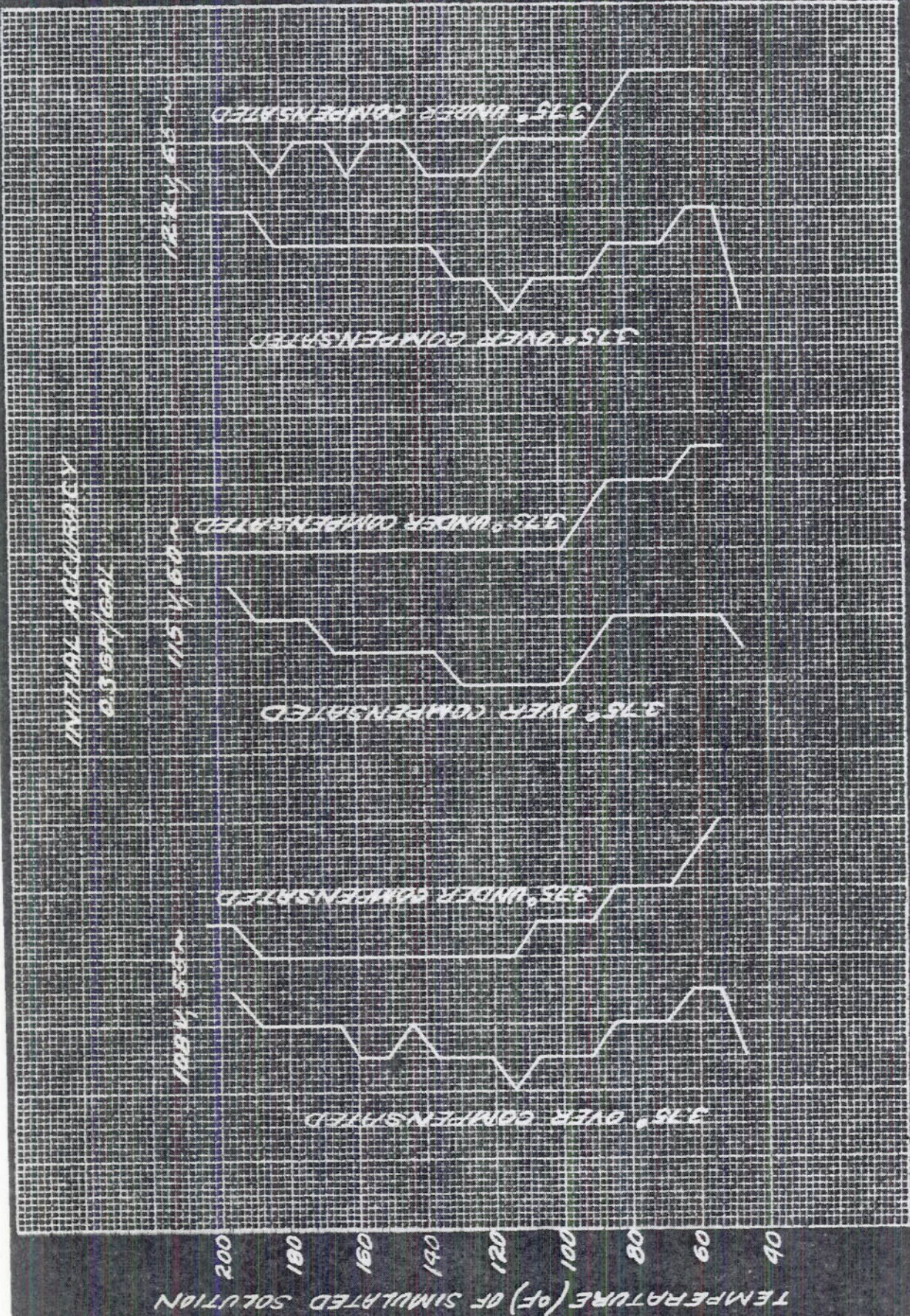
375° OVER COMPENSATED

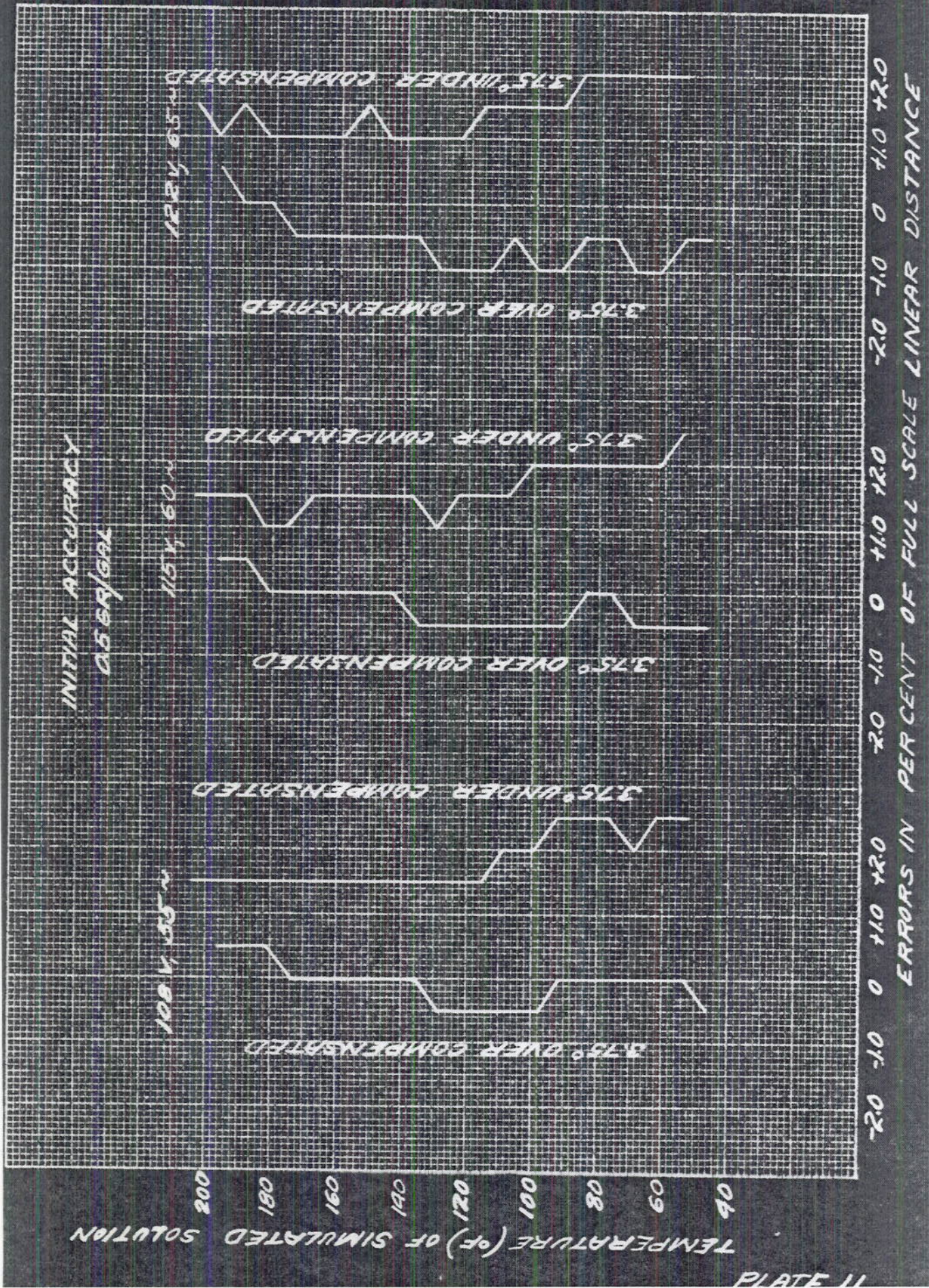
375° UNDER COMPENSATED

375° OVER COMPENSATED

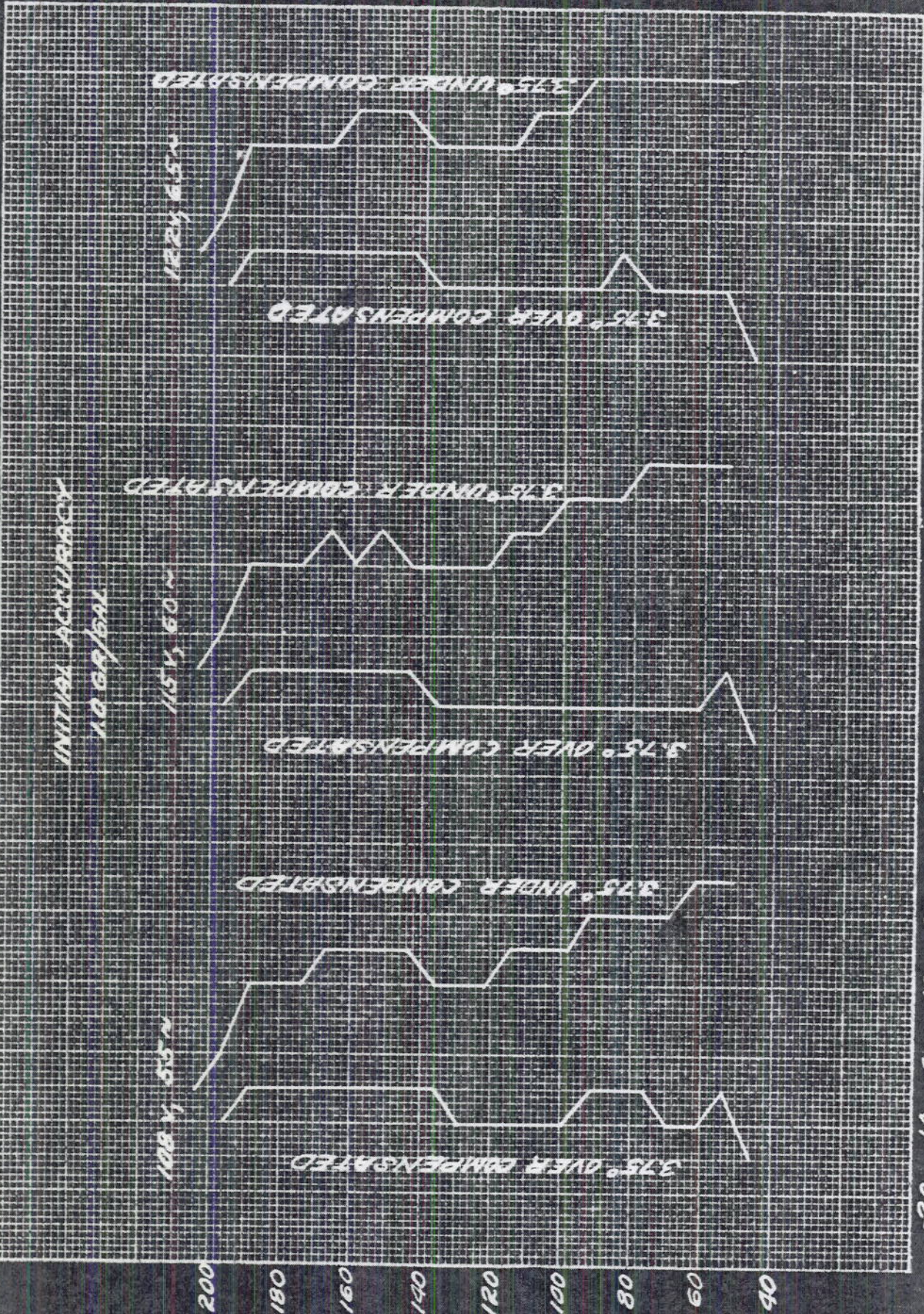
-2.0 -1.0 0 1.0 2.0 -2.0 -1.0 0 1.0 2.0 -2.0 -1.0 0 1.0 2.0
ERRORS IN PER CENT OF FULL SCALE LINEAR DISTANCE

8 11 17 18





TEMPERATURE (% OF SIMULATED SOLUTION)



ERRORS IN PER CENT OF FULL SCALE LINEAR DISTANCE

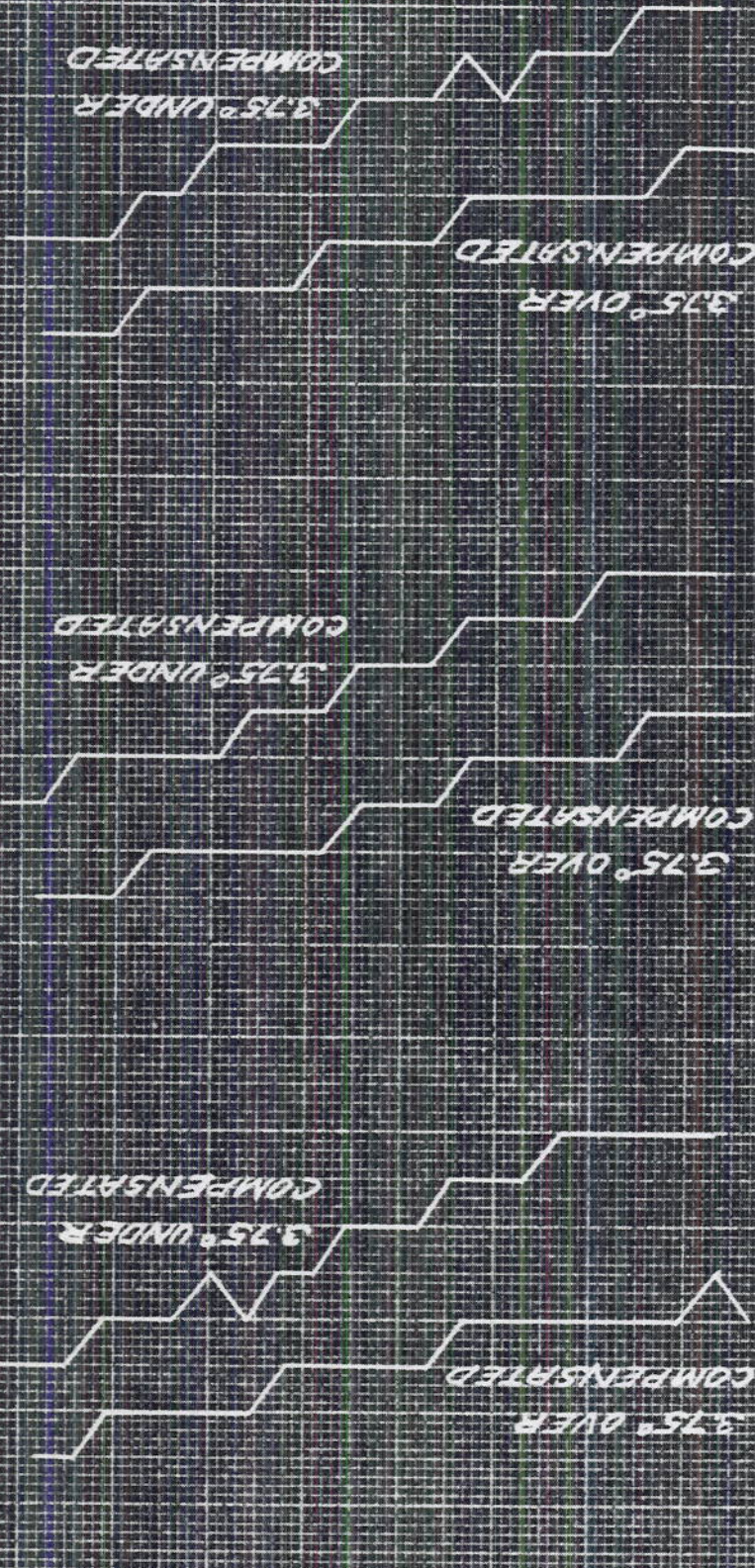
INITIAL ACCURACY
20 cps/cent

1224.65W

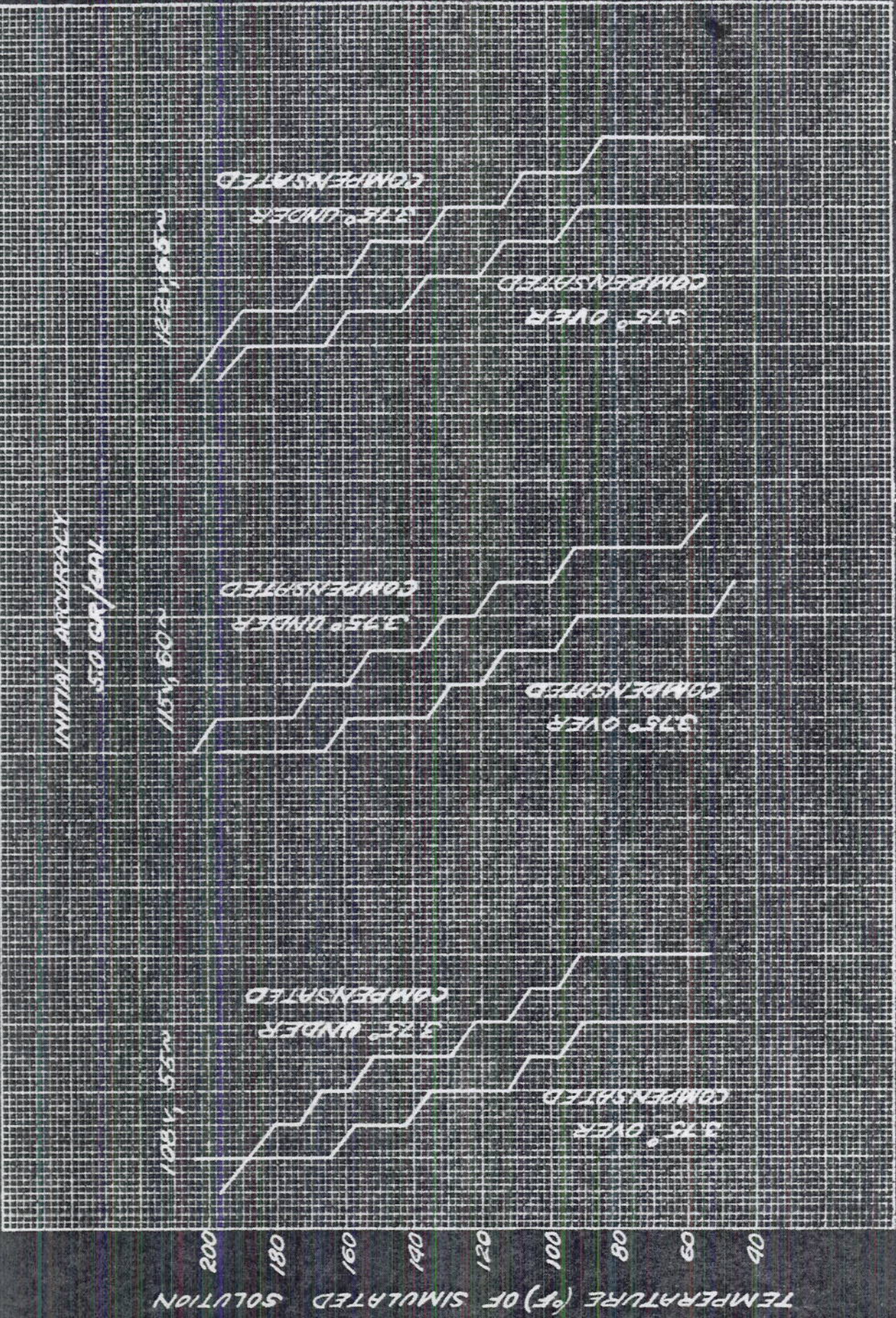
1154.60W

1084.55W

TEMPERATURE (°F) OF SIMULATED



2.0 -1.0 0 +1.0 +2.0 -2.0 -1.0 0 +1.0 +2.0 -2.0 -1.0 0 +1.0 +2.0
ERRORS IN PER CENT OF FULL SCALE LINEAR DISTANCE



INITIAL ACCURACY
570 cps/ft

105, 550

150, 600

185, 650

TEMPERATURE (°F) OF SIMULATED SOLUTION

ERRORS IN PER CENT OF FULL SCALE LINEAR DISTANCE

0 1 2 3 4 5
LINEAR DISTANCE IN INCHES AS
MEASURED ON SCALE PERIPHERY
(ABCISSA FOR CURVE X)

5.0

SALINITY VALUES ON SCALE IN GR/GAL

0

5

5

ERROR IN PER CENT OF FULL SCALE
LINEAR DISTANCE

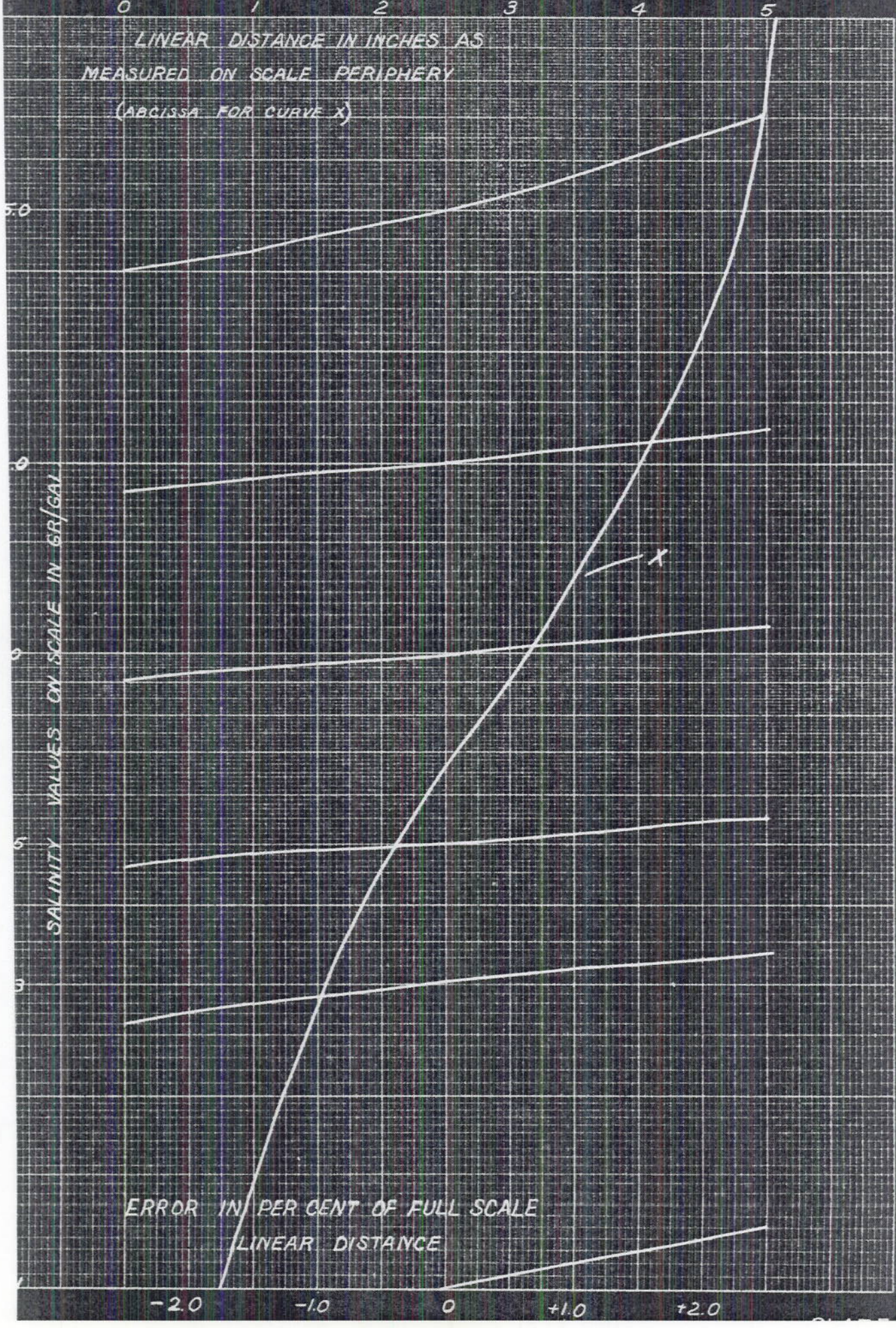
-2.0

-1.0

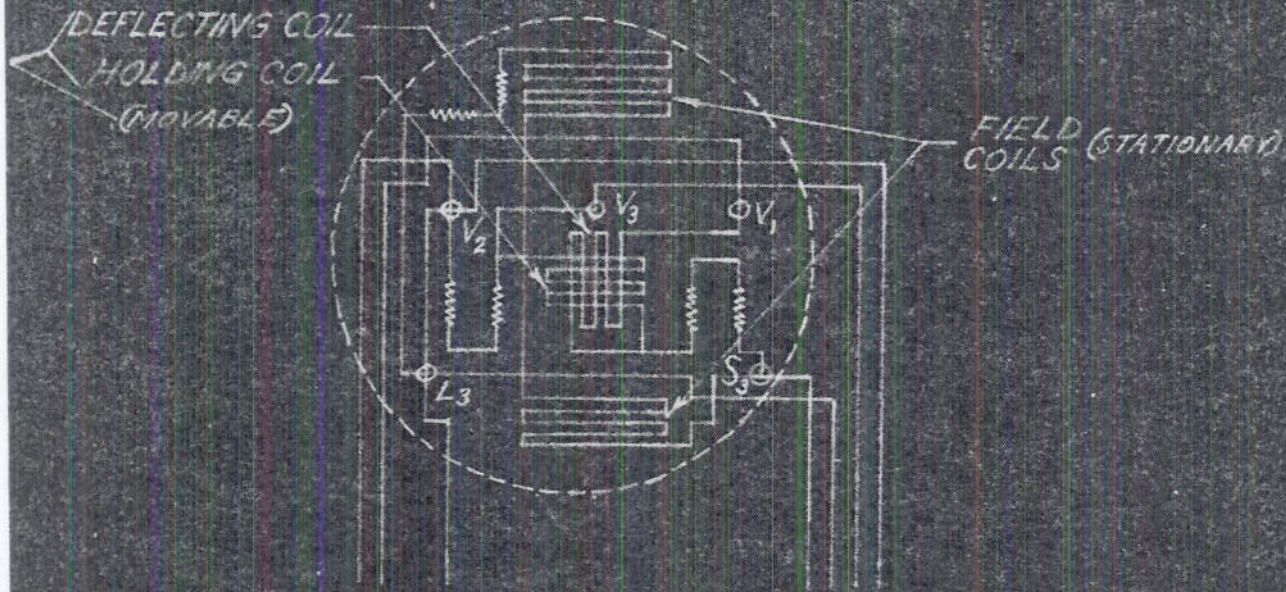
0

+1.0

+2.0



INDICATOR METER
INTERNAL CIRCUIT



AS VIEWED
FROM REAR
OF PANEL