

FR-1340

REPORT NO. B-1340

DATE 28 January 1937

SUBJECT

TEST ON SALINITY INDICATOR EQUIPMENT



BY

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

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NRL Report No. B-1340

NAVY DEPARTMENT
BUREAU OF ENGINEERING

Report of

Test on Salinity Indicator Equipment

Submitted by
Sperry Gyroscope Company

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON DC

Number of Pages: Text - 5 Tables - 2 Plates - 6
Authorizations: Bu.Eng.ltr.S65-5/L5(12-4-Ds) of 7 December 1936.
Date of Tests: December 1936 and January 1937.

Prepared by: W.B. Roberts, Pr.Eng.Aide, Chief of Section.

Reviewed by: J.A. McNally, Lieutenant, U.S.N.

Approved by: H.M. Cooley, Captain, U.S.N., Director.

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AUTHORIZATION

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

- Reference: (a) Bu.Eng.ltr.S65-5/L5 (12-4-Ds) of 7 December 1936.
(b) Specifications SGS(65)-131a, Salinity Indicator Equipment, of 15 April 1936.
(c) Manufacturer's Drawing (no number assigned), forwarded to Bureau under separate cover.

OBJECT OF TEST

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

ABSTRACT OF TEST

3. The subject system, shown by Plates 1 to 4 inclusive, was set up at this Laboratory in suitable test circuits and carefully checked for conformance with the specifications, reference (b). All tests were made in order as specified, except that the vibration test was omitted and the 500-hour endurance test was shortened to 50 hours as requested by the Bureau in order to expedite the tests. The test was concluded with the usual inspection of the equipment to ascertain whether it complied with the requirements in the matter of materials, design and workmanship.

CONCLUSIONS

(a) The performance of the modified indicator, under shock, was entirely satisfactory.

(b) The accuracy of this indicator following the shock test was slightly less than the accuracy of the original indicator before the application of shock. However, it complies with the specifications.

(c) The indicator complied with the insulation and dielectric test requirements.

(d) The conductivity cells withstood the required hydrostatic tests.

(e) The following changes in the indicator are suggested:

- (1) Substitute an engraved "Monel" nameplate for the painted nameplate furnished.
- (2) Engrave on compensator dial to read "Set to cell temperature".
- (3) Provide "bulls' eyes" for the fuse indicating lights.
- (4) Engrave on cell selector dial beneath word "check", "Set comp. to 110°".

RECOMMENDATIONS

(a) In view of the salinity indicating equipment being, in general, satisfactory and of its compliance with the specifications as amended, it is recommended that it be approved for Naval use.

Indicate the water content of the boiler feed and other water lines.

5. The indicator unit weighs 49-1/4 pounds, is 8-1/2" x 12-1/2" x 21" and consists of the following parts:

- (a) A power factor meter, its dial graduated to read the salt content in salinity units (gr./gal.).
- (b) A transformer, ratio 115/100-60, for insulating the indicator circuits from the circuits of the ship.
- (c) A rotary Navy Type J selector switch for connecting any one of the conductivity cells or the checking resistor to the indicator.
- (d) A temperature compensator rotary selector switch, having a dial graduated from 50°F to 200°F, in steps of 10°F, to be set to the temperature of the water under test.
- (e) A checking resistor for testing the operation of the system with compensator set at 110°F.
- (f) A pair of fuses, each mounted with a Navy Type BU-2-B lamp which glows when a fuse is blown.
- (g) A pilot light, equipped with a blue glass lens and a G-5 lamp, for indicating when the secondary circuit of the supply transformer is energized.

6. All of these parts are mounted on a blazed brass cover of a steel case of diamond construction finished in gray. Flexible lead wires, flame resistant, connect the units to a terminal block located in the back of the case.

7. Four shock absorbing units, located in the back of the case, are provided for mounting the indicator unit.

8. The indicator dial is divided into three sections, the markings and gradations being as follows:

<u>Dial Reading</u>	<u>Indications</u>
0 to 0.5 grains	White, "Clear"
0.5 to 1.0 grains	Green, "Caution"
1.0 to 10.0 grains	Red, "Danger"

DESCRIPTION OF MATERIAL UNDER TEST

4. The equipment submitted consists of one indicator unit and two conductivity cells, both shown by Plates 1 to 4 inclusive. The system operates from a supply of 115 volts, A.C., 60 cycles, its purpose being to indicate the saline contents of the boiler feed and other water lines.

5. The indicator unit weighs 49-1/4 pounds, is 8-1/2" x 12-1/2" x 21" and consists of the following parts:

- (a) A power factor meter, its dial graduated to read the salt content in salinity units (gr./gal.).
- (b) A transformer, ratio 115/100-60, for insulating the indicator circuits from the circuits of the ship.
- (c) A rotary Navy Type J selector switch for connecting any one of the conductivity cells or the checking resistor to the indicator.
- (d) A temperature compensator rotary selector switch, having a dial graduated from 50°F to 200°F, in steps of 7.5°F, to be set to the temperature of the water under test.
- (e) A checking resistor for testing the operation of the system with compensator set at 110°F.
- (f) A pair of fuses, each shunted with a Navy Type VG-2-N lamp which glows when a fuse is blown.
- (g) A pilot light, equipped with a blue glass lens and a CS-5 lamp, for indicating when the secondary circuit of the supply transformer is energized.

6. All of these parts are mounted on a hinged brass cover of a steel case of dripproof construction finished in gray. Flexible lead wires, flame resistant, connect the units to a terminal block located in the back of the case.

7. Four shock absorbing units, located in the back of the case, are provided for mounting the indicator unit.

8. The indicator dial is divided into three sections, the markings and graduations being as follows:

Dial Reading

Indications

0 to 0.5 grain

White, "Clear"

0.5 to 1.0 grain

Green, "Caution"

1.0 to 10.0 grains

Red, "Danger"

CONDUCTIVITY CELLS

9. The conductivity cell is designed for installation in the boiler feed line, or others as desired, and is electrically connected to the indicator unit from which salinity indications may be read in "Grains of Chlorine Per Gallon". The cell consists of two platinum sheathed electrodes housed in a cylindrical brass tube enclosed in a second brass tube which is equipped with a gate-valve so that the cell may be withdrawn for inspection. The electrodes are protected from injury by a cylindrical guard. Each cell is equipped with six feet of portable rubber cord extending through a stuffing gland.

OPERATION OF SYSTEM

10. When a cell circuit is closed, the deflecting coil in the meter, being connected in series, moves a pointer across a graduated dial; the displacement of the coil and pointer with respect to the fixed coil being proportional to the current flowing in the cell circuit. The power factor meter, used as an indicator, self-compensates for variations in the voltage and frequency, and the ambient temperature.

11. The manufacturer's drawing of the indicator unit, reference (c), gives further details in the design and construction. The wiring diagram of the system is shown by Plate 5.

METHOD OF TEST

12. The indicator was first tested for accuracy by substituting resistors of suitable values taken from temperature resistance curves for standard salinity solutions, shown by Plate 6. The readings were taken at six points on the dial at four compensator positions.

13. An endurance test was next conducted by successively connecting the correct values of resistance in a cell circuit causing the pointer to indicate 0.1, 0.5, 1.0, 2.0 and 5.0 grains of chlorine per gallon. This change occurred at the rate of thirty readings per minute and was continued for fifty hours.

14. The endurance test was then interrupted for the purpose of conducting the shock test, consisting of one blow at each value between 25 and 250 foot pounds, in steps of 25 foot pounds, followed by 10 blows of 250 foot pounds.

15. As the power factor meter was damaged during the shock test, no further tests could be conducted.

16. After modifications by the manufacturer, which included additional supports for the meter scale and rubber mountings for the indicator case, the indicator was again installed on the shock stand. Shocks of five 150-foot pound blows, five 200-foot pound blows and fifteen 250-foot pound blows were applied with the system operating.

17. Following the second shock test, the indicator was again checked for accuracy, as outlined under paragraph 12. The remaining endurance test was omitted by direction of the Bureau.

18. The conductivity cells were subjected to a hydrostatic pressure of 150 pounds per square inch for a period of one hour. The temperature of the water was held at 150°F.

19. The insulation resistance and dielectric strength tests and an inspection of the material to ascertain whether it was in conformance with the specifications concluded the test.

RESULTS OF TESTS

20. Tables 1 and 2 give the results of the accuracy tests prior to and following the modifications by the manufacturer. If there were any errors caused by variations of ± 5 cycles in frequency or ± 10 volts, they could not be read on the indicator.

21. Under the first shock test, no change was observed until the sixth blow, when the pointer contacted the dial. The following blow freed the pointer, but the nineteenth blow caused it to break off. No other damage was noted.

22. The shock test on the modified instrument had no apparent effect.

23. The conductivity cells successfully withstood the required hydrostatic tests. The test set-up is shown by Plate 4.

24. The insulation resistance between all current-carrying parts and ground was 100 megohms by 500 volt Megger, following the application of a dielectric test of 1500 volts, A.C., 60 cycles for one minute.

CONCLUSIONS

25. The performance of the modified indicator, under shock, was entirely satisfactory.

26. The accuracy of this indicator following the shock test was slightly less than the accuracy of the original indicator before the application of shock. However, it complies with the specifications.

27. The indicator complied with the insulation and dielectric test requirements.

28. The conductivity cells withstood the required hydrostatic tests.

29. The following changes in the indicator are suggested:

- (1) Substitute an engraved "Monel" nameplate for the painted nameplate furnished.
- (2) Engrave on compensator dial to read "Set to cell temperature".
- (3) Provide "bulls' eyes" for the fuse indicating lights.
- (4) Engrave on cell selector dial beneath word "check", "Set comp. to 110°".

TABLE 1.

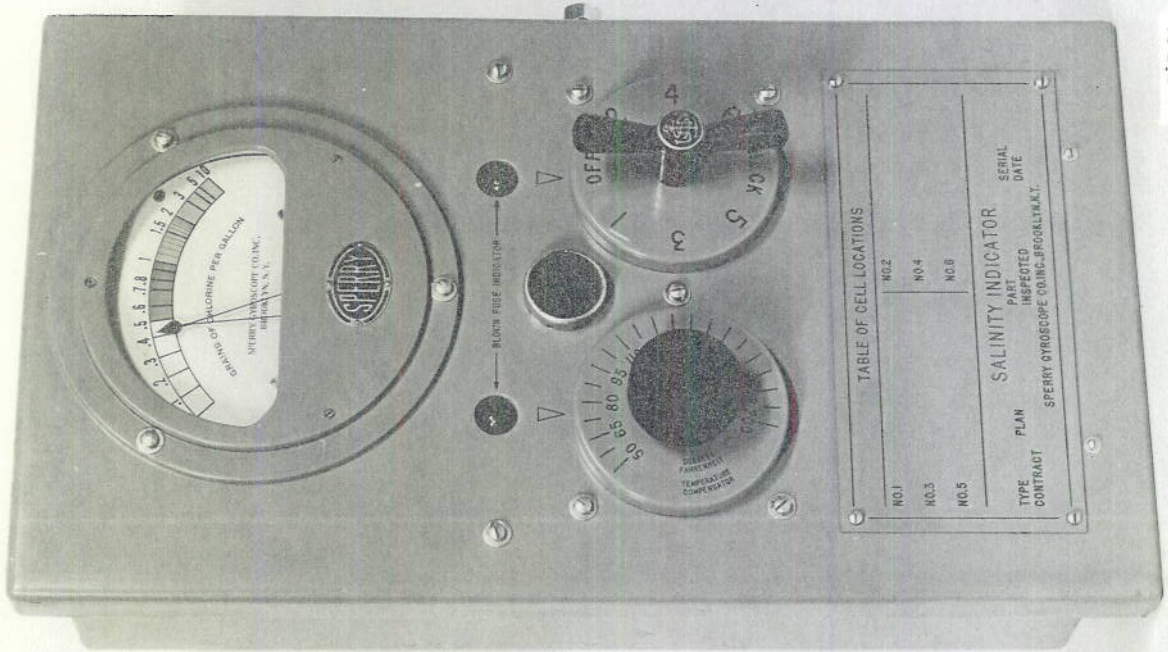
ACCURACY TEST ON SALINITY SYSTEM (BEFORE SHOCK).

Test with compensator set at 80°F using original meter.				Test with compensator set at 110°F using original meter.			
Simulated Salinity	Resistance used - from curves ohms	Indicated Salinity	Resistance value used for zero error ohms	Simulated Salinity	Resistance used - from curves ohms	Indicated Salinity	Resistance value used for zero error ohms
.1	25,550	.1	25,800	.1	18,800	.1	18,800
.2	12,800	.2 ⁺	12,800	.2	9,350	.2	9,350
.5	5,100	.5 ⁺	5,130	.5	3,750	.5	3,720
1.0	2,580	1.0	2,570	1.0	1,890	1.0	1,890
2.0	1,310	2.0 ⁻	1,290	2.0	960	2.0 ⁻	950
5.0	520	5.0 ⁺	540	5.0	385	5.0 ⁺	400
Test with compensator set at 155°F using original meter.				Test with compensator set at 200°F using original meter.			
Simulated Salinity	Resistance used - from curves ohms	Indicated Salinity	Resistance value used for zero error ohms	Simulated Salinity	Resistance used - from curves ohms	Indicated Salinity	Resistance value used for zero error ohms
.1	13,200	.1	13,200	.1	10,000	.1	10,000
.2	6,600	.2	6,500	.2	5,000	.2 ⁻	4,910
.5	2,600	.5	2,590	.5	1,980	.5 ⁻	1,960
1.0	1,330	1.0 ⁻	1,300	1.0	1,000	1.0 ⁻	990
2.0	660	2.0	660	2.0	500	2.0	500
5.0	265	5.0 ⁺	280	5.0	200	5.0 ⁺	210

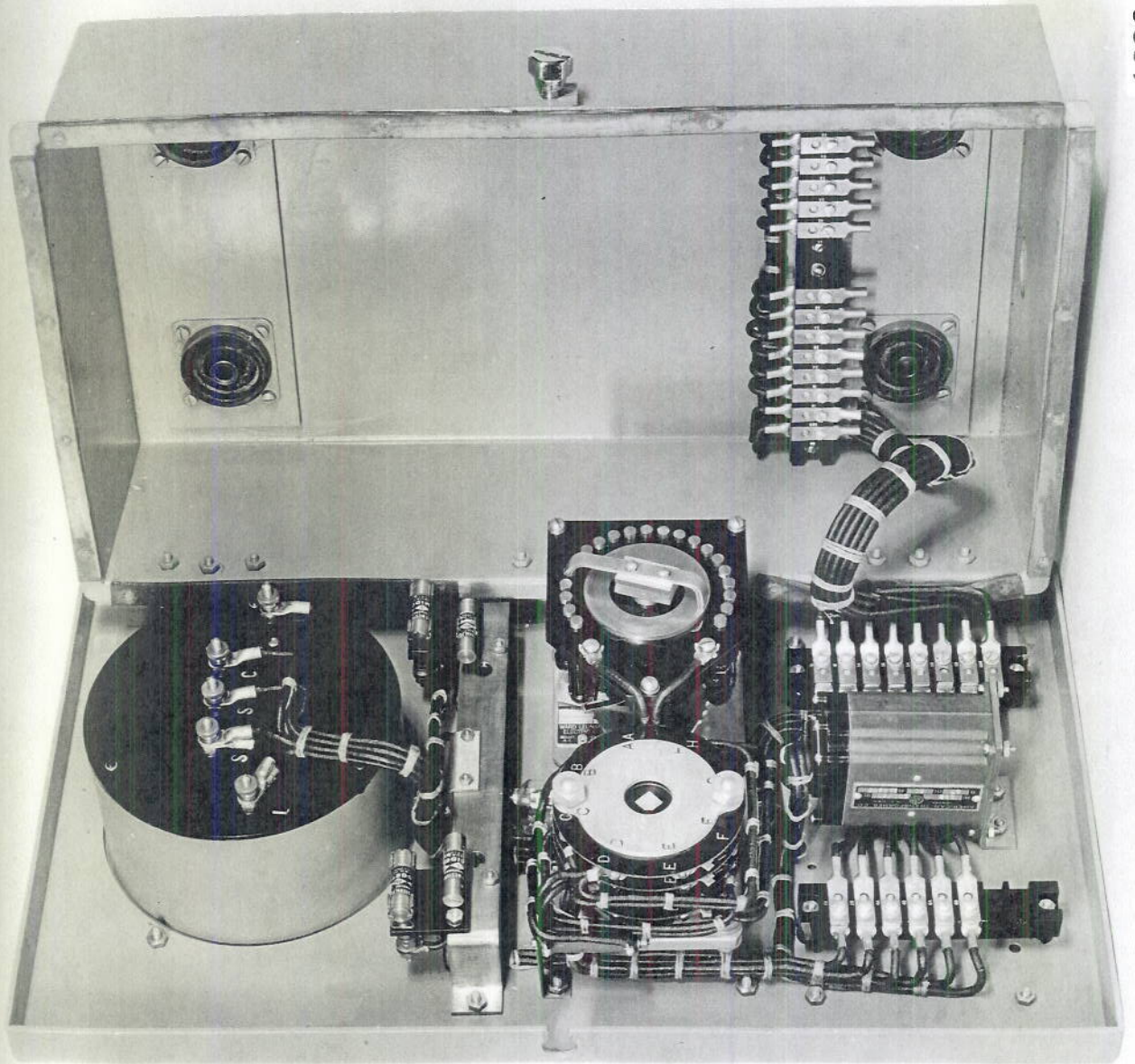
TABLE 2.

ACCURACY TEST ON MODIFIED SALINITY SYSTEM (AFTER SHOCK).

Test with compensator set at 80°F.				Test with compensator set at 110°F.			
Simulated Salinity	Resistance used - from curves	Indicated Salinity	Resistance value used for zero error	Simulated Salinity	Resistance used - from curves	Indicated Salinity	Resistance value used for zero error
.1	ohms 25,550	.1	ohms 25,500	.1	ohms 18,800	.1	ohms 18,880
.2	12,800	.2 ⁻	12,600	.2	9,350	.2	9,400
.5	5,100	.5 ⁺	5,130	.5	3,750	.5	3,760
1.0	2,580	1.0	2,590	1.0	1,890	1.0	1,890
2.0	1,310	1.95	1,290	2.0	960	1.9	925
5.0	520	4.8	480	5.0	385	4.7	355
Test with compensator set at 155°F				Test with compensator set at 200°F			
Simulated Salinity	Resistance used - from curves	Indicated Salinity	Resistance value used for zero error	Simulated Salinity	Resistance used - from curves	Indicated Salinity	Resistance value used for zero error
.1	ohms 13,200	.1	ohms 13,200	.1	ohms 10,000	.1	ohms 10,000
.2	6,600	.2	6,500	.2	5,000	.2	5,000
.5	2,600	.5	2,620	.5	1,980	.5	1,980
1.0	1,330	1.0	1,310	1.0	1,000	1.0	1,000
2.0	660	1.95	640	2.0	500	1.95	487
5.0	265	4.7	245	5.0	200	4.8	185



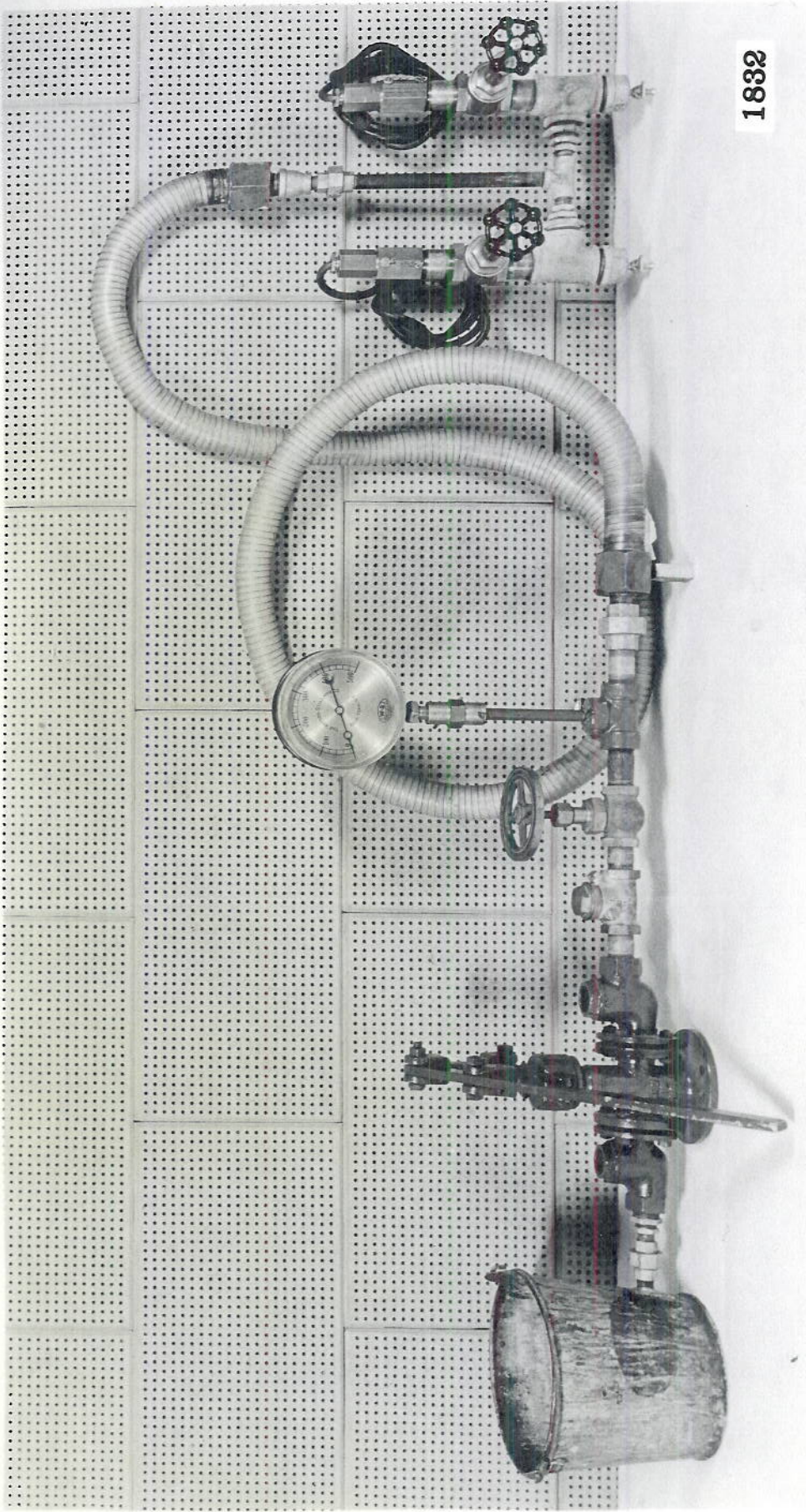
1835



1836



1833

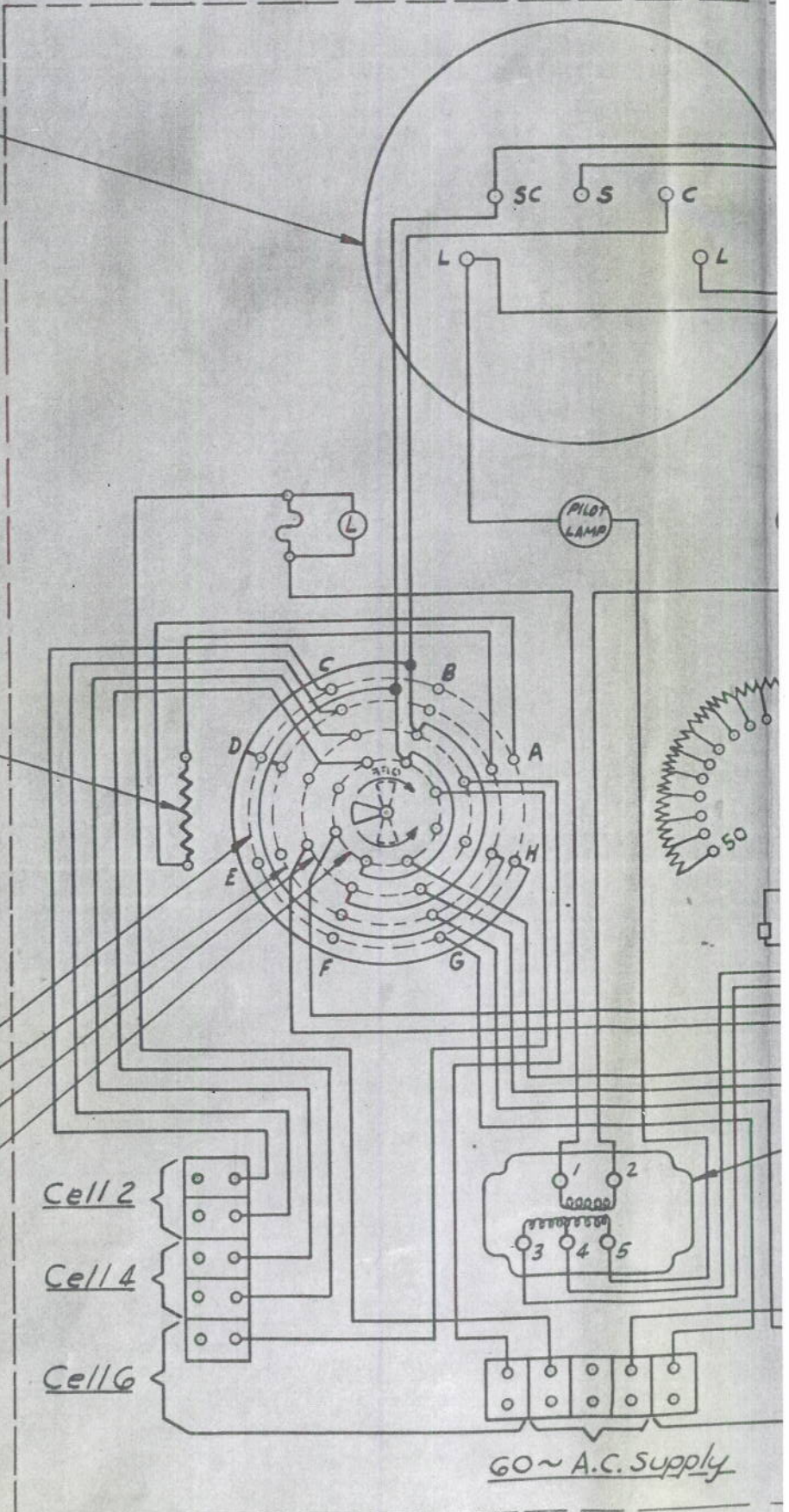


1832

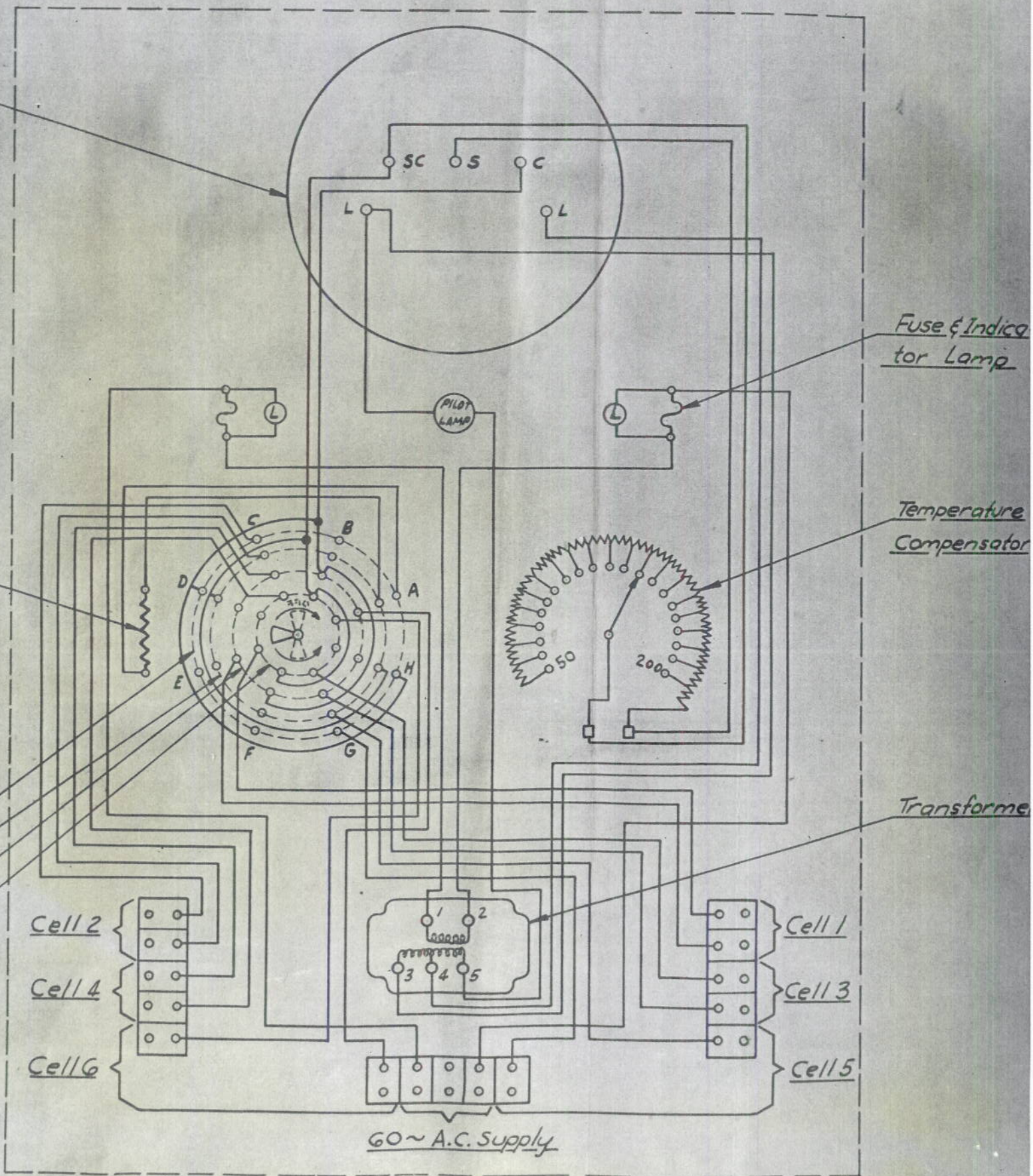
Indicator Meter

Checking Resistor

Plate 1
Plate 2
Plate 3
Plate 4



WIRING DIAGRAM OF SINGLE UNIT PANEL - VIEWED FROM



Fuse & Indicator Lamp

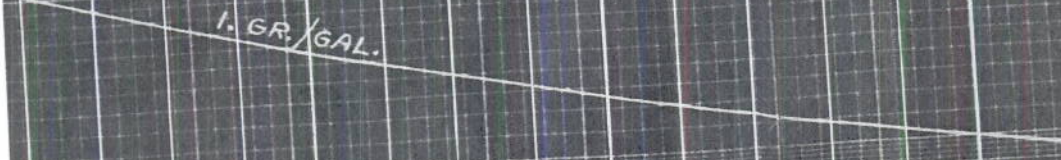
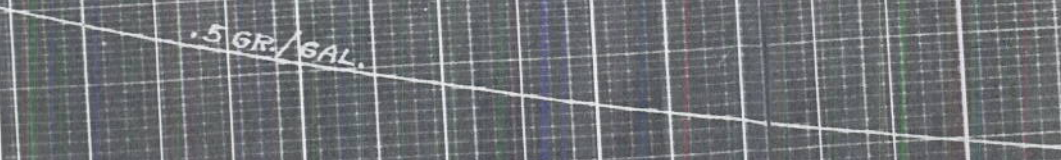
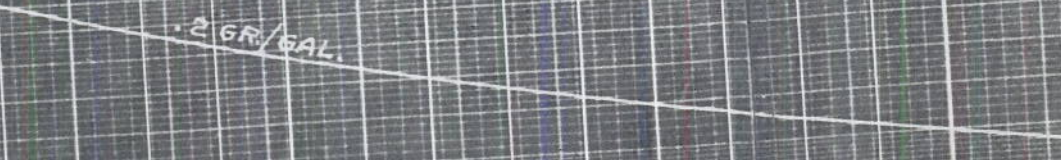
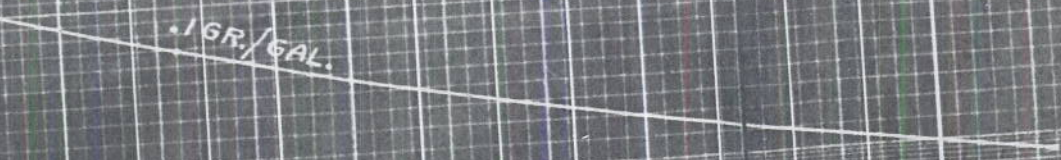
Temperature Compensator

Transformer

60~ A.C. Supply

WIRING DIAGRAM OF SINGLE UNIT PANEL - VIEWED FROM REAR OF PANEL

APPROXIMATE RESISTANCE
OF
SALINITY SOLUTIONS
ASSUMING CELL CONSTANT = 0.100



120 140 150 160 170 180 190 200 210 220

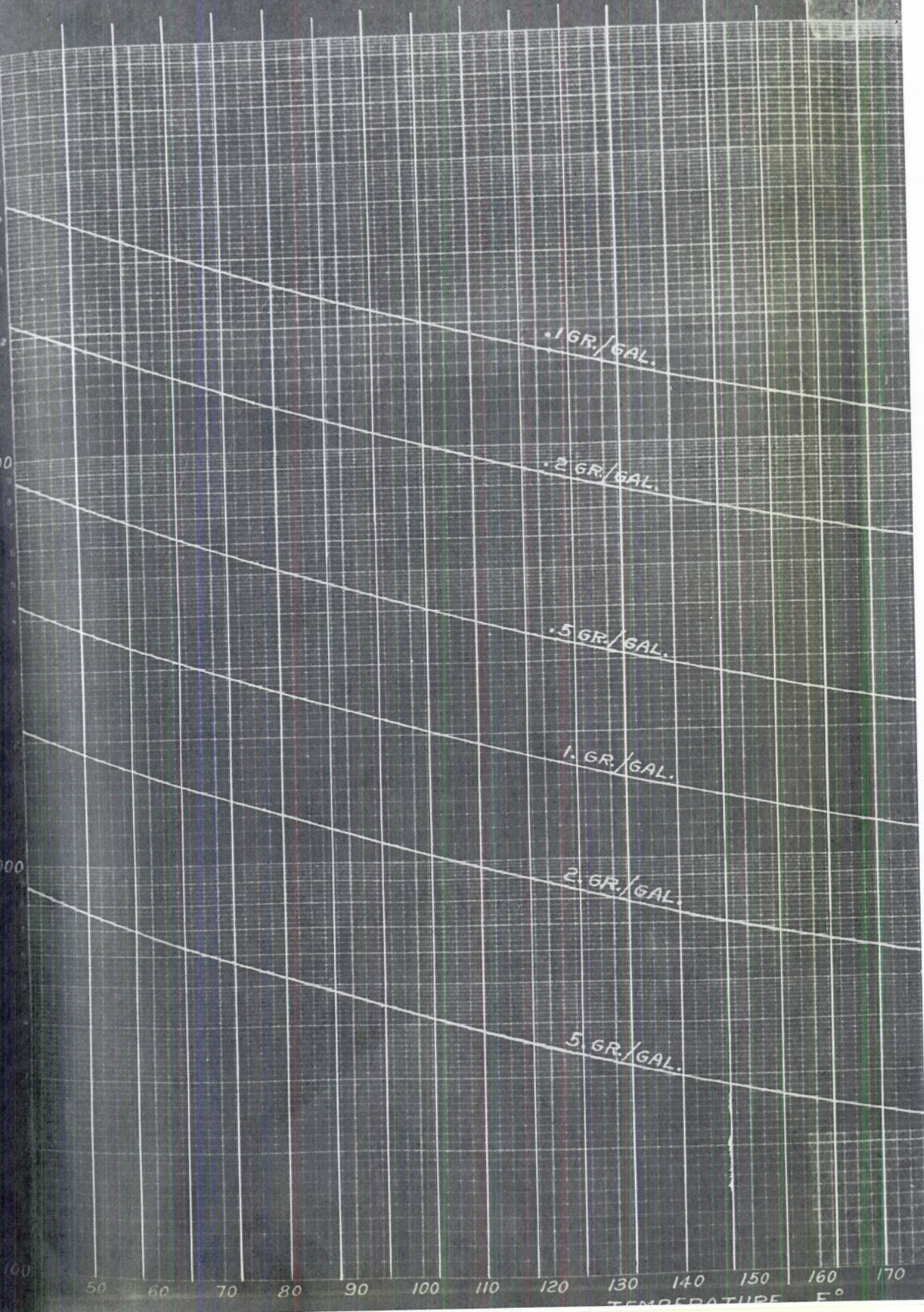
0 000

0 000

1000

100

RESISTANCE, OHMS



TEMPERATURE F°