INSTRUCTION MANUAL

YSI MODEL 31
CONDUCTIVITY BRIDGE

Scientific Division
Yellow Springs Instrument Co., Inc.
Yellow Springs, Ohio 45387, U.S.A. • Phone 513-767-7241

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II. Specifications

Range	.2 ohms to 2.5 megohms .2 micromhos to 2.5 mhos
Accuracy (not including cell error):	±1% of reading from 5 ohms to 0.5 megohms, and from 2.0 micromhos to 0.2 mhos. $\pm(\frac{5}{R})$% of reading from 0.2 ohms to 5 ohms. $\pm(\frac{100G}{G+20})$% of reading from 0.2 mhos to 2.5 mhos. $\pm(\frac{2R}{10^6})$% of reading from 0.5 megohms to 2.5 megohms. $\pm(\frac{2 \times 10^6}{G})$% of reading from 0.2 micromhos to 2.0 micromhos. (where R = numerical value of indicated resistance in ohms and G = numerical value of indicated conductance in mhos).

YSI MODEL 31 CONDUCTIVITY BRIDGE

I. General Description

The YSI Model 31 is a laboratory instrument designed for precise, direct measurement of electrical resistance or conductance.

The instrument utilizes a manually balanced AC bridge which can be operated either at line frequency or 1 KHz. The bridge contains two fixed legs, a voltage divider range switch, and a precision potentiometer which is mechanically connected to a readout dial.

The bridge output is amplified and applied to the grid of an indicator tube. As the bridge output approaches zero, a rectangular "shadow" appears on the screen of the indicator tube. In operation, the sensitivity control, range switch, and drive control are adjusted until a maximum "shadow" appears on the indicator tube. Resistance or conductance is then read from the dial.

II. Specifications

Range	.2 ohms to 2.5 megohms .2 micromhos to 2.5 mhos
Accuracy	±1% of reading from 2.0 ohms to 2.0 megohms, and from 2.0 micromhos to 2.0 mhos. Accuracy decreases outside these ranges.
Resolution	0.5% or better, except x 100,000 micromhos and x 1 ohm which have a 1% resolution.
Indicator	EM84/6FG6 high intensity electron ray tube.
Bridge Supply	Line frequency or 1 KHz selected by front panel switch.

Ambient Range	0 to 50°C at rated accuracy.
Power Requirements	95-125 VAC, 50-60 Hz, .15 amp, 20 watts. (Instruments also are available for 230 volts, operable from 190-250 VAC, 50-60 Hz, .075 amp, 20 watts).

OPERATING PROCEDURES

I. Controls

Instruments are equipped with the following controls.

1. Function Switch – controls power to instruments and selects line or 1 KHz bridge frequency.
2. Sensitivity – controls effective sensitivity of electron ray tube. Set at minimum when determining range of resistance or conductance. Set at maximum when making measurements.
3. Range Switch – selects proper multiplier for direct measurement of resistance or conductance.
4. Drive – drives dial and potentiometer.

II. Making Conductance Measurements

Use the following procedures to make conductance measurements.

1. Connect the instrument to a power source, 117 VAC or 230 VAC depending on the instrument model.
2. Set the Function Switch to the line position and allow 5 minutes for warm-up.
3. Place the conductivity cell in the unknown solution. The electrodes must be submerged and the electrode chamber must not contain trapped air. Tap the cell to remove any bubbles and dip it two or three times to assure proper wetting.

NOTE: The Solution being measured must not be grounded if the instrument is grounded. The instrument may be operated un-grounded by use of a line cord adaptor with the pigtail un-grounded.

4. Connect the cell leads to the HI and LO terminals.
5. Set the Sensitivity control to minimum.
6. Rotate the Range Switch to the conductance range which gives the maximum shadow length on the indicator tube.
7. Adjust the Drive control for the longest shadow.
   NOTE: "Shadow" means the area of the elctron ray tube which is not lighted.
8. If the dial indication is above 20.0 or below 2.0, set the Range Switch to the next higher or next lower range and re-adjust the Drive control for the widest shadow.
9. Set the Sensitivity control to maximum and re-adjust the Drive control for maximum shadow.
   NOTE: If a long, well-defined shadow indication cannot be obtained, set the Function Switch to the 1 KC position. If this does not correct the problem, use an external capacitor (refer to the paragraph describing the External Capacitor Terminal).
10. The conductance value of the solution is the dial reading times the multiplier which is in line with the pointer.
11. The conductivity of the solution is the conductance value in micromhos *times* the cell constant (K).

III. Making Resistance Measurements

Resistance measurements are made in much the same way as conductance measurements. The difference being that the operator uses the resistance ranges on the Range Switch, and the resistance value of the solution in ohms is *divided* by the cell constant (K).

IV. External Capacitor Terminal

Under some conditions it may be difficult to obtain a good maximum shadow on the indicator tube. This is due to phase shift in the bridge circuit caused by the conductivity cell's capacitive reactance. Although the accuracy of the bridge is not affected, there is a possibility of error in determining precisely where the maximum shadow occurs.

By adding a capacitor of the proper value to the bridge leg opposite the cell, the operator may correct the phase shift. The bridge can then be balanced correctly for a sharp, long shadow.

When it is necessary to use an external capacitor, the bridge frequency and dial reading should first be set for the longest shadow possible. A decade capacitor variable from .01 mfd to 1.0 mfd should then be connected between the EXT. CAP. and HI terminals. The capacitor should be adjusted until the shadow is sharply defined. The drive control should then be re-adjusted for a maximum shadow.

CALIBRATION

The instrument was fully calibrated and tested at the factory before shipment. If components are replaced or the instrument has been in service for a long time, a calibration check is desirable. The YSI Customer Service Department at the factory can provide prompt, inexpensive calibration. Should it be inconvenient to return your instrument for this service, observe the following calibration procedure.

I. Basic Calibration

1. Remove the 2 slotted head screws from the sides of the instrument and 4 similar screws from the bottom and then lift the instrument out of the case.

2. Plug the instrument into a power source, set the Function Switch to the line position, and allow 5 minutes warm-up.
3. Set the Range Switch to the x 1000 Ohms position and the Sensitivity control to its maximum setting (full clockwise).
4. Connect the precision resistors called for below to the HI and LO Terminals of the instrument.

   NOTE: A high precision resistance box, such as a GR or ESI, is recommended for accurate calibration. If this is not available, resistors of 2K, 10K, 20K at ±.25% accuracy may be used for basic calibration.
5. Adjust the Drive control for a dial indication of 2.0.
6. Set 2000 ohms on the decade resistance.
7. Adjust the LO control on the rear of the assembly until the shadow on the indicator tube is at maximum.
8. Adjust the Drive control for a dial indication of 20.0.
9. Set 20,000 ohms on the decade resistance.
10. Adjust the HI control on the rear of the assembly until the shadow on the indicator tube is a maximum.
11. Repeat steps 6 through 10 until the shadow is at maximum for both settings.
12. Set 10,000 ohms on the decade resistance.
13. Adjust the Drive control until the shadow on the indicator tube is at maximum – the dial should be reading within 1/2 minor division of 10.0.
14. If the dial reading is not correct, re-check calibration steps 6 thru 10.

II. Range Resistor Check

1. Set the Drive for reading of 10.0.
2. Set up multiples of 10 (10 ohms, 100 ohms, etc.) on the decade resistance and check that all resistance ranges of the

instrument read within 1/2 division of the specified resistance values.

NOTE: Keep in mind that lead resistance will cause an apparent increase in the indicated resistance on the instrument, especially on the x 1 ohm range. The lead resistance of the decade resistance should be measured before starting this calibration check and subtracted from the indicated resistance measured by the instrument.

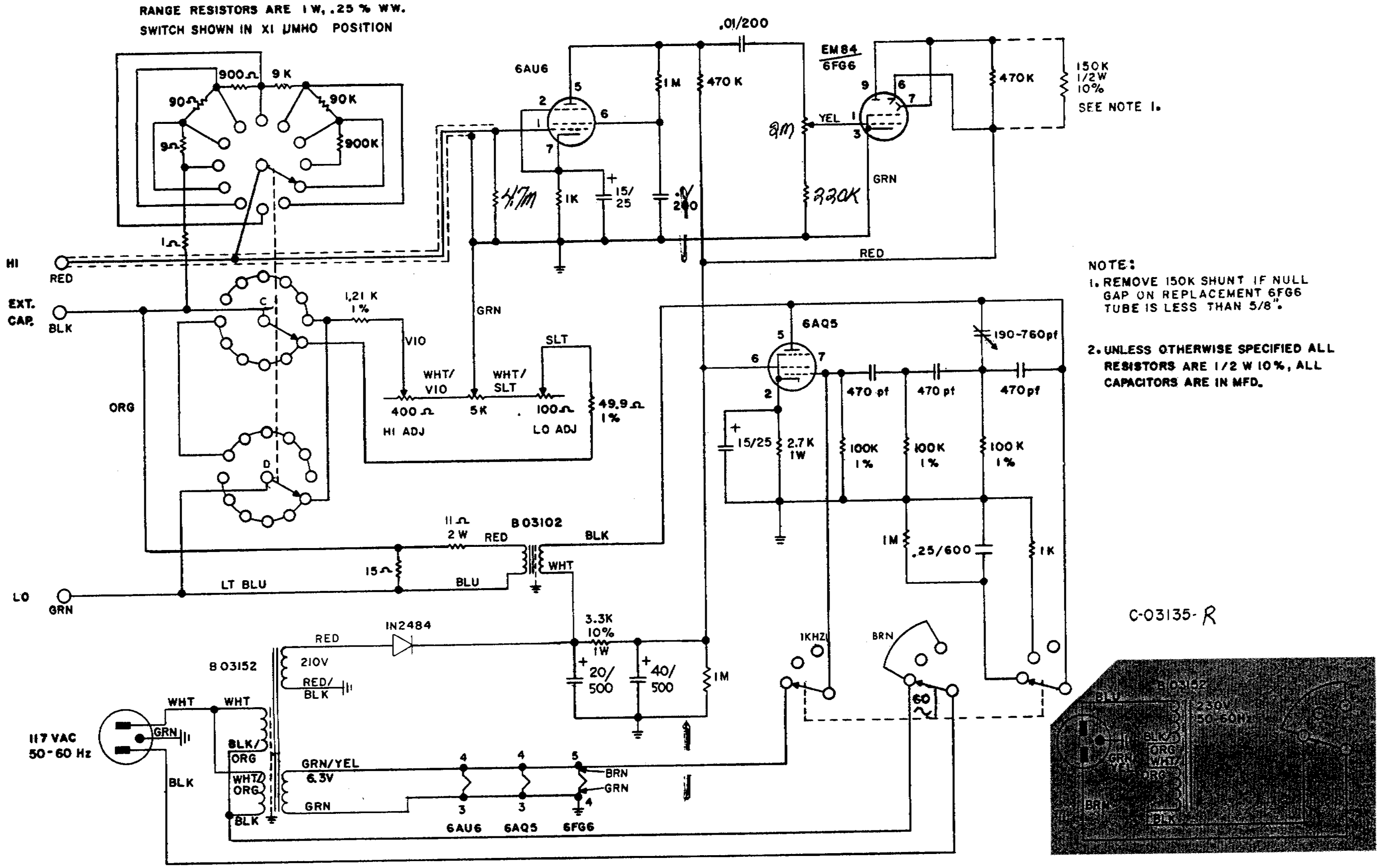
3. If one or more of the instrument ranges is more than 1/2 division off at the 10.0 setting, the .25% bridge resistors should be checked for out-of-tolerance values.
4. Set up multiples of 1 (1 ohm, 10 ohms, etc.) and check all conductance ranges.

RESISTANCE	READING	CONDUCTANCE RANGE
1 ohm	10.0	X100,000 micromhos
10 ohms	10.0	X10,000 micromhos
100 ohms	10.0	X1,000 micromhos
1,000 ohms	10.0	X100 micromhos
10,000 ohms	10.0	X10 micromhos
100,000 ohms	10.0	X1 micromhos

The above list shows the values of conductance which the YSI Model 31 should indicate when the resistances shown are set up on the resistance decade.

5. The dial indication should be within 1/2 minor division of 10.0 on each conductance range when the above values of resistance are measured.

NOTE: When measuring conductance on the x100,000 micromhos and x10,000 micromhos ranges the lead resistance should be added to the resistance values set in on the decade. The reciprocal of the total resistance should be found and used as the specified conductance value. The formula for conductance is as follows:



NOTE:

1. REMOVE 150K SHUNT IF NULL GAP ON REPLACEMENT 6FG6 TUBE IS LESS THAN 5/8".

2. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/2 W 10%, ALL CAPACITORS ARE IN MFD.

Conductance (mhos) = [1/Resistance (ohms)] x 1,000,000. For example, if the lead resistance were .15 ohms, and 1 ohm were set into the decade, the conductance reading would be 8.7 x 100,000 micromhos. (1/1.15) x 1,000,000 = 870,000 micromhos.

CONDUCTIVITY CELLS

I. General Description

YSI offers five standard conductivity cells, each containing platinized platinum-iridium electrodes, except YSI 3418 which has platinized nickel electrodes, that meet the following specifications:

Part no.	Cell Constant	Material	Overall Length	Max. O.D.	Chamber I.D.	Chamber Depth
YSI 3401	K = 1.0/cm	Pyrex 7740	7-1/2"	1"	13/16"	3"
YSI 3402	K = 0.1/cm	Pyrex 7740	6-1/4"	1"	13/16"	2-1/16"
YSI 3403	K = 1.0/cm	Pyrex 7740	7"	1/2"	3/8"	2"
YSI 3417	K = 1.0/cm	ABS Plastic	~6"	1/2"	3/8"	3/4"
YSI 3418	K = 0.1/cm	ABS Plastic	~6-1/2"	1/2"	3/8"	1-3/16"

The cell part number and constant (K) are fired onto the pyrex cells and stamped on the plastic cells.

The cell leads are 48 inches long, with smooth rubber outer insulation.

The cell constants are calibrated to ±1% accuracy against a YSI standard cell. The standard cell is periodically calibrated in a standard solution. (Refer to Cell Calibration and Standard Solutions.)

II. Cell Constant

The cell constant (K) is a factor which is used to determine resistivity (ohms-cm) or conductivity (mhos/cm) of a solution. It is determined by the physical configuration of the cell and the electrodes. Cells with constants of 1.0/cm or greater normally have small, widely spaced electrodes while cells with constants of 0.1/cm or less have large electrodes which are closely spaced.

The user should decide which cell will be most useful based on the resistivities of the solutions in which he will be making measurements. Generally, cells with K = 1.0/cm should be used for solutions with resistivities less than about 50,000 ohms and conductivities of more than 20 micromhos. Cells with K = 0.1/cm should be used for solutions with resistivities more than 50,000 ohms and conductivities less than 20 micromhos.

Resistivity is determined by *dividing* the resistance measured in ohms by cell constant (K).

Conductivity is determined by *multiplying* the conductance measured in micromhos by the cell constant (K).

III. Measurement Techniques

After selecting the proper cell, observe the following precautions in order to assure accurate, repeatable results:

1. The cell must be clean before making any measurement.
2. The cell should be suspended in the solution in such a way that the vent slots are submerged. The electrode chamber should be free of trapped air. (This may be accomplished by tilting the cell slightly and tapping the side.)
3. The cell should be at least 1/4 inch away from any other object, including the walls or bottom of the solution container.
4. If it is possible, the container or system in which measurements are to be made should be isolated from ground potential. If this cannot be done, the YSI Model 31 Conductivity Bridge must be operated ungrounded.
5. The presence of electrical fields and stray currents caused by stirrer motors, heaters, etc., can cause difficulties in obtaining

good measurement results. The user should determine the effects of these and make the necessary corrections, either by shielding or by disconnecting those units which cause trouble during measurements.
6. The cell should always be handled carefully to decrease the possibility of breakage or loss of calibration accuracy.
7. The cell should never be transferred from one type of solution to another without having first been carefully cleaned. (Refer to Maintenance of Cells.)
8. Never store a dirty or contaminated cell.
9. In order to construct an easily calibrated, rugged cell, YSI solders the electrodes and supports in the 3400 series cells with gold solder. For this reason, the cells should not be submerged in aqua regia or any solution which might etch or dissolve gold.

IV. Small Sample Measurements

It is not always possible to immerse the conductivity cell in a solution for measurements. If the quantity of solution is limited or the solution is not accessible to a dip cell, a sample must be removed and used for determinations. For this type of use, any 3400 Series cell, except #3418, may be inverted and used as a sample holder.

The selection of a proper cell for sample use will depend upon the quantity of solution available and the conductivity of the solution. The #3401 cell (K = 1.0/cm) requires 15 ml, the #3402 cell (K = 0.1/cm) requires 12 ml, the #3403 cell (K = 1.0/cm) requires 3 ml, and the #3417 cell (K = 1.0/cm) requires 1 ml.

In use, the cell's vent slots are sealed and the electrode chamber is filled with solution. Solution conductance is measured and multiplied by a corrected cell constant. This corrected constant may be determined as outlined in the following steps and example.

1. Before sealing the vent slots, immerse the cell in room temperature tap water and measure conductance.
2. Multiply by the cell constant to determine conductivity.
3. Seal the vent slots and fill the electrode chamber with some of the same water and again measure conductance.
4. Multiply by the cell constant to determine conductivity.
5. Divide the difference between the two conductivity determinations by the conductivity obtained in Step 4.
6. The result of Step 5 is a percent variation of cell constant. Add this variation to the constant marked on the cell. The result is the cell constant to use whenever the vent slots are closed.

   EXAMPLE: Cell constant (K) = 1.0/cm
   Step 1 – conductance = 1200 micromhos
   Step 2 – Conductivity = 1200 x 1.0 = 1200 micromhos/cm
   Step 3 – Conductance = 1000 micromhos
   Step 4 – Conductivity = 1000 x 1.0 = 1000 micromhos/cm
   Step 5 – Difference – 200 micromhos/cm divided by 1000 micromhos/cm = .20
   Step 6 – .20 = 20% of 1.0
   Cell constant (K) with closed slots = 1.20/cm

V. Maintenance of Cells

There are a number of maintenance procedures which are of importance to the user of YSI conductivity cells. These procedures are listed below:

A. CLEANING AND STORAGE

The single most important requirement for accurate and reproducible results in conductivity measurement is a clean cell. A

contaminated cell will contaminate the solution causing the solution conductivity to change. Clean cells as follows:

1. Prepare a solution containing 100 ml isopropyl alcohol, 100 ml ethyl ether, 50 ml concentrated HCl, and 50 ml distilled water.

   CAUTION: Ingredients are extremely flammable and caustic. Observe proper safety precautions, including rubberized skin protection, safety glasses, no spark or flame within 50 feet, and good ventilation.

2. Dip the cell into the solution, making certain it is submerged beyond the vent slots in the electrode chamber.
3. Agitate the solution for 1 to 2 minutes.
4. Remove the cell from the solution and rinse it in several changes of distilled water. Inspect the platinum black to see if re-platinizing may be required.

B. PLATINUM BLACK INSPECTION

The electrodes of YSI 3400 cells are coated with platinum black before calibration. This coating is extremely important to proper cell operation, especially in solutions of high conductivity. In these solutions, a poor coating of platinum black will cause the shadow on the indicator tube to be blurred and indistinct.

The cell should be inspected periodically. If the coating appears to be thin or is flaking off, the electrodes should be cleaned as noted in Cleaning and Storage, and re-platinized.

C. RE-PLATINIZATION

A YSI #3139 Platinizing Kit is available from your dealer. The kit includes three 1.5 volt batteries, a milliammeter, a current control, and a reversing switch. These are mounted in a convenient plastic case. The kit also includes a bottle to hold platinizing solution. A 2-oz bottle of platinizing solution is available from your dealer as YSI #3140. Platinizing is done as follows:

1. Place platinizing solution in the platinizing bottle.
2. Connect the cell to the power supply.
3. Place the cell in the solution with both electrodes submerged.
4. Adjust the current control for a 50 ma indication.
5. Reverse polarity to the cell every 30 seconds until both electrodes are covered with a dense, velvet-black layer of platinum black. Platinize for 3 to 4 minutes.
6. Remove the cell from the solution and the power supply and rinse the electrodes in running tap water for about 15 minutes.
7. Rinse the cell in distilled water, allow it to air-dry, and store it in a clean place.

VI. Cell Calibration and Standard Solutions

The YSI #3400 series cells are calibrated to absolute accuracy of ±1% based on a standard solution. Since the literature on conductivity does not indicate a consistently accepted standardization method, we have chosen the .01 demal KCI solution method as determined by Jones and Bradshaw in 1937 as our standard. Recent textbooks, as well as the ASTM standards, concur in this choice.

The solution is prepared by diluting .745 grams pure dry KCI with distilled water until the solution weight is 1 kilogram. The table below shows the values of conductivity this solution would have if the distilled water were non-conductive. However, since even high purity distilled water is slightly conductive, the measured conductivity will be higher by an amount equal to the conductivity of the water.

Temperature (°C)	Conductivity (Absolute Micromhos/cm)
15	1141.5
16	1167.5
17	1193.6
18	1219.9
19	1246.4
20	1273.0
21	1299.7
22	1326.6
23	1353.6
24	1380.8
25	1408.1
26	1435.6
27	1463.2
28	1490.9
29	1518.7
30	1546.7

The operator may use the standard solution and the table to check accuracy of a cell's constant or to determine an unknown constant. The formula is shown below:

$$K = \frac{R\,(C_1 + C_2)}{10^6}$$

Where: K = Cell constant
R = measured resistance in ohms
C_1 = conductivity in absolute micromhos
C_2 = conductivity in absolute micromhos of the distilled water used in making solution.

R, C_1 and C_2 must either be determined at the same temperature or corrected to the same temperature to make the equation valid.

NOTE: For further information on conductivity and the above standard information, refer to ASTM Standards Part 23 – Standard Methods of Test for Electrical Conductivity of Water and Industrial Waste Water – ASTM Designation D1125-64.

WARRANTY

The YSI Model 31 Conductivity Bridge and Cells carry a one-year unconditional warranty on all workmanship and components. Damage through accident, misuse, or tampering will be repaired at a nominal charge, if possible.

If you are experiencing difficulty with a YSI product, it may be returned to the YSI Customer Service Department for repair, even if the warranty has expired. YSI maintains complete facilities for prompt servicing of all YSI products.

Service Department
Yellow Springs Instrument Co., Inc.
Box 279
Yellow Springs, Ohio 45387
Phone: 513-767-7241