YELLOW SPRINGS
INSTRUMENT CO. INC.

YELLOW SPRINGS OHIO

INSTRUCTIONS

FOR

YSI

MODEL 51

OXYGEN

METER

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MODEL 51 OXYGEN METER

SPECIFICATIONS

The Model 51 Oxygen Meter is a readout instrument designed to be used with YSI oxygen probes and YSI temperature probes.

I. Oxygen Measurement

Range: 0 - 25 PPM Dissolved Oxygen

0 - 50% Oxygen in Gas at 760 mm.

0 - 50% Dissolved Oxygen Saturation at 760 mm.

Note: If the sample temperature is in the range 25 to 45°C then the scale may be expanded to give 0 - 12.5 PPM or 0 - 25% oxygen.

Accuracy: With direct calibration the error is less than ½% saturation or 0.25 PPM.

Readability: 0.2% saturation or 0.1 PPM.

Response Time: 90% of reading in 10 sec. dependent on temperature and oxygen level.

Ambient Temperature Range of O_2 Measurement: 5 to 45°C

Battery Life: 500 hours

Two Mallory TR165 7.0 Volt Mercury batteries

One Mallory RM1R 1.35 Volt mercury battery

Probes	5101 – Oxygen Probe (10 ft. lead)
	5102 – Ten ft. Oxygen/Temperature Probe
	5103 – Fifty ft. Oxygen/Temperature Probe
	5104 – B.O.D. Bottle Oxygen Probe See YSI catalogs or Dealer for complete line.
Service Kit	5034 – Contains membranes, KCl solution, "O" rings, etc.
Oxygen Computer	5042 – Convenient slide rule computer for determining calibration values

II Temperature Measurement

Range	0 - 50°C
Accuracy	As indicated – ±1.5°C (See Discussion)
Readability	0.2°C
Probes	Certain YSI oxygen probes have integral temperature probes. Any YSI 400 series probe can be used.

SHORT INTRODUCTION TO OXYGEN MEASUREMENT

I. How the Sensor Works

The Clark type oxygen sensor measures oxygen pressure. Oxygen is consumed at the cathode. A pressure drop appears across the membrane. Inside the membrane next to the cathode the oxygen pressure is zero because the oxygen is consumed as it reaches the cathode. Outside the membrane the oxygen pressure is the ambient pressure to be measured. Oxygen flows or diffuses through the membrane because of the pressure difterential. The flow of oxygen through the membrane is directly proportional to the differential oxygen pressure across the membrane (since the oxygen pressure is zero on the cathode side of the membrane the flow is proportional to the absolute oxygen pressure on the outside of the membrane). The chemical reaction within the sensor produces a current which is in direct stiochiometrical relation to the amount of oxygen being consumed. Hence, the cell current is directly proportional to the oxygen pressure to which the sensor is exposed. The proportionately constant includes factors of cathode area, membrane material, membrane thickness and membrane permeability to oxygen. From a practical measurement viewpoint the sensor requires field calibration because changing membranes can affect calibration and further all practical membrane materials exhibit large temperature coefficients of permeability (3 to 5%/°C).

II. Calibration

The YSI system of field calibration is based upon two facts.

1. The oxygen concentration in FRESH air is nearly constant.

2. When a liquid is saturated with a gas, the partial pressure of the gas dissolved in the liquid is equal to the partial pressure of the gas above the liquid. (For example: in water saturated with air and at the same temperature as the air, the oxygen sensor produces the same current when immersed in the liquid as when exposed to the air above the liquid.)

Further, calibration and measurement are made at the same temperature whenever possible to reduce errors arising from large and variable membrane temperature coefficients.

PPM DISSOLVED OXYGEN: A convenient way to report the dissolved oxygen content of water is in weight ratios — milligrams per liter (MG/L) or parts per million (PPM). Tables are available which give the solubility of oxygen (at saturation) for various temperatures. For instance, see "Standard Methods for the Examination of Water & Waste Water" published by American Public Health Association, American Water Works Association, and Water Pollution Control Federation.

% SATURATION: There is some confusion in the use of this term. For clarity we suggest two terms.

% OXYGEN SATURATION: The amount of oxygen present in the liquid relative to the amount that could be there for the same **total** system pressure at the same temperature.

% AIR SATURATION: The amount of oxygen present in the liquid relative to the amount that could be there if the liquid were saturated with air at the same temperature and the same barometric pressure.

Water in equilibrium with air containing 21% oxygen would have —

21% oxygen saturation
100% air saturation

THE CARE AND FEEDING OF THE OXYGEN PROBE

The YSI Oxygen Probe is a precision device and requires good treatment if high accuracy measurements are to be obtained.

The electrode is protected from dirt, dust, etc., during shipment by a membrane over the sensitive end.

WARNING: Use only YSI recommended membranes and filling solution. Distilled water must be used in making the KCl solution. Tap water contains iron and other salts that result in poor electrode performance and will contaminate the electrodes and result in short life.

YSI Maintenance Kit #5034 is available for this purpose and contains everything necessary except distilled water.

I. Preparing the Probe for Operation

1. Add distilled water to the KCl crystals and dissolve completely.
2. Transfer a part of the KCl solution to the eyedropper bottle.
3. Remove the sensor guard from the probe.
4. Remove the protective membrane and "O" ring.
5. Select a membrane from the vial — lay on a clean sheet of paper — handle only by the ends.
6. Support the probe in a vertical position.
7. With one thumb secure the membrane to the side of the probe.
8. With the eyedropper, fill the central hole avoiding air bubbles. Wet the gold electrode and the lucite around it. The surface tension of the KCl will cause a large drop or meniscus to form above the electrode. This will ensure complete contact between the membrane and the KCl.
9. Stretch the membrane over the top of the electrode.
10. Stretch an "O" ring into place — inspect for wrinkle-free membrane. A taut smooth membrane surface is required. A lax membrane will result in erratic performance, slow speed of response and poor shock performance. Remove the excess membrane about ¼" beyond the "O" ring with scissors or knife.

11. A small air bubble may appear under the membrane. This is normal.

12. Remove excess KCl solution and reassemble the sensor guard.

13. The probe is ready for operation.

II. Changing the Membrane

The only reasons for changing the membrane and KCl solution are mechanical damage to the membrane or accumulations of dirt or stains which impair performance. If the sensor guard is kept in place and the probe used with reasonable care, weeks or months of service can be expected.

When the membrane is changed, flush out the sensor cavity with distilled water (or KCl solution) several times. Do not attempt to polish the surface of the gold and plastic. Wipe gently with a soft lint-free cloth if required.

The life of the electrode is limited by the silver anode which is consumed by the electrochemical process. The silver should last for a year under the most severe conditions of use.

It should be noted that some other gases can be reduced at the cathode at the polarizing potential required for oxygen. Included are SO_2 and Halogens. H_2S reacts with the metals and poisons the cell. This poisoning can usually be overcome by periodic wiping of the gold surface gently with a clean lint-free coarse cloth or a hard paper. Do not use any form of abrasives. The poisoning of cell shows as a tarnish on the gold and the polishing should be continued until the gold is shiny.

THE MEASUREMENT OF DISSOLVED OXYGEN

Each measurement consists of two operations:

a. Calibration

b. Measurement

Whenever possible calibration should be performed at the same temperature as the measurement. Under some routine conditions a calibration may be valid for multiple measurements.

I. The YSI Model 5075 Calibration Chamber (See Figure 1)

The unit consists of a 4½ foot stainless steel tubing (1) connected to chamber (5). Ring (7) is used for measurement.

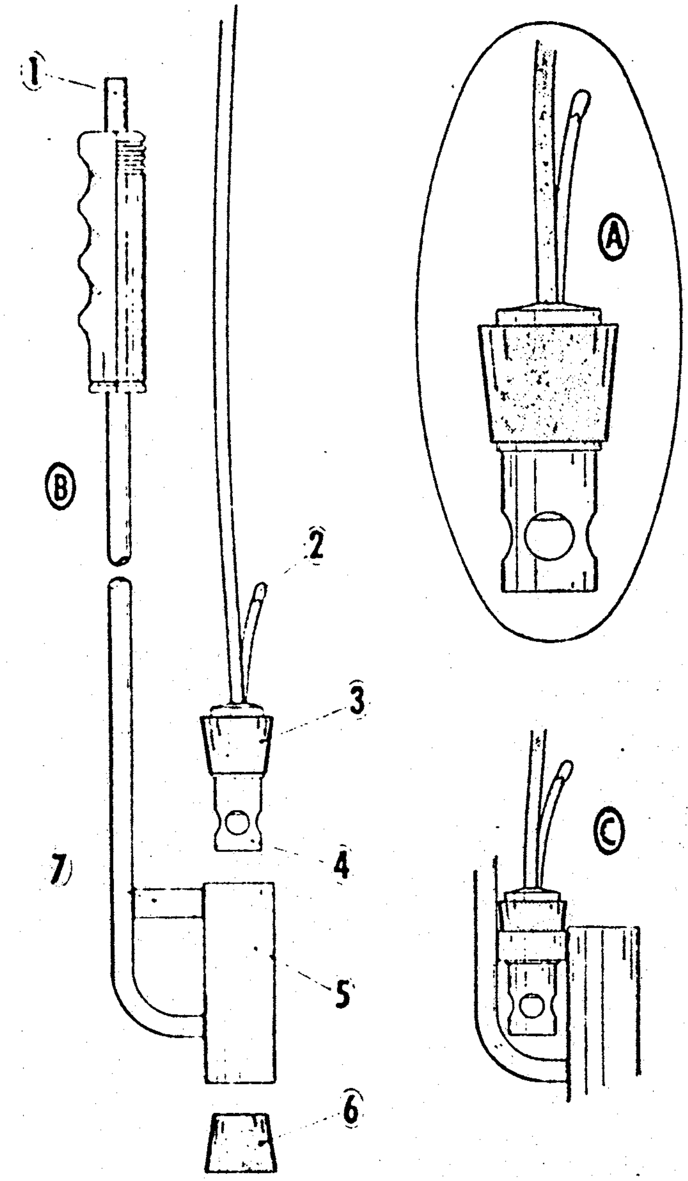
To Assemble for Calibration Use:

1. Assemble stopper (3) onto probe (4) as shown in Detail (A). (2) represents the temperature sensor).
2. Insert probe-stopper assembly into top of calibration chamber (5).
3. Insert stopper (6) into bottom of (5).

Unit is now ready for use in calibration. The stoppers seal the chamber against water entry. Tube (1) connects to chamber (5) thus establishing pressure equilibrium.

FIGURE 1

5102



For Measurement Use:

Transfer the probe-stopper from chamber (5) to ring (7). In this position the sensor is protected and can be positioned easily for measurement.

II. The Direct Calibration Method of Measuring Dissolved Oxygen.

(Calibration and measurement achieved at same spot and temperature.)

1. Prepare the oxygen sensor for operation.
2. Assemble probe in calibration chamber.
3. Connect probe to Model 51. Combination oxygen/temperature probes have two connectors; one for the OXYGEN jack, one for the TEMP. jack. The plugs are diferent in size — it is impossible to connect both improperly.
4. Lower unit in water — locate chamber in spot where oxygen measurement is desired.
5. Turn selection switch to RED LINE.
6. Wait 3 to 5 minutes for temperature equilibrium.
7. With selector switch at RED LINE — set meter pointer to RED LINE with coin-operated control.
8. Turn selector switch to TEMP. — read temperature from meter.
9. Use calibration tables (page ___) or YSI Oxygen Meter Computer to determine calibration value.
10. Turn selector to ZERO — bring meter to zero with control marked ZERO.

11. Turn selector to READ — if reading is steady set meter to calibration value determined in Step 9. If meter drifts wait for temperature equilibrium and repeat Steps 8, 9, 10 and 11.

12. Remove calibration unit from water — remove sensor probe from chamber and secure in ring.

13. Return unit to former position under water — twist handle to induce water flow across membrane. Low reading will result if not agitated.

14. Read oxygen value from meter.

III. The Indirect Calibration Method of Measuring Dissolved Oxygen.

(Calibration and measurement achieved at different spot and temperature.) This method used to make measurements in deep water. Prepare unit as for Direct Calibration. Follow Steps 1 thru 11.

EXCEPT. . In step 4 lower unit to a depth of 2 to 3 feet.
In Step 8 record calibration temperature.

THEN. . . .

12a. Remove calibration unit from water — remove sensor probe from unit.

13a. Lower probe to the depth required for measurement.

14a. Turn selector to TEMP. — record this temperature.

15a. Turn selector to READ — move the probe up and down continuously to induce water flow across the membrane. Low readings result if not agitated.

16a. When steady reading is attained, record.

17a. Use YSI Oxygen Meter Computer to ascertain the true oxygen value. (See directions on Computer.)

NOTES:

a. The rubber stopper can be left on the sensor permanently.

b. The numbered labels included with the unit can be applied to the cable as depth indicators.

c. The sampler handle is a tube and must be open to the air to maintain air pressure control during calibration.

d. The YSI Oxygen Meter Computer (No. 5042) provides a rapid and convenient means for determining calibration values and for correcting for temperature differences between calibration and measurement. Calibration values are given for fresh water and salt water — altitude corrections are given — also a "spare window" allows the operator to construct special calibration scale.

e. To agitate the probe in deep water, sharply pull cable vertically 6 to 10 inches — allow to settle to original depth — repeat every 3 to 6 seconds. The motion is similar to fishing with a hand line.

f. The membrane must be dry for accurate calibration. Before inserting sensor into calibration chamber shake off moisture — examine membrane if water droplets persist — shake or blow them away.

g. Accuracy of measurement is increased if the difference between surface calibration temperature and depth temperature can be kept to a minimum by choosing location of surface calibration point.

h. If weight is added to the probe to overcome currents, limit the weight to two pounds. For heavier weights, use independent cable.

IV. B.O.D. Bottle Measurements

The YSI 5104 Oxygen Probe is especially designed for use with standard B.O.D. bottles.

A series of grooves along the lucite body serve to position an "O" ring. This "O" ring serves as a "stop" to position the probe in the bottle at the desired depth.

Prepare or procure a sample of known oxygen concentration at the temperature of the incubation chamber. This may be a solution part of which has been analyzed for oxygen by standard analytical methods. Bring this standardizing sample to the temperature of the incubator (thus the standard and unknown samples are at the same temperature).

Calibration:

1. Prepare the oxygen probe for operation.
2. Connect oxygen probe (5104) to Model 51 readout.
3. Turn selector to ZERO.
4. Remove standard sample from incubator.
5. Remove stopper — drop in magnetic stirring bar.
6. Place 5104 probe in the neck of bottle.
7. Place bottle on stirring table.
8. With selector switch at ZERO — adjust the meter to zero with ZERO control.
9. Turn selector to READ — when meter reading is steady calibrate by setting meter to indicate the known oxygen value of the sample.

Measurement

1. Remove B.O.D. sample from incubator.
2. Remove stopper — drop in magnetic stirring bar.
3. Place 5104 probe in neck of bottle.
4. Place bottle on stirring table.
5. Read oxygen directly from meter.

NOTES:

a. Check calibration once an hour or as often as experience indicates.

b. Other methods of standardization are possible:

   1. Air saturated water is of known oxygen content if the temperature is known — see section "Tables for Calibation."

   2. Fresh air can be used if the temperature can be reliably ascertained as that of the portion of incubator where the sample has been kept. Temperature gradients within the incubator can cause significant errors unless air calibration is carefully done.

      In all cases be certain that the temperature of the standardizing sample is the same as that of the unknown samples.

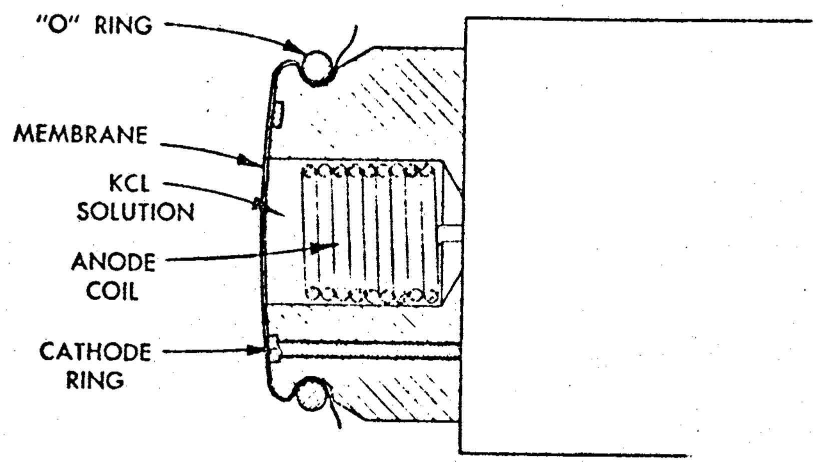
c. The probe has no guard to protect the membrane from damage — care in handling will reduce the frequency of membrane replacement.

d. The proper position of the probe in the B.O.D. bottle is so that the end of the probe projects ¼ to ½ inch into the body of the bottle.

e. The 5104 probe uses a special size "O" ring (⅜" x 5/16" x 3/32") which is not supplied with the 5034 Service Kit. A dozen extra "O" rings are supplied with the probe.

GENERAL DISCUSSION OF THE OXYGEN PROBE AND MEASUREMENT THEORY

FIGURE 2



I. Operation Principle

The YSI Oxygen Probe is a polarographic system (See Figure 2).

The cathode is a gold ring imbedded in a lucite block; the anode is a silver coil recessed in the central well. The interior is filled with an aqueous solution of potassium chloride (KCl). A thin Teflon® membrane stretched across the end of the sensor isolates the sensor elements from their environment. The membrane is permeable to gasses and allows them to enter the interior of the sensor. When a suitable polarizing voltage is applied across the cell, oxygen will react at the cathode causing a current to flow through the cell. The amount of current which flows is proportional to the amount of oxygen to which the membrane is exposed. The sensor actually measures the oxygen pressure. Since oxygen is consumed at the cathode, it can be assumed that the oxygen pressure inside the membrane is zero (this is nearly so at the gold cathode). Hence, it can be seen that the force causing oxygen to diffuse through the membrane is proportional to the absolute pressure of oxygen outside the membrane. If the oxygen pressure increases, more oxygen diffuses through the membrane and more current flows through the cell. A lower pressure results in less current. The membrane diffusion is directly proportional to pressure and the oxygen-cell current relationship obeys stoichiometric laws, thus a linear relationship exists between external oxygen pressure and cell current.

Temperature control is important because the membrane permeability varies with temperature and changes at a rate of about 4% per °C depending on the membrane material.

II. Measuring Oxygen in Gas Mixtures

Outdoor air and air within any reasonably ventilated building or enclosure can be assumed to contain 21% oxygen. Thus it is convenient to use air to calibrate the instrument. To avoid errors the temperature of the air used for calibration and the temperature of the gas to be tested must be the same. If it is difficult to maintain the two gases at the same temperature a sampler technique may be useful to assure that the two gases are at the same temperature. For example, a small modified plastic bottle (included with the probe maintenance kit) can be slipped over the probe unit. The bottle is filled with one gas, say the air for standardizing, and put into the area containing the second gas. Allow the temperature to reach equilibrium, (wait for stable oxygen indication) calibrate the instrument. Remove the bottle and wave the probe to dispel the standardizing gas — the instrument will now read the oxygen concentration in the gas under analysis.

By modifying the procedure a sample of gas to be analyzed can be brought to air temperature. Standardize the instrument with air at room temperature. Surround the probe with a sample of unknown gas in the bottle. Wait for temperature equilibrium before reading oxygen content. The sampler technique is not needed when the temperatures of the two gases are within a few degrees of each other; correction may be made by assuming the temperature coefficient is 4% per °C. Thus at an indicated reading of 21% at 1°C difference in temperature relates to 0.84% O_2. Increased temperature requires the correction to be subtracted.

III. Measurement of Oxygen Dissolved in Water

The amount of oxygen which can be dissolved in water is a function of the temperature of the water. When water is saturated with oxygen the pressure of the dissolved oxygen is equal to the pressure of oxygen above the water. In this state of equilibrium, oxygen from the gas above the water enters the surface of the water at the same rate that dissolved oxygen escapes from the water into the gas above it. If the temperature rises more oxygen leaves the water than enters it from the gas — a new equilibrium is eventually established. Lowering the temperature permits more oxygen from the gas to become dissolved in the water until again pressure equilibrium is established.

The oxygen probe is responsive to oxygen pressure. Thus if a container of water is at the same temperature as the air above it and the water is saturated with the air, the oxygen probe will produce the same current whether immersed in the water or exposed to the air above it.

The two currents will be the same at any temperature for a system where the water is saturated with the air above it. It is this characteristic of the sensor upon which the calibration techniques described here are based.

1. Determining PPM Dissolved Oxygen:
   Tables are available which relate PPM of oxygen dissolved in water saturated with air to the temperature of the water. If a sample of air at known pressure is brought to the temperature of the water, the electrode current (measuring in air) will be the same as that obtained when the probe is dipped into the water IF the water is saturated with air.

   Knowing the temperature of the water and referring to a table of PPM dissolved oxygen vs. temperature an instrument can be calibrated to read directly in PPM dissolved oxygen. (A small air pressure correction must also be made.) Another advantage of this method is that the temperature coefficient of the probe does not influence the measurement.

2. Determining % Saturation of Dissolved Oxygen:
   If, as above, a sample of air is brought to the temperature of the water the electrode current is the same in air and water IF the water is saturated with air.

   To relate the O_2 in the air to % saturation of O_2 dissolved in the water, consider that the % oxygen in the air is 21% by volume; then the water (if saturated with air) contains 21% of the oxygen it could hold if it were in equilibrium with pure oxygen at the same total atmospheric pressure. Thus the instrument can be calibrated to read directly in % saturation of oxygen. If the measurement is to be made below the surface of the water the pressure of the water must be taken into consideration because the amount of dissolved oxygen for 100% saturation is related to the total pressure on the layer of water being analyzed. Automatic pressure compensation for sample depth can be effected by calibration chamber design.

IV. Use of the Gas Sampler

A special one-ounce plastic bottle (with a hole in the bottom) is included with the electrode. This air sampler provides an easy way to calibrate the instrument for gas measurements.

To check the oxygen content of an area suspected to be other than normal, take the instrument and probe unit to an area known to contain fresh air. Take the cap off the sampler bottle and wave through the air to flush out the bottle then push the bottle over the guard end of the probe; cap the bottle. Transport the probe and instrument into the measurement area; wait until the oxygen indication is steady. It is at this time the temperature of the calibration gas within the bottle is the same as the surrounding air or gas. Calibrate the meter to read 21% oxygen. Remove the sampler bottle from the probe; wave the probe a few times to dispel any remaining calibrating air from the interior of the guard. Read the oxygen content of the new air environment.

Another procedure may also be used. Allow the probe to assume the temperature of the surrounding air; calibrate to 21% oxygen. Remove the cap from the sampler bottle and push over the probe guard, but do not completely cover the holes. Connect the gas to be analyzed to the top of the bottle. Flush out the bottle well, then push the sampler bottle further down on the guard to cover the holes and cap the bottle. Allow temperature equilibrium to be established before taking an oxygen reading.

V. Tables for Calibration

The PPM tables in accordance with standard practice include the vapor pressure of water in the indicated pressure. The sample of air used for calibration should be saturated with water vapor and a slight bit of moisture in the sampler cup will insure water vapor saturation.

The error which may result from use of completely dry air (extreme condition) is small and is maximum at higher temperatures and altitudes. At 25°C and 760 mm pressure the extreme error would be 0.3 PPM; for 50% R.H., 0.15 PPM. If the error is of concern, wet the inside of the sampler cup before use to provide 100% R.H. Then no error will occur using the tables provided.

SOLUBILITY OF OXYGEN IN WATER (Saturated with Air) AT VARIOUS TEMPERATURES AND PRESSURES*

P inches	30.51	29.92	29.53	28.54	27.56	26.57	25.59	24.61
P mm	775	760	750	725	700	675	650	625
T-°C								
0	14.9	14.6	14.4	13.9	13.4	13.0	12.5	12.0
1	14.5	14.2	14.0	13.6	13.1	12.6	12.1	11.7
2	14.1	13.8	13.6	13.2	12.7	12.3	11.8	11.4
3	13.7	13.4	13.2	12.8	12.3	11.9	11.5	11.1
4	13.4	13.1	12.9	12.5	12.1	11.6	11.2	10.8
5	13.0	12.8	12.6	12.2	11.8	11.3	10.9	10.5
6	12.7	12.5	12.2	11.9	11.5	11.0	10.6	10.2
7	12.4	12.2	11.9	11.6	11.2	10.7	10.4	9.9
8	12.1	11.9	11.6	11.3	10.9	10.5	10.1	9.7
9	11.8	11.6	11.4	11.1	10.7	10.2	9.9	9.5
10	11.5	11.3	11.2	10.8	10.4	10.0	9.6	9.3
11	11.2	11.0	10.9	10.5	10.1	9.8	9.4	9.1
12	11.0	10.8	10.7	10.3	9.9	9.6	9.2	8.9
13	10.7	10.5	10.4	10.0	9.7	9.4	9.0	8.6
14	10.5	10.3	10.2	9.8	9.5	9.2	8.8	8.5
15	10.3	10.1	10.0	9.6	9.3	9.0	8.6	8.3
16	10.1	9.9	9.8	9.4	9.1	8.8	8.4	8.1
17	9.9	9.7	9.6	9.3	8.9	8.6	8.3	7.9
18	9.7	9.5	9.4	9.1	8.8	8.4	8.1	7.8
19	9.5	9.3	9.2	8.9	8.6	8.2	7.9	7.6
20	9.3	9.1	9.0	8.7	8.4	8.0	7.8	7.5
21	9.1	8.9	8.8	8.5	8.2	7.9	7.6	7.3
22	9.0	8.8	8.7	8.4	8.1	7.8	7.5	7.2
23	8.8	8.6	8.5	8.2	7.9	7.6	7.3	7.0
24	8.6	8.4	8.3	8.0	7.7	7.4	7.1	6.9
25	8.5	8.3	8.2	7.9	7.6	7.3	7.0	6.8
26	8.3	8.1	8.0	7.7	7.4	7.2	6.9	6.6
27	8.2	8.0	7.9	7.6	7.3	7.1	6.8	6.5
28	8.0	7.8	7.7	7.4	7.2	6.9	6.6	6.4
29	7.9	7.7	7.6	7.3	7.1	6.8	6.5	6.3
30	7.7	7.5	7.4	7.1	6.9	6.6	6.4	6.1

* All values shown are for water in equilibrium with air saturated with water vapor.

RELATION OF ATMOSPHERIC PRESSURE TO ALTITUDE

Altitude	Atmospheric Pressure
Sea Level	760
1000 Feet	733
2000 Feet	707
3000 Feet	681
4000 Feet	656
5000 Feet	632

It should be noted that the barometric pressure as quoted by the Weather Bureau is *not* the true atmospheric pressure of the locale, but it is corrected to an equivalent sea level reading.

A simpler working table can be generated for work in a particular location. Determine the altitude and use the enclosed table to find the true pressure for normal barometric pressure 760 mm at sea level.

Interpolate the table showing the PPM at various temperatures and pressure and generate a new list of values.

For example, an altitude of 1500 feet is equivalent to a pressure of 720 mm (from altitude table). Referring to the PPM chart the PPM values lie between 725 and 700 mm. The new table is generated.

PPM O_2 for 720 mm (1500 Feet)

°C	PPM	°C	PPM	°C	PPM
0	13.8	11	10.4	21	8.4
1	13.5	12	10.2	22	8.3
2	13.1	13	9.9	23	8.1
3	12.7	14	9.7	24	7.9
4	12.4	15	9.5	25	7.8
5	12.1	16	9.3	26	7.6
6	11.8	17	9.2	27	7.5
7	11.5	18	9.0	28	7.3
8	11.2	19	8.8	29	7.2
9	11.0	20	8.6	30	7.1
10	10.7				

A change in altitude of ± 500 feet will cause an error of 0.2 PPM (about 2% at 10 PPM). Barometric pressure changes of .5 inch (12.5 mm) will introduce an error of about 0.2 PPM (about 2% at 10 PPM). A check with the Weather Bureau each day should provide an easy correction to add or subtract to the table.

The Weather Bureau states that the normal extremes of barometric pressure variation is plus or minus 1.0 (25mm) inches from mean value of 29.92 (760 mm).

Thus the combined error of not making daily barometer corrections and changing altitude by ± 500 feet would be a maximum of ± 0.5 PPM for a value of 10.0 PPM.

TEMPERATURE MEASUREMENTS

The range of this system is 0 - 50°C. This range is read directly on the meter with the use of any YSI 400 series probe.

The resolution is determined by the readability of the meter dial. Each division is 1°C and each division can be easily interpolated to less than ½°C.

The accuracy is a function of both instrument tolerances and probe tolerances. The maximum error due to the combined tolerances is ±1.5°C.

Part of this error arises from using a common scale for both temperature and oxygen measurements to avoid confusion. This part of the error can be corrected by using the correction graph shown in the OPERATION section to yield a maximum combined tolerance of ±0.6°C at 50°C to ±0.7°C at 0°C.

Operation:

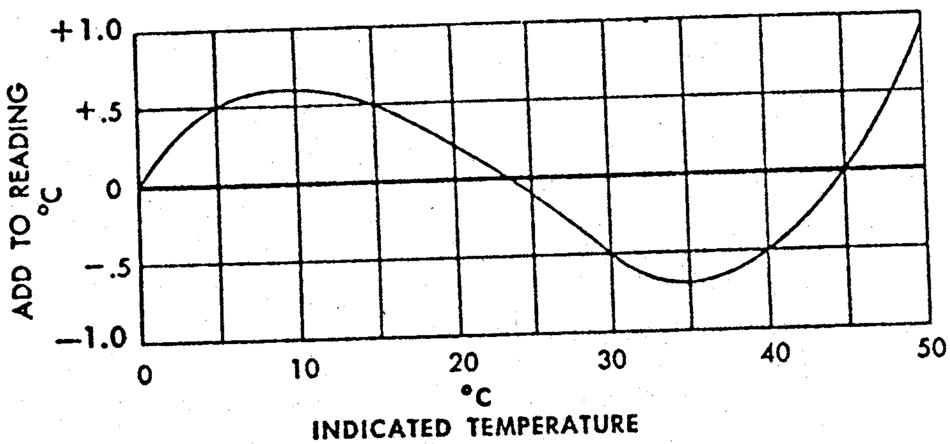
With the instrument turned off, the meter pointer should be aligned with the zero mark on the meter scale. This can be adjusted by the small screwdriver adjustment on the front of the meter case. This adjustment is not normally required with each measurement.

With the YSI #401 probe (or any other YSI 400 series probe) in place, turn the selector switch to RED LINE, and set the coin-operated RED LINE adjustment until the meter pointer aligns with the red line on the meter scale.

Turn the selector switch to TEMP. and read the temperature of the area surrounding the end of the thermistor probe. If the probe should be accidentally unplugged during these operations no damage will result, but the meter will read off scale to the right when the selector switch is in the TEMP. position.

If better than ±1.5°C accuracy is desired, the following correction can be applied to the readings on the thermometer to achieve an accuracy of ±0.6°C at 50°C to ±0.7°C at 0°C.

FIGURE 3



CIRCUIT OPERATION AND MAINTENANCE

I. Operation

The Model 51 contains two separate circuits which share a common meter.

1. An amplifier used for oxygen measurement.
2. A temperature bridge circuit.

The oxygen measuring portion of this system consists of two mercury battery power sources, a polarographic probe, a transistorized differential DC amplifier, and a DC meter readout. One of the power sources is used to establish the polarizing voltage of the polarograph cell. The other power source is used to supply power for the amplifier and meter. Under the proper conditions the change in cell current is a function of oxygen present at the cell. This change in current is amplified and then used to cause a change in meter deflection. Through the use of proper design conditions in the system and proper calibration by the operator, a direct readout of either PPM dissolved oxygen or of % saturation can be obtained on the meter dial.

The temperature measuring system consists of a mercury battery power source, a thermistor probe, and a Wheatstone bridge with a meter readout. By the appropriate switching the same power source mentioned above for obtaining polarizing voltage is used to furnish power to the Wheatstone bridge, and the readout. By the proper bridge design, the non-linear characteristics of the thermistor can be compensated for by the inherent non-linearity of a loaded Wheatstone bridge so that the meter deflection vs. temperature change is nearly linear, thus allowing the linear dial used for the oxygen measurement to also be used for temperature measurement thus eliminating one possible source of operation confusion. The operator needs only to make occasional adjustments of one control to correct for changes in ambient temperature and battery life. A precision resistor is used as reference for this operation. The use of a precision thermistor for temperature compensation and mercury cells for long life at constant voltage make this adjustment small and the need for it infrequent.

II. Maintenance

The only normal maintenance on this instrument is battery replacement. Since there are three batteries the first step is to determine which batteries need replacement. For preventive maintenance all batteries should be replaced about every six months if the instrument is used very frequently, or about every one year if the use is only occasional. If the batteries are only replaced after failure the following procedure will determine replacement. The thermometer will not reach red line and the oxygen probe readings may become erratic when the 1.35 volt battery has failed. This should be replaced with Mallory RMLR or equivalent. If the oxygen meter will not reach normal calibration and again if the oxygen readings are erratic both 7 volt batteries need replacing. These should be Mallory TR165 or equivalent.

The procedure for doing this follows:

1. Remove the entire front panel assembly from the dust cover by removing two slotted screws in front and two slotted screws on top (no Phillips screws need removing) and lifting the panel assembly up and out.
2. Remove the batteries from the holders using a screwdriver to gently pry the batteries. Be careful to restrict the battery from "popping" out and damaging some other part.
3. Replace the batteries noting the polarity marked on the battery and comparing it with the decal on the terminal board. The + end should always contact the red terminal in the battery holder.
4. Replace the front panel assembly and screws, and go through the normal calibration procedures.
5. For any other maintenance the instrument should be returned to the Yellow Springs Instrument Company or the dealer from whom the instrument was purchased. Several of these dealers have their own repair facilities, others can give assistance in packaging and ensuring that the instrument is returned to the factory properly.

GUARANTEE

1. Instrument:

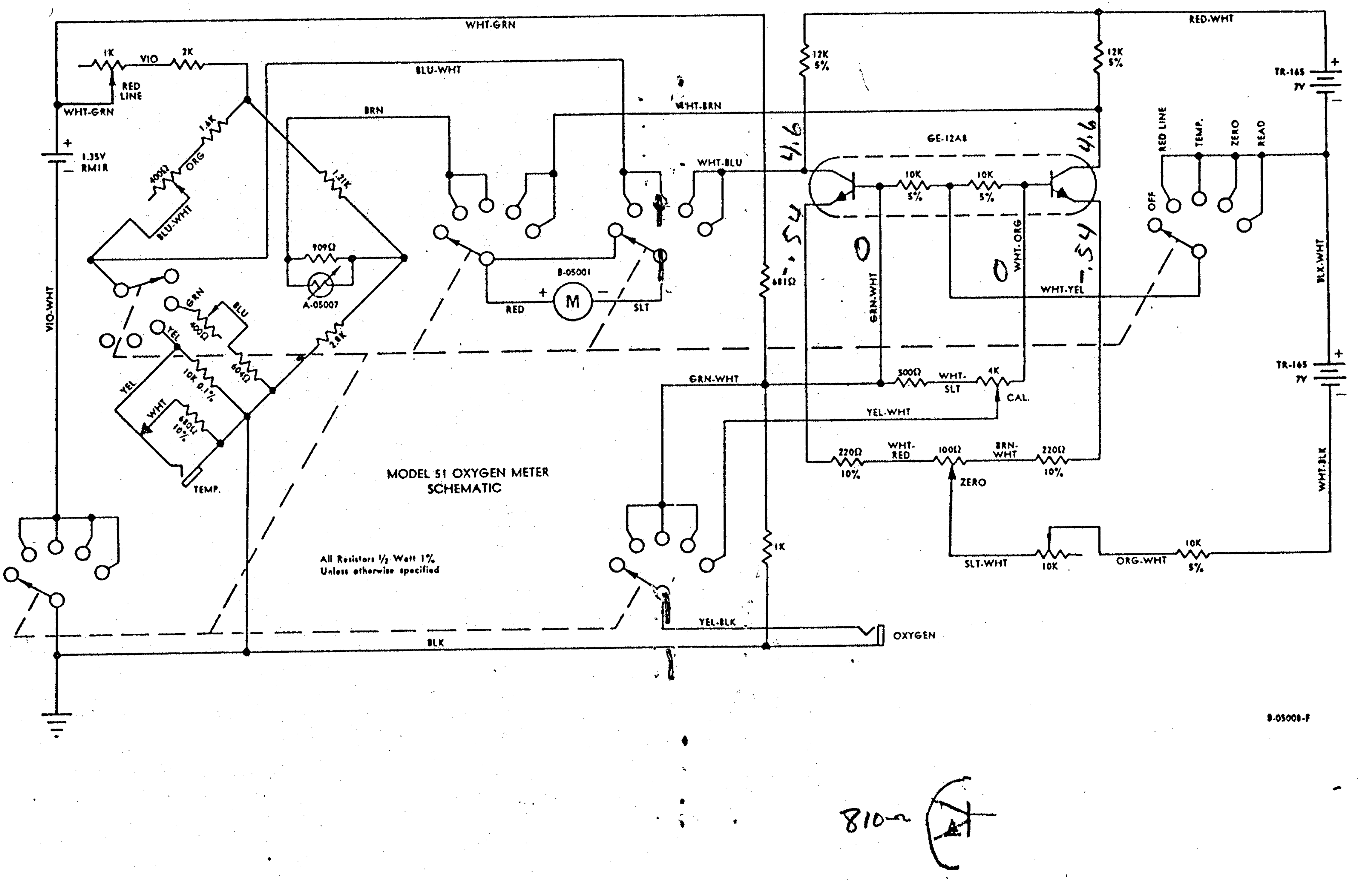
   The Model 51 Oxygen Meter (exclusive of oxygen probes and thermistor probe) is unconditionally guaranteed for one year against defects in components and workmanship. Damage through accident, misuse, or tampering will be repaired at a nominal charge when the instrument is returned to the factory or to a YSI authorized dealer.

2. Probes:

   The oxygen probes and thermistor probes are similarly guaranteed for a period of six months.

NOTE:

In communications regarding this instrument please mention model number and serial number.



MODEL 51 OXYGEN METER SCHEMATIC
All Resistors 1/2 Watt 1% Unless otherwise specified
WHT-GRN
BLU-WHT
BRN
WHT-BRN
WHT-BLU
RED-WHT
VIO
RED LINE
1.35V RM1R
VIO-WHT
ORG
BLU-WHT
GRN
BLU
YEL
WHT
TEMP.
909Ω
A-05007
B-05001
RED
SLT
GE-12A8
12K 5%
681Ω
10K 5%
GRN-WHT
WHT-ORG
WHT-YEL
500Ω
WHT-SLT
4K
CAL.
YEL-WHT
220Ω 10%
WHT-RED
100Ω
ZERO
BRN-WHT
SLT-WHT
10K
ORG-WHT
OFF
TEMP.
READ
TR-165 7V
BLK-WHT
WHT-BLK
YEL-BLK
OXYGEN
BLK
1K
B-05008-F
4.6
-.54
0
810