SPECIAL NOTICE - READ BEFORE USING SENSORS

CAT. NO'S. 5000-A and 5100-A SOIL SALINITY SENSORS

It is essential to soak the sensors in a salt solution for a period of 4 to 7 days prior to use in order to remove entrapped air from the pores of the electrolytic element. The process of drying the sensors for storage and for shipment introduces air into the pores of the ceramic of the electrolytic element and may also deposit an abnormal amount of salt on the surface of the electrolytic element. After initial rewetting, it requires time for the air that has been entrapped during the wetting process to go into solution. The calibration of the sensor will not be stable nor will it match the calibration data supplied with each unit until all entrapped air has been dissolved and any excess salt deposits have dispersed. It is desirable to soak the sensors in a salt solution in the general conductivity range of 1-1/2 to 16 mmhos concentration.

Entrapped air in the pores of the ceramic of the electrolytic element restrict the flow of ions and result in higher than normal resistance readings (lower conductivities). Over a period of 4 to 7 days, this entrapped air gradually dissolves into the solution within the pores and migrates to the outside. Progress of this dissolving action can be followed by reading the conductivity indicated by the sensor when read out on the conductivity scale of the Cat. No. 5500 Salinity Bridge. When the conductivity readout is stable, all of the air will have been dissolved. After the rewetting, the reading of the sensor will correspond to the calibration curve supplied, and the sensor will respond quickly to changes in solution conductivity. After the sensors have been rewetted, do not dry sensors prior to installation in the field.

Prior to installation and after completing any desired checkout of the calibration, it is recommended that the sensors be immersed in a solution of approximately 2 mmhos concentration for a period of 4 to 6 hours to bring them to equilibrium with that solution. The sensors are then maintained in this solution until installed in the field. The purpose of bringing the sensors to equilibrium in the rather weak 2 mmho solution is to avoid the introduction of any abnormal amount of salt into the soil which will require time to dissipate.

OPERATING INSTRUCTIONS for the

Cat. No. 5000-A and 5100-A

SOIL SALINITY SENSORS

Cat. No. 5000-A SALINITY SENSOR

FIG. 1 Assembled

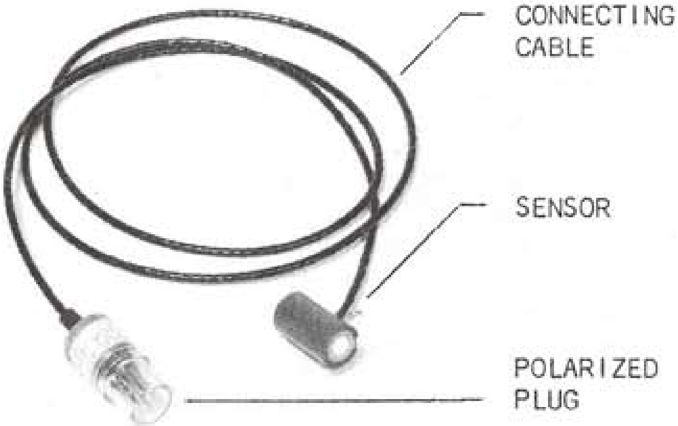

FIG. 2 Disassembled

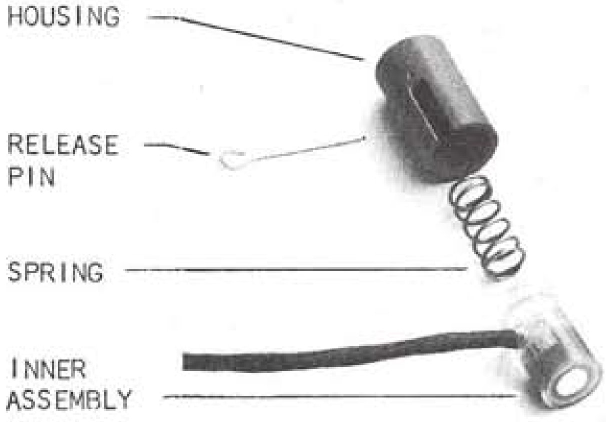

FIG. 3 Cross Section View

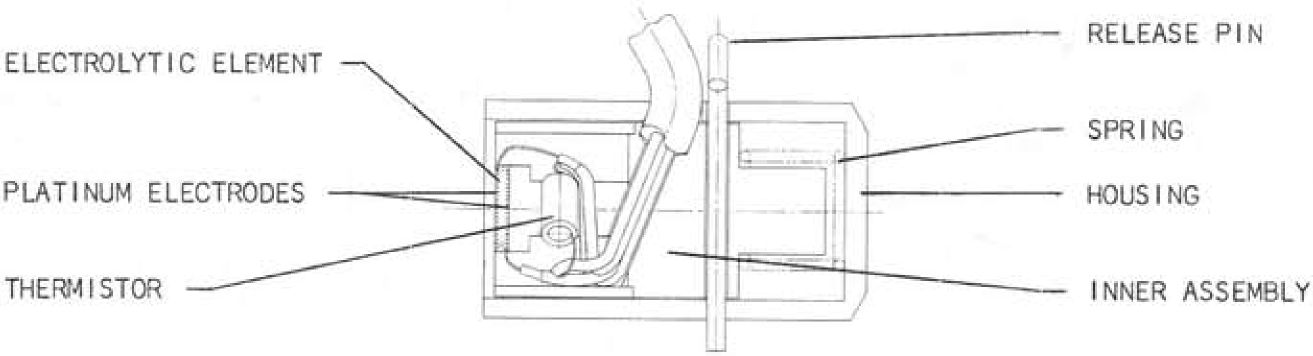

FIG. 4 Cat. No. 5100-A SALINITY SENSOR

The Cat. No. 5100-A Salinity Sensor is of the same design as the Cat. No. 5000-A except that it does not have the spring loading feature and the cable comes out coaxially from the end of the sensor

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FEATURES

The Cat. Nos. 5000-A and 5100-A Soil Salinity Sensors are supplied completely assembled, calibrated, and ready for installation. An individual data sheet accompanies each sensor. The photos on page 1 show these two sensors.

In handling the sensor, be sure to protect at all times the exposed ceramic surface of the electrolytic element at the end of the sensor. The surface should be protected from mechanical damage as well as fouling by oil or other contaminates that could soak into the porous surface.

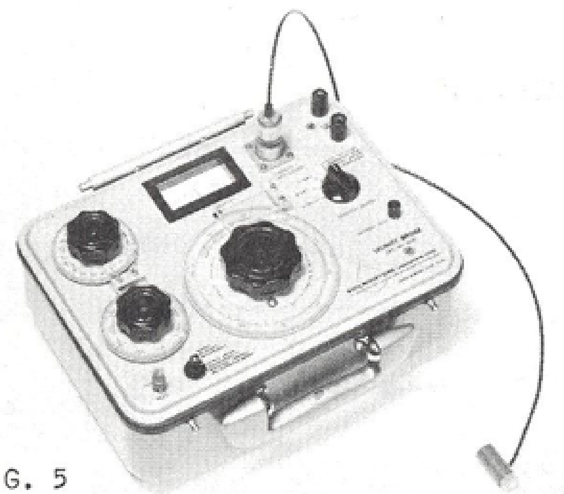


FIG. 5

The sensors are designed for use with the Cat. No. 5500 Salinity Bridge, see Fig. 5. When used with the salinity bridge, the sensors permit direct read out of soil solution conductivity in millimhos automatically corrected to the standard temperature at 25°C.

The Cat. No. 5000-A Soil Salinity Sensor is packed assembled and under spring pressure. Do not pull the release pin unless pressure is applied to the front and rear of the sensor with the thumb and forefinger. The release pin may then be pulled out. Decreasing the pressure with the thumb and forefinger will permit the internal spring to expand and push the housing off the sensor body, see Fig. 2. To assemble, reverse the process, compressing the sensor body into the housing until the release pin holes are in line. Then, insert the pin to hold parts in place.

The sensor incorporates the electrolytic element, exposed at one end of the sensor, with a thermistor just behind the electrolytic element, see Fig. 3. The assembly is encapsulated to produce a permanently sealed unit. The electrical cable from the sensor is a four-conductor cable, four feet long. Each conductor in the cable is #27 gauge, stranded copper with PVC insulation. The four separate conductors are encased in a heavy, black polyethylene jacket. The jacket of the cable enters the inner area of the sensor and is sealed to it with epoxy resin. The cable is color coded with two blue wires going to the two electrodes of the electrolytic element, and two red wires going to the two leads of the thermistor. The opposite end of the cable is potted into a polarized plug for direct connection to the Cat. No. 5500 Salinity Bridge. Sensor characteristics for setting the bridge dials are permanently marked on the plug of the sensor.

The electrolytic element is fabricated from ceramic with pore size so small that it will remain saturated throughout the soil suction range of 0 to 15 bars, the full plant growth range, to give consistent salinity measurements. The electrolytic element is a round disc, cross-section area of .32 sq. cm with fine grid platinum electrodes of the same area fired into the porous ceramic and spaced 1 mm apart.

The thermistor incorporated into the sensor has a resistance of 2,000 ohms ±10% at 25°C. The specific resistance of the particular thermistor at 25°C. for each sensor is given on the data sheet accompanying each sensor. By reading separately the resistance of the thermistor, one can readily determine the temperature of the sensor in the range between 0°C. and 40°C.

The four-pronged, polarized plug on each sensor corresponds to amphenol connector size and configuration #14S-2 and is interchangeable with amphenol fittings in this series.

Sensors with extra length cable can be supplied on special order. The sensor cable may also be spliced to provide additional length for special application.

The Cat. No. 5000-A Soil Salinity Sensor is designed to fit crosswise into a 1-1/4" dia. hole cored into the soil, such as made with Soilmoisture Cat. No. 215 Soil Sampling Tubes. For this reason, the cable of the Cat. No. 5000-A Soil Salinity Sensor comes out from the side of the sensor and the outer housing is spring loaded to force the electrolytic element into contact with the soil.

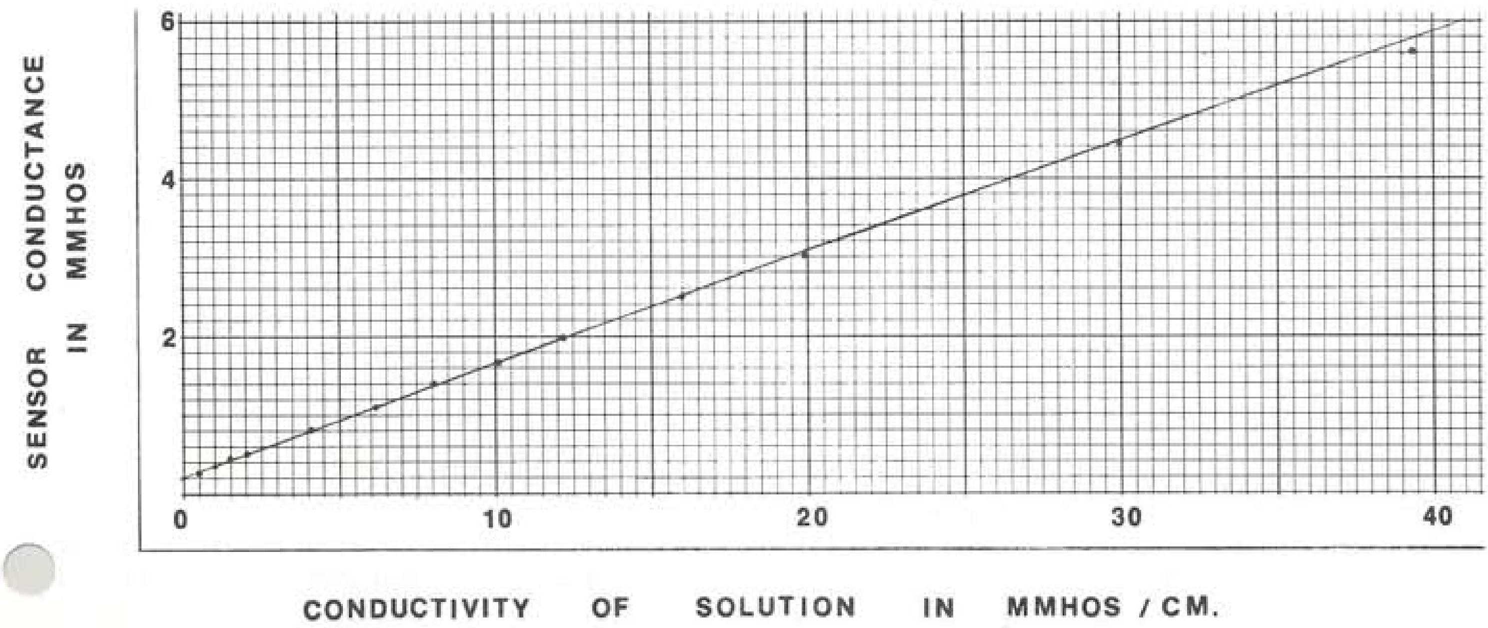
The Cat. No. 5100-A Soil Salinity Sensor is of coaxial design with cable coming out from the end of the sensor. This sensor is designed to fit into a 1/2" dia. hole cored into the soil.

Both sensors are suitable for installation in the field or in test soil cores in the laboratory.

The sensors are calibrated in standard solutions made up of a 1 to 1 mixture (on an equivalent basis) of calcium and sodium chloride. The combination of calcium and sodium chloride salts appears to match closely the characteristics of the soil solutions found in the arid and semiarid regions where soil salinity is a problem. A data sheet accompanying each sensor carries the calibration information on the sensor.

FIG. 6 RELATIONSHIP OF TYPICAL SENSOR CONDUCTANCE TO SOLUTION CONDUCTIVITY

Data obtained from Cat. No. 5100-A Soil Salinity Sensor, Serial No. 1993, at 25°C. over a wide range of solution conductivities using the Cat. No. 5500 Salinity Bridge



CHECK OUT OF SENSORS PRIOR TO USE

Where careful research is to be done with sensors and where facilities are available, it is desirable to check the salinity sensors and confirm the calibration prior to installation in the field. For check out of the sensors, refer to the section on sensor calibration, page 7.

After one has become familiar with the sensors, and for most work, the sensors can be installed in the field immediately without a calibration check, providing that all measurements are made with the Cat. No. 5500 Salinity Bridge.

The sensors are shipped in dry condition. After calibration has been completed at the factory, the sensors are brought to equilibrium in a solution of approximately 1 mmho conductivity. The sensors are then removed and dried prior to packaging. In subsequent handling, in order to preserve maximum sensitivity and stability of calibration, avoid immersing the sensors in distilled water. The sensor conductance shows a linear relationship to conductivity in the range from .5 mmho through 30 mmhos, as shown in Fig. 6. However, when the sensors are in dilute solutions of less than .5 mmho/cm the sensor conductance shows a curvelinear relationship to conductivity. In this region of dilute solutions, it appears that ions normally held close to the pore walls, and which provided a means of transport of current independent from the normal ion transport of current through the solution, are released. As a result the conductance of the sensor is lower in this region than would be indicated by the normal calibration line. Once these ions are released it temporarily changes the calibration line for the sensor, until such time as this ion layer is again built up by immersion in solutions above .5 mmho in conductivity. It seems to require a number of days to restore this ion layer depending upon the concentration of the solution in which the sensors are immersed. To avoid this difficulty it is recommended that the sensors be kept in a dry condition or immersed in solutions with higher conductivities than .5 mmho.

FIELD INSTALLATION

The Cat. No. 5000-A Soil Salinity Sensor is designed to fit crosswise into a 1-1/4 dia. hole, such as made with the Soilmoisture Cat. No. 215 Soil Sampling Tubes. After the hole is cored to the desired depth, a length of string or fine wire is attached to the loop or eye of the release pin. Care should be taken not to pull the release pin prematurely. A stick can be made up of small enough size that it will fit into the cored hole and of such length to reach to the depth of insertion. Two nails can be driven into the stick to form a yoke to support the sensor in

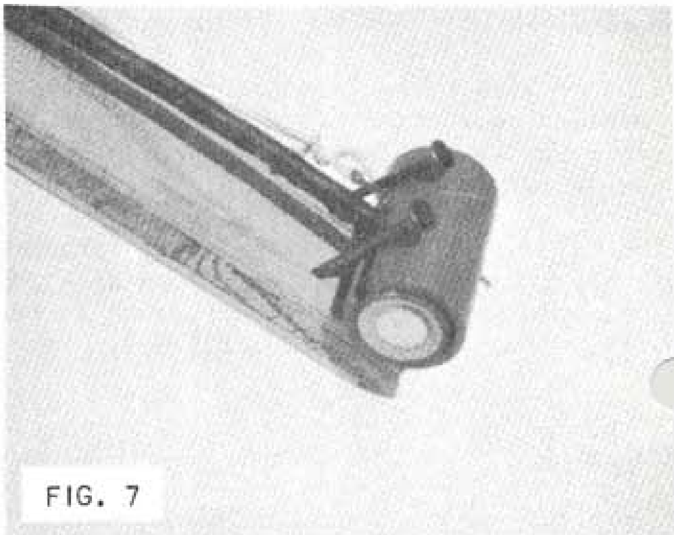


FIG. 7

the manner shown in Fig. 7. The sensor is held in place on the stick by pulling up on the cable. When in this position, the sensor can be inserted into the hole to the desired depth. While holding the sensor on the stick at the desired depth, the release pin wire or string is pulled out. This will release the sensor from its housing and allow the electrolytic element to make positive contact with the soil. The cable can now be released and the insertion stick removed. The hole is then back filled and tamped. The plug end of the electrical cable, of course, must be left sufficiently above the ground to make convenient electrical connection for measurements.

The Cat. No. 5100-A Soil Salinity Sensor is of coaxial design and will fit into a

1/2" dia. cored hole in the soil. The hole can be made by simply driving a 1/2" dia. rod into the soil to the desired depth. The sensor is then inserted into the soil using a small diameter rod and tamped securely in place to make sure the soil is in good contact with the face of the electrolytic element. A larger diameter hole can also be cored to accept the sensor, if soil conditions require this approach.

It is important to carefully back fill the holes made to insert the sensor to prevent flow of subsequent irrigation water directly to the sensor area which may result in measurements that are not consistent with the surrounding soil. This is particularly important in soils that are highly layered and offer substantial resistance to the downward movement of water. Where a problem of this nature is suspected, it is a good idea to partially fill the hole with bentonite or a ball clay to form a plug which will prevent surface water from moving directly down through the disturbed portion of the soil to the sensor area.

When installing either the Cat. No. 5000-A or the Cat. No. 5100-A Soil Salinity Sensors it is essential that the exposed surface of the electrolytic element be in intimate contact with the soil. It is only through this contact that the soil solution can permeate the porous ceramic of the electrolytic element allowing ions to migrate freely between the soil and the electrolytic element. Care should be taken to be sure that the exposed surface of the electrolytic element is in contact with the fine grain soil particles to afford maximum contact.

Where the soil is stoney or otherwise not of uniform texture, a larger diameter hole should be cored, such as with one of our Cat. No. 230 Soil Augers. A portion of the soil removed can then be sieved and the fine grain material used to backfill around the sensor. A series of soil layers should be added and individually tamped to obtain a firm, uniform soil mass around the sensor. Where the Cat. No. 5000-A Soil Salinity Sensors are installed in this manner, the release pin would not be pulled until the soil level was packed several inches above the sensor.

After installation, significant readings cannot be made on the sensor until after the first irrigation or until the soil has been wetted at the sensor location down to the depth of installation. This initial wetting establishes the water film connection between the ceramic electrolytic element and the soil mass.

The polarized plug of the sensor must be protected in the field against mechanical damage as well as from soil particles which can damage the receptacle on the Salinity Bridge into which the plug fits. Plastic bags, a great variety of which are generally available, have been found quite adequate for protecting these plugs from soil particles and other contaminates. To protect the plug, simply cover individually or cover a group of plugs with a plastic bag and hold bag in place with a rubber band.

READING THE SENSORS WITH THE CAT. NO. 5500 SALINITY BRIDGE

Routine Field Measurements of Conductivity

Once the sensors are installed in the field, routine measurements of soil solution conductivity can be made by simply inserting the polarized plug of the sensor into the sensor receptacle on the panel of the Cat. No. 5500 Salinity Bridge. The Intercept Setting Dial and the Slope-Thermistor Setting Dial are adjusted to the values marked on the plug of the sensor. After balancing the bridge, the conductivity of the soil solution at 25°C. can be read out directly on the conductivity scale of the bridge. For complete details on making these readings, refer to the instruction information on the Cat. No. 5500 Salinity Bridge.

Measuring Resistance of the Thermistor to Determine Temperature

The thermistor that is in each of the Soil Salinity Sensors provides a convenient means of measuring the temperature of the sensor and its immediate surroundings. It provides an accurate means of measuring the temperature of the calibrating solution when sensors are being recalibrated, in the event temperature controlled facilities are not available.

The Cat. No. 5501 Plug-Terminal Adapter is used for this type of measurement. The "Thermistor" lugs on the adapter are connected to the resistance terminals of the Cat. No. 5500 Salinity Bridge and the polarized plug of the sensor is inserted into the receptacle on the adapter. Readings can then be made in accordance to instructions as carried in the instruction information on the Cat. No. 5500 Salinity Bridge.

The data sheet accompanying each sensor carries the resistance of the thermistor at 25°C. for that particular sensor. With this resistance value and the chart on page 12 of these instructions it is possible to determine the temperature corresponding to any thermistor resistance value, for temperatures between 0°C. and 40°C. To determine the temperature, measure the thermistor resistance and divide this value by the thermistor resistance at 25°C. as given on the data sheet for the sensor. The ratio determined will be greater than 1 for temperatures below 25°C. and less than 1 for temperatures above 25°C. Find the ratio on the chart, page 12, and read the temperature where the ratio value intersects the ratio-temperature curve.

Measuring Resistance of Electrolytic Element

The Cat. No. 5501 Plug-Terminal Adapter is used in conjunction with the Cat. No. 5500 Salinity Bridge to read the resistance value of the electrolytic element of the sensor, such as is required in recalibration of the sensors, or in checking the calibration data supplied with the sensor. The "Electrolytic Element" lugs on the Plug-Terminal Adapter are connected to the resistance terminals of the bridge. The polarized plug of the sensor is then inserted into the receptacle on the Plug-Terminal Adapter. Readings can then be made in accordance to instructions as carried in the instruction information on the Cat. No. 5500 Salinity Bridge.

In order for the resistance value of the electrolytic element to be interpreted as solution conductivity, it must first be converted to the equivalent resistance at 25°C. The temperature at which the electrolytic element is read can be determined by reading the resistance of the thermistor as explained above, and by converting this thermistor resistance into °C. Once the temperature is known, the resistance reading of the electrolytic element can be converted to the equivalent resistance at 25°C. by reference to the table on page 13 of these instructions. The table is reproduced from Agriculture Handbook 60, of the U. S. Department of Agriculture, and gives the temperature factor for correcting resistance and conductivity data on soil solution to the standard temperature of 25°C.

To correct the resistance value of the electrolytic element to 25°C. simply find the temperature factor F_t on the table, page 13, corresponding to the temperature at which the reading was made, and divide the resistance by the factor. For temperatures below 25°C., the temperature factor is greater than 1, for temperatures above 25°C. the temperature factor is less than 1.

After the resistance value of the electrolytic element has been corrected to 25°C., the conductance of the element in millimhos can be determined by dividing the resistance into 1000. For example, if the resistance of the electrolytic element, corrected to 25°C., is 500 ohms, the conductance will be 1000/500 ohms = 2.00 millimhos.

The conductivity of the soil solution corresponding to the conductance of the electrolytic element can be found on the graph carried on the data sheet supplied with each sensor. A typical data sheet is found on page 14 of these instructions. With reference to this typical data sheet, the 2.00 millimhos conductance of electrolytic element of the sensor corresponds to a solution conductivity of 11.7 mmhos/cm.

READING THE SENSORS WITH OTHER BRIDGES

In general, it is not recommended that resistance bridges other than the Cat. No. 5500 Salinity Bridge be used to measure the Cat. No. 5000-A and Cat. No. 5100-A Soil Salinity Sensors.

For significant measurements, it is essential that an alternating current bridge be used. However, the capacitance characteristics of the Soil Salinity Sensors which change with conductivity of the solution reduce the sensitivity of many bridges to the point where accurate measurements are not possible. Furthermore, the resistance value read by other bridges will vary, depending on the frequency and electrical characteristics of the individual bridge. In the event the resistance of the electrolytic element of the sensor is to be read with another type of bridge, it will be necessary to first recalibrate the sensor using the same bridge to make measurements during recalibration.

The calibration data supplied with the Cat. No. 5000-A and Cat. No. 5100-A Soil Salinity Sensors is only applicable when measurements are made with the Cat. No. 5500 Salinity Bridge.

SENSOR CALIBRATION

The Cat. No. 5000-A and Cat. No. 5100-A Soil Salinity Sensors are calibrated at the factory in solutions which are a 1 to 1 mixture (on an equivalent basis) of calcium and sodium chloride. This combination of ions is characteristic of soil solution found in arid and semiarid regions and follows the same conductivity versus temperature curve as the soil extracts reported on the table, page 13, reproduced from Agriculture Handbook 60.

Data on the relationship of solution conductivity to the concentration of specific ions is available from many sources. As background information, you will find on page 15 and page 16 graphs relating the concentration of typical salts found in soil solution to the conductivity of the solution. These graphs are reproduced from Agriculture Handbook 60 of the U. S. Department of Agriculture.

Checking Calibration of Sensor

Where it is desired to check the sensor calibration against the data given on the data sheet for the individual sensor, or where it is desired to confirm that the calibration of a sensor has not changed after a considerable length of time; this can be readily done by preparing several solutions of different ion concentrations and immersing the sensor successively in the different solutions.

The sensors were calibrated at the factory in solutions of approximately 2 mmhos, 4 mmhos, 8 mmhos, and 16 mmhos/cm conductivity. The sensors may be checked in solutions of these approximate concentrations or at other levels of particular interest. In preparing the solutions, equivalent amounts of calcium and sodium chloride should be weighed out then dissolved in distilled water to make up the strongest solution desired. Portions of the strong solution can then be diluted with distilled water to produce the less concentrated solutions. A standard conductivity cell can be used to determine the conductivity of the final set of calibrating solutions.

In checking the conductivity of calibrating solutions, the Cat. No. 5500 Salinity Bridge can be used to measure the solution resistance with various commercially available conductivity cells. The conductivity cell leads are connected to the resistance terminals on the panel of the bridge. The resistance terminal switch is turned to the "NORMAL RESISTANCE MEASUREMENTS" position. The galvanometer is balanced and the resistance read on the read-out dial, as given in the instruction information on the Cat. No. 5500 Salinity Bridge.

The resistance reading from the conductivity cell must then be corrected to 25°C. with reference to the table on page 13. The resistance value at 25°C. is then divided by the conductivity cell constant to give the specific resistance of the solution. The specific resistance in ohms is then divided into 1000 to give the conductivity of the solution in millimhos/cm at 25°C.

When using conductivity cells to determine the conductivity of solutions used for calibrating salinity sensors, it is essential that the conductivity cells be cleaned frequently to the manufacturer's specifications. Films of foreign matter form rather quickly on the platinum black electrode surfaces of the conductivity cell. These films cause resistance readings to be higher than they should and as a result can introduce substantial errors in the determination of the solution conductivity and hence in the calibration of the salinity sensor. Where considerable use is being made of conductivity cells, it is desirable to make up a reference solution on a weight basis of a known salt in the general conductivity range desired. The conductivity cells can then be checked, before use, in this reference solution at a known temperature to determine if they are reading correctly.

It is desirable to prepare and keep the calibrating solutions in glass or porcelain containers to prevent contamination. The containers should be sealed with stoppers during the testing of the sensor and during storage to prevent gradual changing of the solution conductivity because of evaporation.

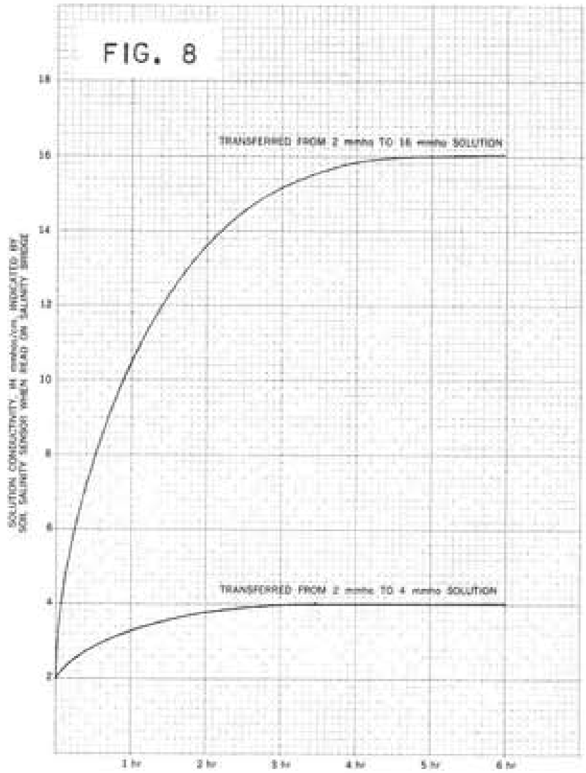
If a constant temperature tank is available, the tests should be run at 25°C. in the tank to eliminate the chore of converting the resistance readings to 25°C. If a constant temperature tank is not available, the containers of the solution should be insulated as well as possible to prevent rapid fluctuation of the temperature. The temperature of the calibrating solution can then be read with a conventional thermometer or by reading the resistance value of the thermistor incorporated in the soil salinity sensor as described on page 5. All resistance readings made on the electrolytic element of the sensor during the test must be converted to the equivalent reading at 25°C. by reference to the table on page 13.

Before immersing the Cat. No. 5000-A Soil Salinity Sensors in the calibrating solution, the pin, housing, and spring must be removed in the manner described on page 7

The sensor to be checked is immersed in the strongest calibrating solution and allowed to come to equilibrium with the solution. The approach to equilibrium can be followed by taking periodic readings of the electrolytic element in the manner described under "Measuring Resistance of the Electrolytic Element" on page 6. After correcting the resistance readings of the electrolytic element to 25°C., they may be plotted against time to bring out graphically the response time of the sensor.

Fig. 8 shows typical response times for the Cat. No. 5000-A and Cat. No. 5100-A Soil Salinity Sensors when transferred from solution of one conductivity to a solution of a different conductivity. Although equilibrium is largely reached by these sensors in a period of 6 hours, it is recommended that the sensor be left in each calibrating solution for a period of 24 hours or until the reading becomes stable.

FIG. 8



After the final resistance reading has been made on the electrolytic element in the first calibrating solution, it is recommended that the conductivity of the calibrating solution be checked immediately thereafter with the conductivity cell. The final conductivity reading of the calibrating solution will be the one most accurately related to the resistance reading of the electrolytic element.

The final resistance reading of the electrolytic element is converted into the conductance value as given under "Measuring Resistance of Electrolytic Element" page 6. This sensor conductance and solution conductivity can then be compared with the values given on the graph of the data sheet for that particular sensor.

After readings have been completed in the strong solution the sensor should be removed from the solution. Solution clinging to the sensor should be removed with absorbent tissue and the sensor placed immediately in the next weaker solution. Here the process is repeated.

The sensor is again moved until equilibrium values are established for each calibrating solution, and comparison made with the data sheet, throughout the conductivity range desired.

Do not remove the sensor from a strong solution and allow it to air dry. If the sensor is to be air dried, first immerse it in a solution of from 1 mmho to 2 mmhos conductivity for at least 6 hours. This procedure will prevent large evaporation deposits of salt on the surface of the electrolytic element and will assure optimum sensitivity.

Recalibrating the Sensor

The procedure for recalibrating the sensor is the same as that used for "Checking Calibration of Sensor" as given above. Namely, the sensor is brought to equilibrium in a series of solutions of known conductivity. The conductance value of the sensor at 25°C. in each of the calibrating solutions is then plotted on a graph against the conductivity of the solutions in the same manner as shown in the graph on the typical Data Sheet, page 14. The line connecting the points on the graph then respresents the correlation between the conductance of the sensor determined from the resistance of the electrolytic element, and the conductivity of any solution to which the sensor is exposed.

The sensor should be recalibrated if there is indication that the sensor has been mechanically damaged. It is also desirable to recalibrate the sensor after a long period of time, or if readings appear to be illogical, to confirm that the original calibration has not changed. The Cat. No. 5000-A and Cat. No. 5100-A Soil Salinity Sensors are very stable and have maintained their original calibration after several years use under field conditions.

If an alternating current resistance bridge other than the Cat. No. 5500 Salinity Bridge is to be used for field measurement of the electrolytic element of the salinity sensor, then it is essential that the salinity sensors used be recalibrated by the procedure given above but where all equilibrium measurements of the sensor in the various calibrating solutions are made with the same bridge as is used for the field measurements. A graph would be made in the manner indicated above where the conductance value of the electrolytic element of the sensor at 25°C., as determined from readings made with the particular bridge used, are plotted against the conductivity of the calibrating solutions. Subsequent field measurement of the electrolytic element of the sensor made with this bridge would have to be temperature corrected to 25°C. and reference made to the graph in order to interpret the reading in terms of soil solution conductivity.

DEVELOPING VALUES FOR THE INTERCEPT SETTING AND THE SLOPE-THERMISTOR SETTING FOR USE WITH THE CAT. NO. 5500 SALINITY BRIDGE

Values for the Intercept Setting and the Slope-Thermistor Setting are marked on the plug of each of the Cat. No. 5000-A and Cat. No. 5100-A Soil Salinity Sensors. These values can be readily verified from the calibration data supplied with each sensor.

The Intercept Setting and the Slope-Thermistor Setting values can also be developed for sensors previously supplied without plugs. These Soil Salinity Sensors, supplied as Cat. No. 5000 and Cat. No. 5100, without the change letter -A, must first be recalibrated in standard solutions in the manner as given under "Sensor Calibration", page 7. For this recalibration work at least two standard solutions must be used; one in the general conductivity range of 4 mmhos/cm and the other in the general conductivity range of 16 mmhos/cm. All readings must be taken with the Cat. No. 5500 Salinity Bridge. For calculation of the Intercept Setting and the Slope-Thermistor Setting, the resistivity of each of the calibrating solutions must be known as well as the equilibrium resistance value at 25°C. for the electrolytic element of the sensor in each of the calibrating solutions. The resistivity of the calibrating solution is simply the resistance of a conductivity cell in the calibrating solution, corrected to 25°C., and then divided by the cell constant.

Once the above resistance values are available, the Intercept Setting and the Slope-Thermistor Setting for the sensor can be determined by reference to the work sheet on page 17. The work sheet on page 17 is filled out on the basis of the data given on the typical Salinity Sensor Data Sheet, page 14. An additional blank work sheet is given on page 18. This blank sheet can be reproduced on your duplicating machine to provide as many blank work sheets as are required for your use.

As an example of the manner in which the Intercept Setting and Slope-Thermistor Settings are determined we will run through the calculations using the data given on page 14 for the typical Salinity Sensor Data Sheet.

The resistance of the electrolytic element of this sensor is 1110 ohms in a calibrating solution that has a conductivity of 4.25 mmhos/cm. Since the resistivity of a solution is the reciprocal of the conductivity, the resistivity of this calibrating solution is 1000/4.25 mmhos or 235.3 ohms.

The resistance of the electrolytic element of the sensor is 365 ohms in a calibrating solution that has a conductivity of 16.72 mmhos/cm. The resistivity of this calibrating solution is 1000/16.72 mmhos or 59.8 ohms.

The thermistor resistance at 25°C. for this sensor is 1970 ohms.

We will use the above resistance values in the work sheet page 17 for determining the Intercept Setting and the Slope-Thermistor Setting.

On line (1) the thermistor resistance of 1970 is entered in the open space.

On line (2) the value from line (1) is entered in the formula and the computation completed and the result entered on line (2) in the open space.

On line (3) the resistance value of 365 ohms for the electrolytic element in the 16.72 mmhos/cm solution is entered under the 16 mmhos column; and the resistance value of 1110 ohms for the electrolytic element in the 4.25 mmhos/cm solution is entered under the 4 mmhos column.

On line (4) the value of the ratio of line (2) divided by line (3) for each column is calculated and entered in the corresponding column.

On line (5) the 59.8 ohms resistivity corresponding to the conductivity of 16.72 mmhos/cm is entered in the 16 mmhos column; and 235.3 ohms corresponding to the conductivity of 4.25 mmhos/cm is entered in the 4 mmhos column.

On line (6) the value of each column of line (5) is multiplied by 6.5 and entered in the corresponding column.

On line (7) the values from lines (4) and (6) are entered in the formula and the computation completed and the result entered on line (7) in the open space. This value is the Intercept Setting in ohms for the sensor.

On line (8) the values from the 16 mmhos column for line (6) and (7) are entered in the formula and the computation completed and the result entered on line (8) under the 16 mmhos column. This is repeated for the corresponding values from the 4 mmhos column and the result entered on line (8) under the 4 mmhos column.

On line (9) the values from the 16 mmhos column for line (8) and line (4) are multiplied by each other and the result entered on line (9) under the 16 mmhos column. This is repeated for the corresponding values from the 4 mmhos column and the results entered on line (9) under the 4 mmhos column. If the computation has been done correctly, the value for line (9) in the 16 mmhos column will be the same as in the 4 mmhos column. This value is the Slope-Thermistor Setting in ohms for the sensor.

MAINTENANCE

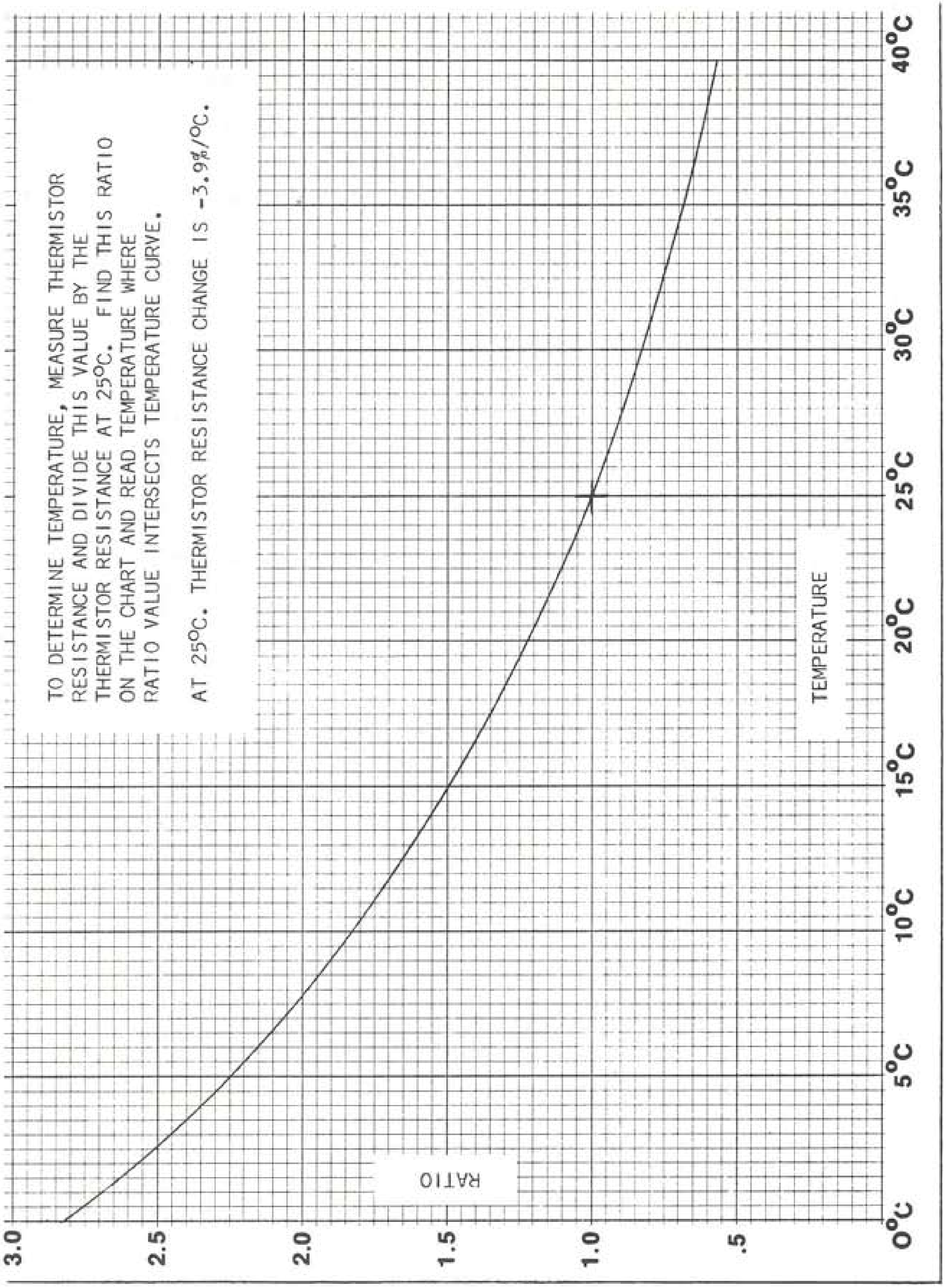
All materials used in the soil salinity sensors have been selected to withstand indefinitely the soil conditions to which they are exposed and no definite maintenance requirements are imposed.

Protect the exposed surface of the electrolytic element from mechanical damage or fouling by oils or grease or other comtaminants that could soak into the pores of the ceramic.

Keep polarized plug of the sensor free from soil particles by keeping it covered in the field with a plastic bag, or other means.

If the sensors are to be stored in a dry condition, soak them overnight in a salt solution with a conductivity in the range of .5 to 2 mmhos before air drying.

Soilmoisture Equipment Corp. maintains facilities for the repair and recalibration of the salinity sensors.


TO DETERMINE TEMPERATURE, MEASURE THERMISTOR RESISTANCE AND DIVIDE THIS VALUE BY THE THERMISTOR RESISTANCE AT 25°C. FIND THIS RATIO ON THE CHART AND READ TEMPERATURE WHERE RATIO VALUE INTERSECTS TEMPERATURE CURVE.
AT 25°C. THERMISTOR RESISTANCE CHANGE IS -3.9%/°C.
TEMPERATURE
RATIO
0°C
5°C
10°C
15°C
20°C
25°C
30°C
35°C
40°C
3.0
2.5
2.0
1.5
1.0
.5

TEMPERATURE FACTORS (F_t) FOR CORRECTING RESISTANCE AND CONDUCTIVITY DATA ON SOIL EXTRACTS TO THE STANDARD TEMPERATURE OF 25°C.

CONDUCTIVITY AT 25°C = (Conductivity at temperature t) × (F_t)
RESISTANCE AT 25°C = (Resistance at temperature t) / (F_t)

°C.	°F.	F_t	°C.	°F.	F_t	°C.	°F.	F_t
3.0	37.4	1.709	22.0	71.6	1.064	29.0	84.2	0.925
4.0	39.2	1.660	22.2	72.0	1.060	29.2	84.6	.921
5.0	41.0	1.613	22.4	72.3	1.055	29.4	84.9	.918
6.0	42.8	1.569	22.6	72.7	1.051	29.6	85.3	.914
7.0	44.6	1.528	22.8	73.0	1.047	29.8	85.6	.911
8.0	46.4	1.488	23.0	73.4	1.043	30.0	86.0	.907
9.0	48.2	1.448	23.2	73.8	1.038	30.2	86.4	.904
10.0	50.0	1.411	23.4	74.1	1.034	30.4	86.7	.901
11.0	51.8	1.375	23.6	74.5	1.029	30.6	87.1	.897
12.0	53.6	1.341	23.8	74.8	1.025	30.8	87.4	.894
13.0	55.4	1.309	24.0	75.2	1.020	31.0	87.8	.890
14.0	57.2	1.277	24.2	75.6	1.016	31.2	88.2	.887
15.0	59.0	1.247	24.4	75.9	1.012	31.4	88.5	.884
16.0	60.8	1.218	24.6	76.3	1.008	31.6	88.9	.880
17.0	62.6	1.189	24.8	76.6	1.004	31.8	89.2	.877
18.0	64.4	1.163	25.0	77.0	1.000	32.0	89.6	.873
18.2	64.8	1.157	25.2	77.4	.996	32.2	90.0	.870
18.4	65.1	1.152	25.4	77.7	.992	32.4	90.3	.867
18.6	65.5	1.147	25.6	78.1	.988	32.6	90.7	.864
18.8	65.8	1.142	25.8	78.5	.983	32.8	91.0	.861
19.0	66.2	1.136	26.0	78.8	.979	33.0	91.4	.858
19.2	66.6	1.131	26.2	79.2	.975	34.0	93.2	.843
19.4	66.9	1.127	26.4	79.5	.971	35.0	95.0	.829
19.6	67.3	1.122	26.6	79.9	.967	36.0	96.8	.815
19.8	67.6	1.117	26.8	80.2	.964	37.0	98.6	.801
20.0	68.0	1.112	27.0	80.6	.960	38.0	100.2	.788
20.2	68.4	1.107	27.2	81.0	.956	39.0	102.2	.775
20.4	68.7	1.102	27.4	81.3	.953	40.0	104.0	.763
20.6	69.1	1.097	27.6	81.7	.950	41.0	105.8	.750
20.8	69.4	1.092	27.8	82.0	.947	42.0	107.6	.739
21.0	69.8	1.087	28.0	82.4	.943	43.0	109.4	.727
21.2	70.2	1.082	28.2	82.8	.940	44.0	111.2	.716
21.4	70.5	1.078	28.4	83.1	.936	45.0	113.0	.705
21.6	70.9	1.073	28.6	83.5	.932	46.0	114.8	.694
21.8	71.2	1.068	28.8	83.8	.929	47.0	116.6	.683

SOILMOISTURE equipment corp.

instruments for the extraction and measurement of soil moisture

DIAL SETTINGS FOR CAT. NO. 5500
SOILMOISTURE SALINTY BRIDGE

INTERCEPT SETTING 3496 OHMS

SLOPE-THERMISTOR SETTING 2915 OHMS

SALINITY SENSOR DATA SHEET (SDS-1)

CAT. NO. 5000 - A SOIL SALINITY SENSOR

SERIAL NO. 2050 BATCH NO. 37F K VALUE 6.78

THERMISTOR RESISTANCE AT 25°C IS 1970 OHMS

SENSOR RESISTANCE IN 2.19 mmho SOLUTION AT 25°C IS 1815 OHMS, OR .55 mmho

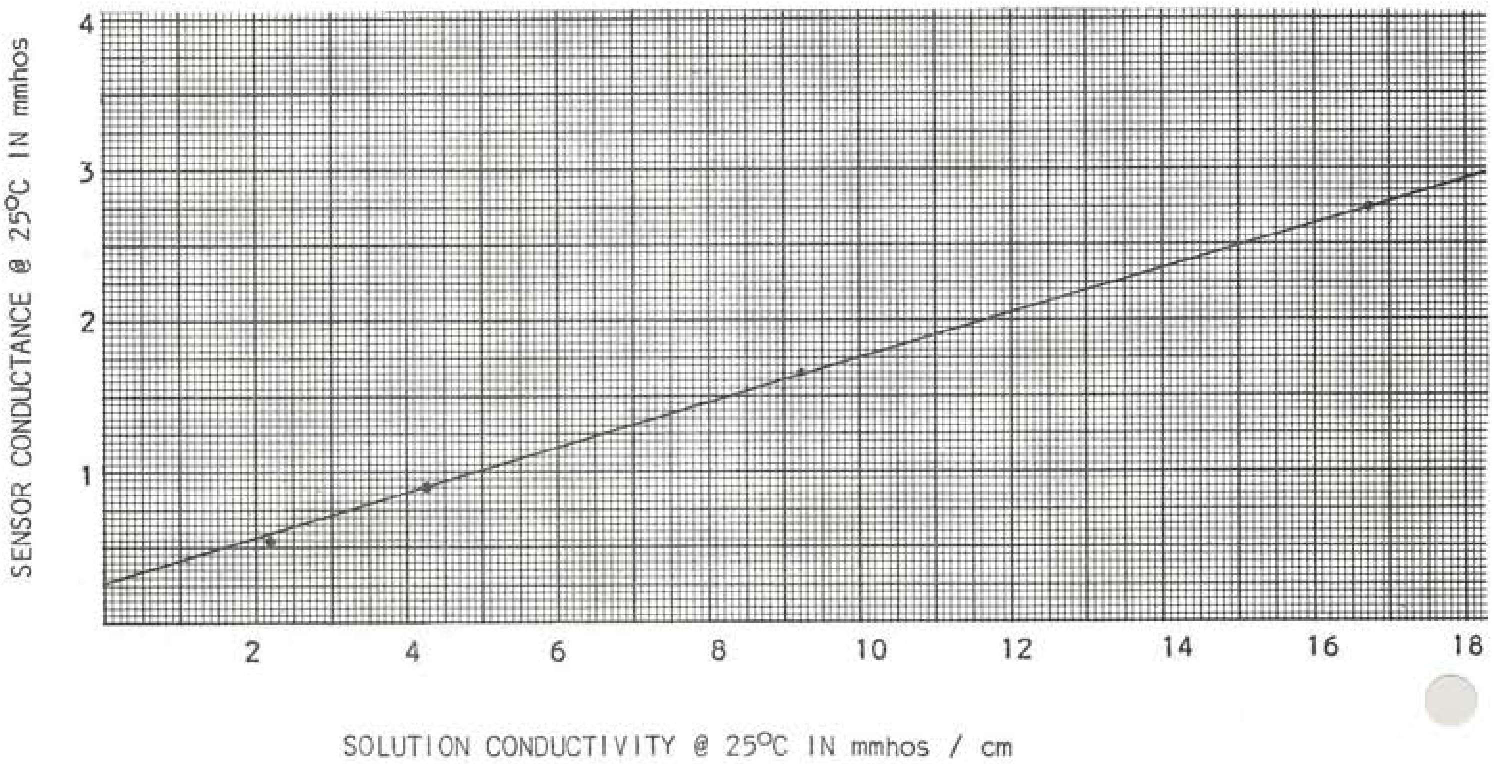
SENSOR RESISTANCE IN 4.25 mmho SOLUTION AT 25°C IS 1110 OHMS, OR .90 mmho

SENSOR RESISTANCE IN 9.22 mmno SOLUTION AT 25°C IS 602 OHMS, OR 1.66 mmho

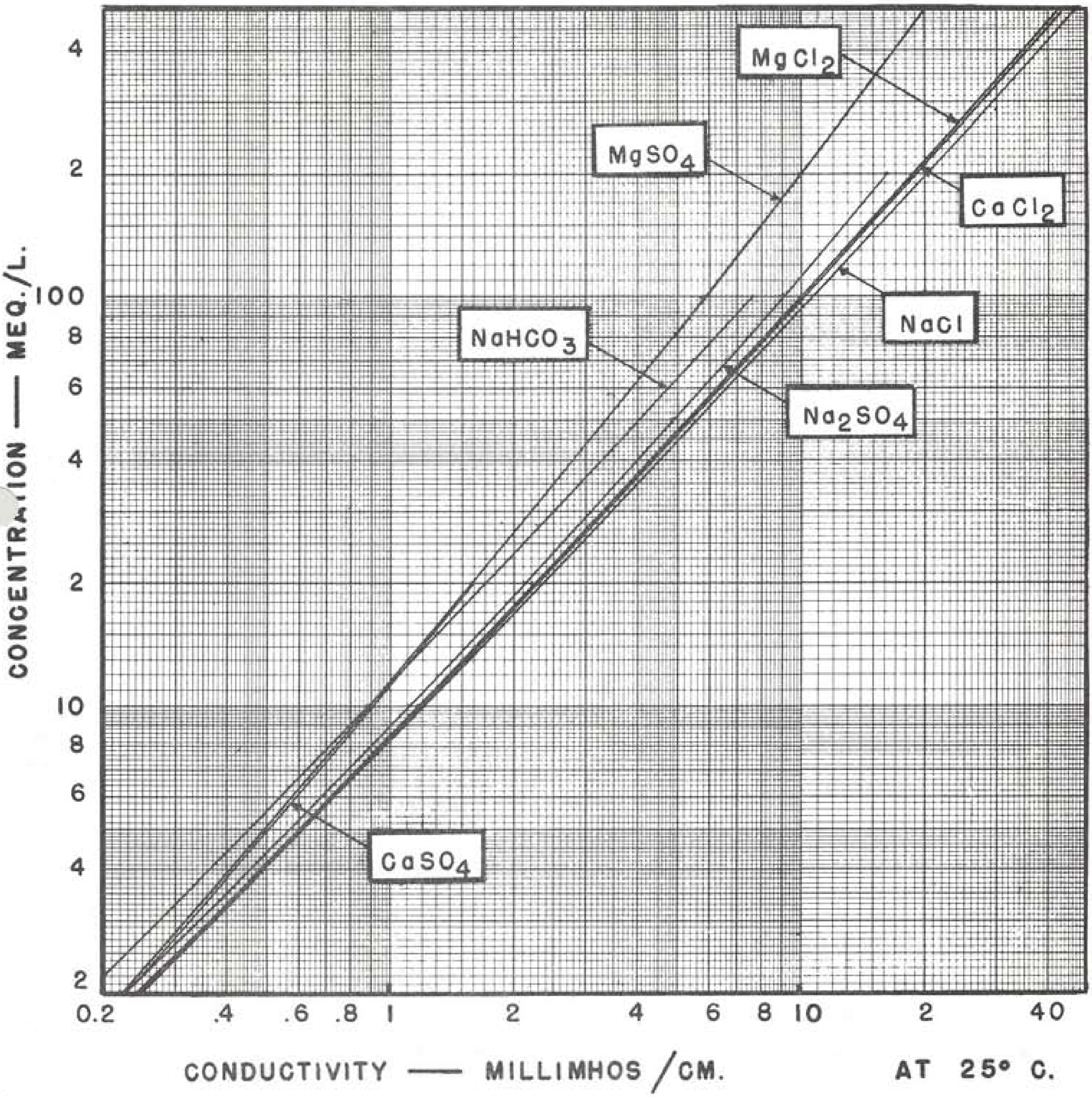
SENSOR RESISTANCE IN 16.72 mmho SOLUTION AT 25°C IS 365 OHMS, OR 2.74 mmho

SENSORS WERE CALIBRATED IN SOLUTIONS WHICH ARE A 1:1 MIXTURE, ON AN EQUIVALENT BASIS (NORMALITY), OF SODIUM & CALCIUM CHLORIDE

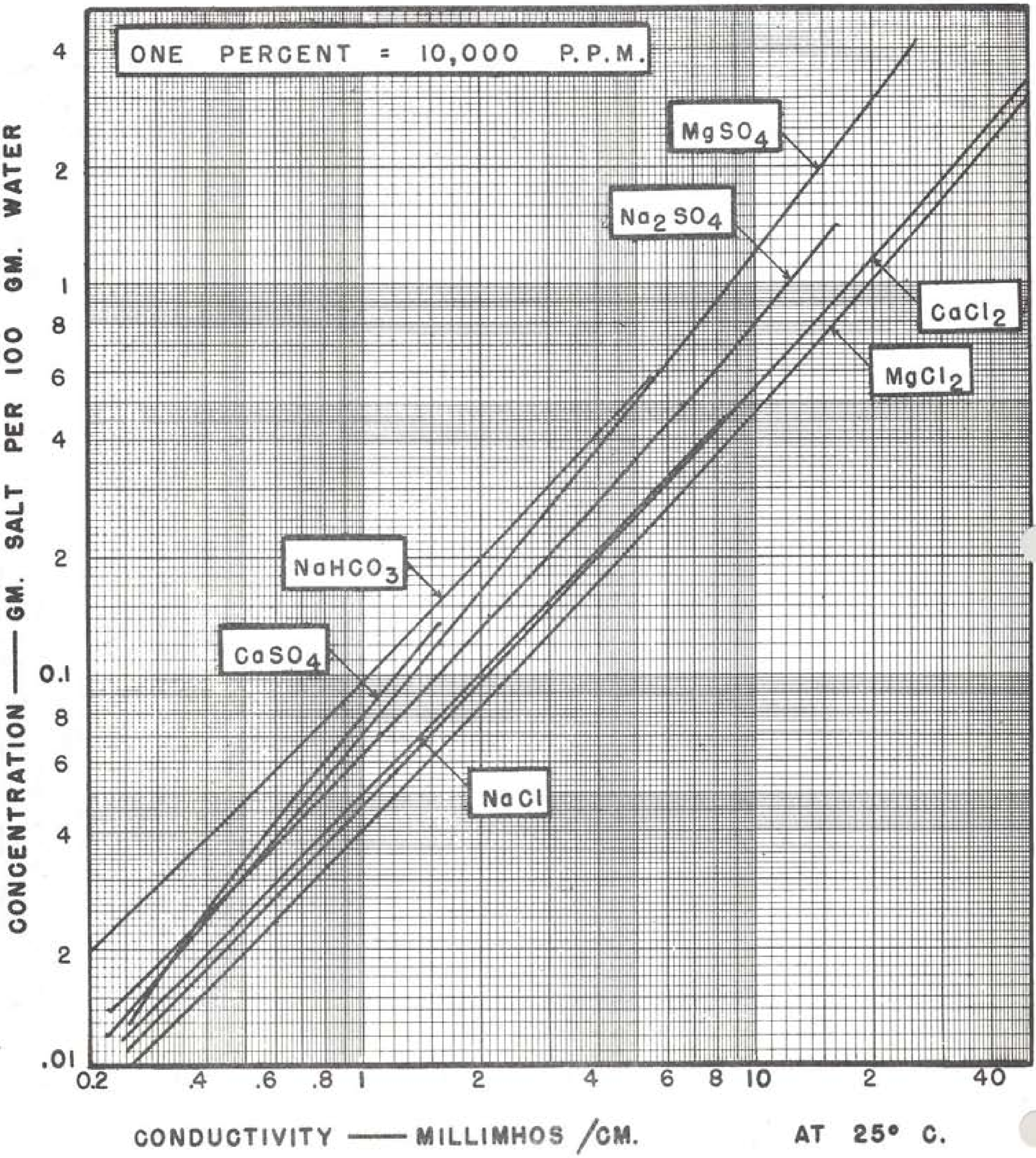
GRAPH OF SOLUTION CONDUCTIVITY VS. SENSOR CONDUCTANCE IN mmhos



CONCENTRATION OF SINGLE-SALT SOLUTIONS IN MILLIEQUIVALENTS PER LITER AS RELATED TO ELECTRICAL CONDUCTIVITY



CONCENTRATION OF SINGLE-SALT SOLUTIONS IN PERCENT
AS RELATED TO ELECTRICAL CONDUCTIVITY



WORK SHEET FOR DETERMINING THE INTERCEPT SETTING AND THE SLOPE-THERMISTOR SETTING

ALL VALUES ARE AT 25°C
ALL ENTRIES ARE IN OHMS

SENSOR SERIAL No. 2050

	APPROXIMATE SOLUTION CONCENTRATION		16 MMHO (16.72)	4 MMHO (4.25)	
			A	**B**	
1	THERMISTOR RESISTANCE				1970
2	THERMISTOR NETWORK RESISTANCE	$\frac{[29{,}495] \times [1421 + ①]}{30{,}916 + ①}$			3041.34
3	RESISTANCE OF ELECTROLYTIC ELEMENT		365	1110	
4	RATIO:	$\frac{②}{③}$	8.332	2.740	
5	RESISTIVITY OF CALIBRATING SOLUTION	$\frac{\text{Resistance of conductivity cell in solution}}{\text{Conductivity cell constant}}$	59.8	235.3	
6	RESISTANCE VALUE OF READOUT POTENTIOMETER	⑤ X 6.5	389	1529	
7	INTERCEPT SETTING IN OHMS	$[④_A - ④_B] \div \left[\frac{④_B}{⑥_A} - \frac{④_A}{⑥_B}\right]$			3496
8	RESISTANCE OF READOUT NETWORK	$\frac{⑥ \times ⑦}{⑥ + ⑦}$	349.85	1064.68	
9	SLOPE-THERMISTOR SETTING IN OHMS	⑧ X ④	2915	2915	

WORK SHEET FOR DETERMINING THE INTERCEPT SETTING

AND THE SLOPE-THERMISTOR SETTING

ALL VALUES ARE AT 25°C
ALL ENTRIES ARE IN OHMS

SENSOR SERIAL No. ______

	APPROXIMATE SOLUTION CONCENTRATION	16 MMHO	4 MMHO	
		A	**B**	
①	THERMISTOR RESISTANCE			
②	THERMISTOR NETWORK RESISTANCE $\dfrac{[29{,}495] \times [1421 + ①]}{30{,}916 + ①}$			
③	RESISTANCE OF ELECTROLYTIC ELEMENT			
④	RATIO: $\dfrac{②}{③}$			
⑤	RESISTIVITY OF CALIBRATING SOLUTION $\dfrac{\text{Resistance of conductivity cell in solution}}{\text{Conductivity cell constant}}$			
⑥	RESISTANCE VALUE OF READOUT POTENTIOMETER ⑤ X 6.5			
⑦	INTERCEPT SETTING IN OHMS $\left[④_A - ④_B\right] \div \left[\dfrac{④_B}{⑥_A} - \dfrac{④_A}{⑥_B}\right]$			
⑧	RESISTANCE OF READOUT NETWORK $\dfrac{⑥ \times ⑦}{⑥ + ⑦}$			
⑨	SLOPE-THERMISTOR SETTING IN OHMS ⑧ X ④			