YELLOW SPRINGS
INSTRUMENT CO., INC.

YELLOW SPRINGS, OHIO 45387

INSTRUCTIONS

FOR

YSI

MODEL 55

OXYGEN

MONITOR

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YSI MODEL 55 OXYGEN MONITOR

220 VOLT INFORMATION

If this instrument has been purchased as a 220 VAC Model, the following notes should apply to statements made in the instructions.

Power Requirements

1. 220 VAC — Operable from 190-250 VAC.
2. Wattage as stated in instructions.
3. Current requirement of instrument is one-half that stated.
4. The schematic contains notes indicating changes which have been made to the circuit.

OPERATION

General Operation

1. Plug the instrument into a 117 VAC line.
2. Set the Selector switch to the ZERO position.
3. Lock the stirrer brake.
4. Insert a tubular probe or glass thermometer in the thermometer well.
5. Bring the sample chamber temperature to the proper point.
6. Prepare the oxygen probe for use.
7. Connect the probe to the instrument.
8. If a recorder is to be used, connect it to the binding posts and set the slide switch on the rear of the instrument to the RECORDER position. If the Model 55 meter is to be used, set the slide switch to the METER position.

9. Pour at least 3.5 ml. of the test solution into a sample vial.
10. Place a magnetic stirring bar in the solution.
11. Place the vial in the sample chamber.
12. Place the oxygen probe in the solution — tilt the probe slightly to force any trapped air out through the plunger access hole.
13. Release the stirrer brake.

Note:

The stirrer must be operating during measurements. This prevents oxygen depletion at the membrane surface due to diffusion through the membrane.

14. Allow 5 minutes for system stabilization.
15. Adjust the ZERO control for a zero meter or recorder indication.
16. Set the Selector switch to the READ position.
17. Check the system calibration.
18. Monitor or record the oxygen uptake or evolution rate.

Sample Chamber (Block) Temperature Set-up

These instructions refer to setting the BLOCK temperature. The sample temperature will lag block temperature by about 0.1°C for each 1.0°C difference between ambient (room) temperature and block temperature. For instance, if the ambient temperature is 20°C and the block temperature is 37°C, the sample temperature will be approximately 35.3°C. If your set-up requires exact knowledge of solution temperature, monitor the temperature in a second vial containing water and a magnetic stirring bar.

a. Above Ambient
   1. Adjust the HEAT control to 100.
   2. When block temperature is within 0.5°C of the required temperature, adjust the HEAT control to the setting indicated in Table #1.
   3. After 5 minutes, check the block temperature — if it has drifted, re-set the HEAT control.
   4. Repeat step 3 until the temperature is stable.

b. Below Ambient
   1. Prepare a mixture of crushed ice and water in a 250 ml. beaker or similar container.
   2. Remove the plastic sleeve from the conductor and mount the coolant so that the conductor is nearly submerged.
   3. Adjust the HEAT control to 0.
   4. When block temperature is within 0.5°C of the required temperature, adjust the HEAT control to the setting indicated in Table #1.
   5. After 5 minutes, check the block temperature — if it has drifted, re-set the HEAT control.
   6. Repeat step 5 until the temperature is stable.

c. Table #1 — Heat Control Setting vs. Block Temperature

This table should be used only for first approximations of settings. The actual settings will depend on conditions and the individual instrument and must be determined experimentally. The table is based on an ambient temperature of 20°C. To use the table for other ambient temperatures, you need only determine the difference in °C between your ambient temperature and the required block temperature. Add this difference to 20°C and use the setting for the temperature indicated by the calculation.

Block Temp. °C	Setting	Block Temp. °C	Setting
15	33	28	57
16	41	29	60
17	48	30	63
18	54	31	66
19	59	32	69
20	0	33	72
21	20	34	75
22	28	35	77
23	35	36	80
24	40	37	83
25	45	38	85
26	49	39	87
27	53	40	89

PROBE PREPARATION

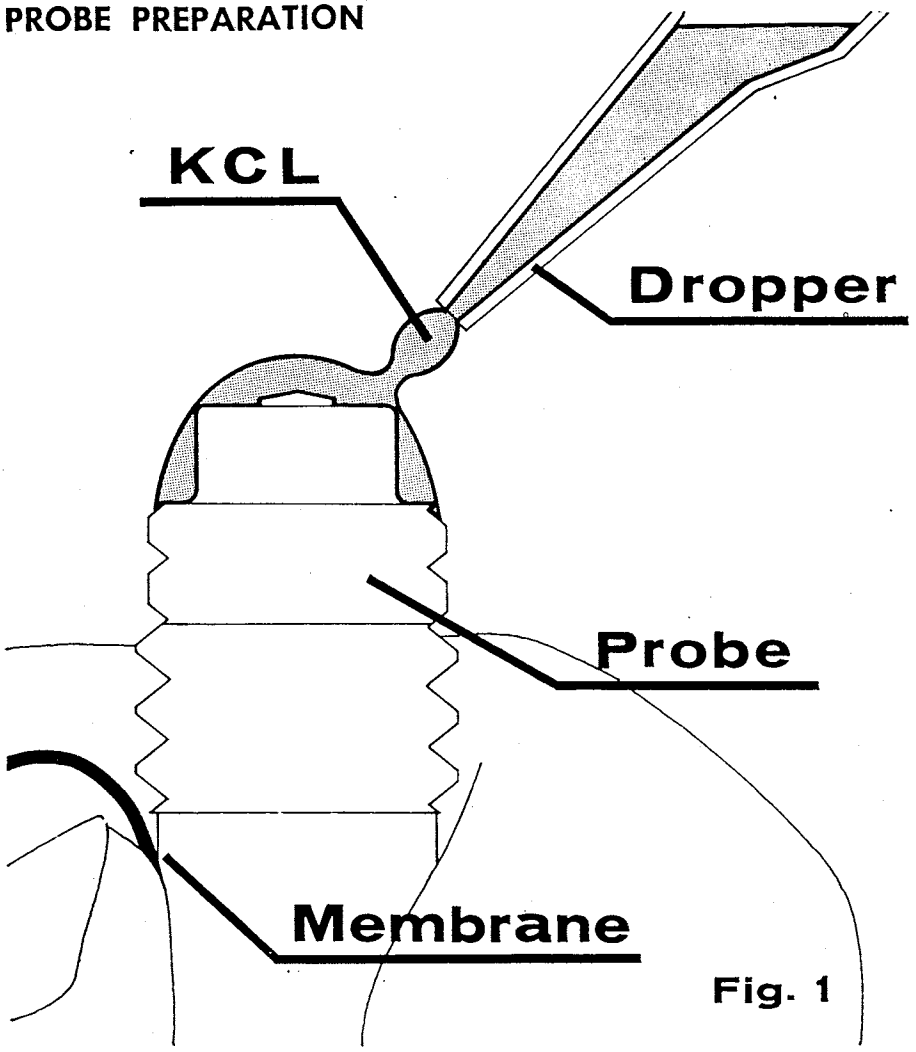

FIGURE 1

1. Cut a 3-inch length of membrane material.
2. Grasp the probe and membrane as shown.
3. Apply KCl solution to the sensor — be sure all surfaces are wetted.

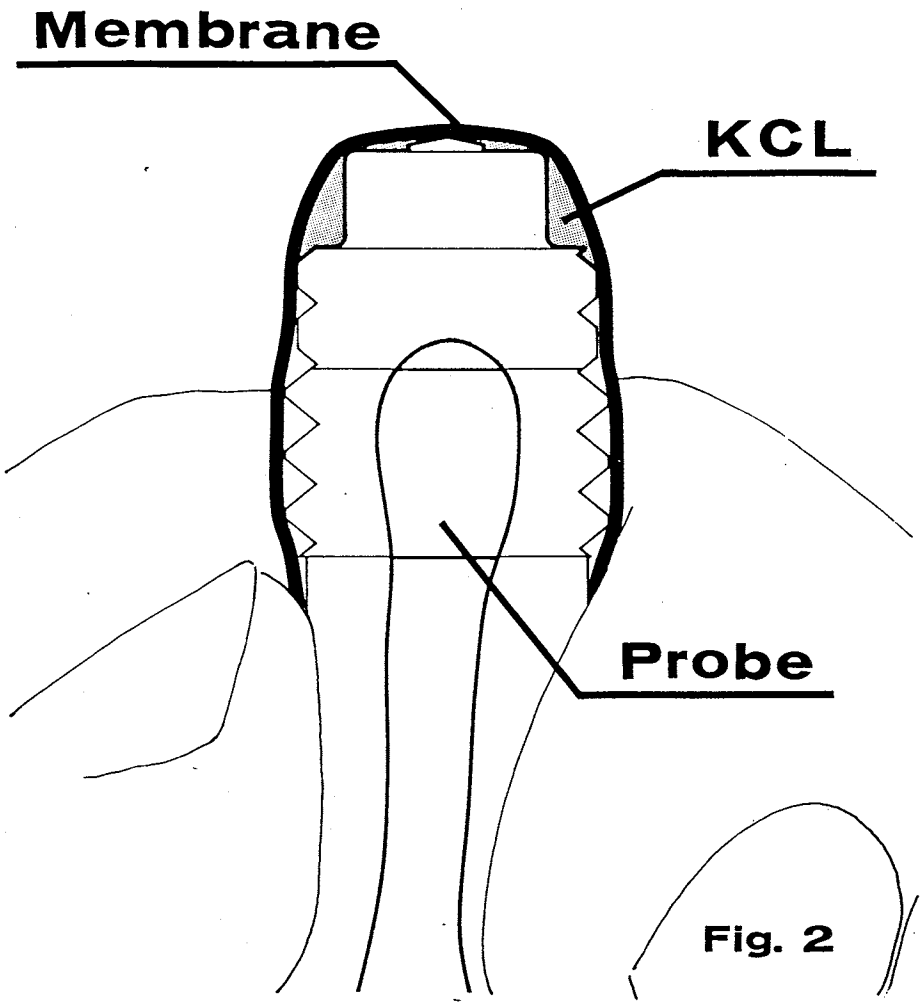

FIGURE 2

4. Stretch the membrane over the sensor end.
5. Grip both ends of the membrane and hold it under tension.

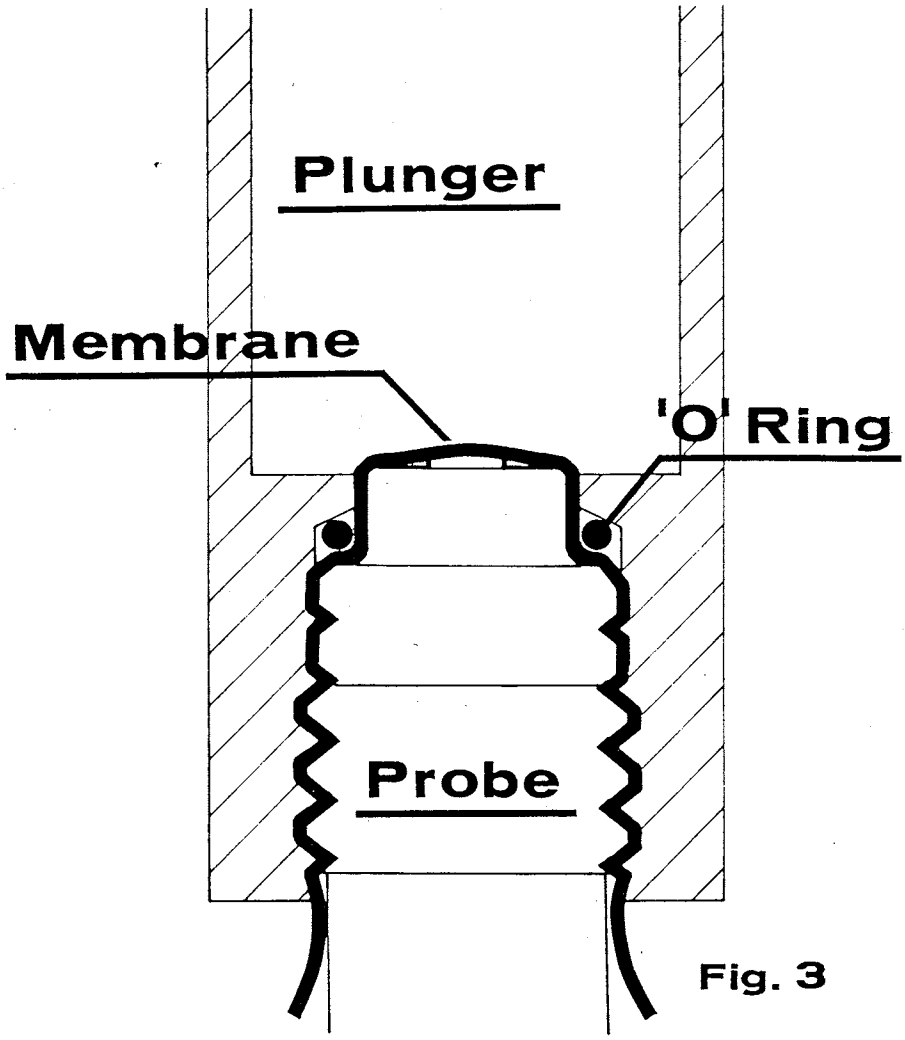

FIGURE 3

6. Screw the plunger onto the probe — keep the membrane tight as you do this.
7. Tighten the plunger until the "O" ring conforms to the plastic — this will be indicated by a change in appearance of the "O" ring as viewed through the plunger.

System Calibration

a. Calibration

Oxygen uptake and evolution measurements are based on the change in dissolved oxygen quantity in a solution. The Model 55 system, however, measures the change in oxygen partial pressure, (pO_2) caused by uptake or evolution. The system must be calibrated so that we can relate these two.

A relationship can be established between pO_2 and oxygen quantity if we refer to solubility tables. For instance, we can refer to a table of oxygen solubility in water and determine that air saturated water at 20°C and 760 mm. atmospheric pressure contains 6.5 microliters O_2 per ml. solution. We can then set the Model 55 to indicate full scale when the probe is placed in this solution. If we now cause oxygen to be removed from the solution, as in uptake, the pO_2 and the meter indication will decrease in direct proportion to the decrease in oxygen quantity. If we plot or record this decrease on a time scale, we can construct a graphic representation of the rate of uptake.

The method of calibration is as follows:

1. Set up the Model 55 system and bring the sample chamber to the proper temperature.

   Note:

   The sample chamber must be at the proper temperature when calibration is performed. The Teflon membrane on the probe exhibits a 3-5%/°C permeability co-efficient. Its effect must be corrected for or large errors will be observed.

2. Place a sample of the test solution or of distilled water in the sample chamber.

   Note:

   It is not necessary to use test solution for calibra-

tion. The pO_2 is constant in all solutions which are saturated with the same gas at the same temperature and pressure.

3. Saturate the solution with the gas which will be used in the test.
4. Set the Model 55 READ control for the desired indication — for example, full scale for O_2 or air saturated solution, or, 10% of full scale for N_2 saturated solution.
5. Determine the quantity of dissolved oxygen contained in the test solution — refer to a solubility table or make an experimental determination.

Note:

Most solubility tables must be corrected for altitude. The correction is simple and direct: the ratio of oxygen quantities in saturated solutions at two altitudes is equal to the ratio of the atmospheric pressures at the two altitudes. Table #2 can be used when making this correction.

b. Table #2 — Atmospheric Pressure vs. Altitude

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

c. Back Leakage

Back leakage on the Model 55 system is a term used to describe the diffusion of oxygen into or out of the solution being tested. It is caused by the difference in pO_2 between the solution and the atmosphere. Although it can usually be ignored, it can cause erroneous readings, especially in cases of large pO_2 differences or in lengthy measurements of uptake or evolution. If back leakage is a problem in your system, support the 5533 probe in the solution so that the solution level is kept below the top of the plunger. One of the flat plastic pieces from the accessory kit can be used as a wedge for this purpose.

Oxygen Uptake and Evolution Measurements

Calibrate the system, then note the meter or recorder indication at the beginning and the end of the test. The per cent change in indication can be used to determine the change in oxygen quantity and the rate of uptake or evolution.

Example:

We calibrated the Model 55 to read full scale with a 4 ml. sample of Ringer's solution at 37°C and 760 mm. atmospheric pressure. From a solubility table we determined that the solution contained 5.0 microliters O_2 per ml. solution, or a total of 4 x 5, 20 microliters O_2.

Readings: Start = 100
Finish = 70
Time Interval = 5 minutes
100-70 = 30% O_2 used

The sample consumed 30% of 20 microliters, or 6.0 microliters O_2 in 5 minutes. The average uptake rate was 1.2 microliters/minute.

SYSTEM DESCRIPTION

General Description

The YSI Model 55 system was designed to measure or record the rate of uptake or evolution of dissolved oxygen in solution. The system consists of: 1 Model 55 Oxygen Monitor

1 5533 Oxygen Probe

1 5526 Accessory Kit

Specifications

Range:	Full scale for air or oxygen saturated solution at 760 mm. atmospheric pressure.
Sample Size:	3.5 ml. minimum as furnished — plunger may be cut down to achieve 2 ml. capacity.
Sample Chamber Temperature Range:	20°C to 40°C. (In normal room conditions lower temperatures can be achieved. High sensitivity membranes may be required.)
Sample Chamber Stability:	0.2°C per hour at constant ambient temperature.
System Calibration Drift:	5% per hour maximum with sample chamber and ambient temperatures constant.
Probe Linearity:	Within 1% from air to oxygen saturation.

Probe Response:	90% final reading in about 10 seconds.
Probe Stabilization Time:	Less than 60 seconds when probe and solution are at temperature.
Probe Oxygen Consumption:	Less than 0.1 ml. oxygen per hour in air.
Recorder Output:	100 mV nominal — recorder input impedance should exceed 50K.
Power Requirements:	117 VAC, 50-60 Hz, 0.2 amps. A 220 VAC, 50-60 Hz, 0.1 amps model is available.

Probe

a. Description

The 5533 Oxygen Probe is a special assembly built around a Clark type polarographic sensor. A removable plunger protects the sensor and holds a Teflon membrane in place. A relief hole drilled through the plunger can be used for the introduction of inhibitors, etc., to the sample under test.

b. Theory

The Teflon membrane covering the polarographic sensor is permeable to gas. If a gas pressure differential is created across the membrane, the gas will diffuse through the membrane until pressure equilibrium is attained.

When a polarizing voltage is applied to the electrodes of the sensor, a reaction occurs at the cathode surface. Dissolved oxygen in the electrolyte at the cathode is reduced and a region

of zero oxygen pressure is created. Oxygen in the sensor's environment now diffuses into the sensor. The rate of diffusion is dependent on membrane material and thickness and the absolute partial pressure of the environmental oxygen. The membrane material and thickness can be controlled so that the diffusion rate and subsequent reaction rate will be directly proportional to the absolute oxygen partial pressure, (pO_2).

The reaction in the sensor causes current to flow between electrodes. This current varies with the reaction rate and can be measured as a direct indication of pO_2.

Sample Chamber (Block)

The sample chamber is an aluminum block which is mounted above the instrument case. The chamber contains two slots in which sample vials are placed. It also contains a thermometer well in which a glass laboratory thermometer or a YSI tubular thermistor probe may be mounted.

The chamber is heated by an internally mounted power resistor. It is cooled through the use of a plated copper strap, or conductor, which is permanently fastened in good thermal contact with the block.

The chamber's mass and thermal isolation combine to give it good control characteristics. Its energy losses are low enough to allow it to be heated or cooled easily. It has a long thermal time constant — more than one hour — and is insensitive to short term ambient temperature variations.

Circuit

a. Amplifier

Probe current develops a voltage across the input resistor, R1. Because the base voltage of the input transistor is held con-

stant, the voltage effectively appears across the amplifier output. This creates a large output current which is directly proportional to probe current.

Amplifier balance with no input is achieved with the ZERO control, R9. The READ control, R10, attenuates the output current and allows the instrument to be calibrated under widely varying input conditions.

b. Probe Supply

The 0.8 volt polarization voltage for the oxygen probe is developed by the base-to-emitter voltages of Q1 and Q2. A thermistor in series with the probe compensates for variations in these voltages due to temperature variations.

c. Heater Supply

The heater resistor, R13, is mounted in the sample chamber and is connected in series with the emitter of transistor Q5. The HEAT control, R12, is connected to the base of the transistor. A change in the setting of the HEAT control causes a change in transistor emitter current and heater power dissipation.

Accessory Kit

The accessory kit is available only with the complete Model 55 system. Some of the components can be purchased as part of YSI service kits. Others are available directly from laboratory or medical supply houses. Those parts which are available from YSI are listed under Replacement Parts on page 18.

MAINTENANCE

Oxygen Probe

a. Probe Filling

1. Fill the KCl bottle with distilled water and dissolve the crystals.

Note:

Do NOT use tap water. It contains iron and salts which will contaminate the sensors electrodes and shorten the probe's life.

2. Transfer part of the KCl solution to the dropper bottle.
3. Fill the probe as shown in Figures 1 thru 3.

b. Probe Inspection

The probe should be inspected after the membrane is installed and at least once daily during use. Replace the membrane and refill the probe if:

1. The membrane shows any sign of wrinkles or holes.
2. There is any sign of crystal growth at the membrane surface.
3. The end of the sensor appears dry beneath the membrane.
4. Meter readings are low or erratic.

c. Probe Cleaning

The probe should be rinsed in distilled water whenever the membrane is changed. In addition, the silver anodes should be cleaned with a cotton swab or a toothbrush dipped in NH_4OH (reagent diluted 1 to 1) when normal rinsing does not solve your difficulties.

Clean the probe and place a membrane over the sensor before storing it.

System

a. Sample Chamber (Block)

The sample chamber may be taken apart for periodic

cleaning. Remove the two screws holding the upper plate. Lift the assembly and clean the plates with a damp cloth. Reassemble the unit — make certain the leads to the heater resistor are not caught under the block or the shield. Tighten the screws snugly — do not over-tighten these screws or you may tear out the threads in the lower plate.

b. Instrument

To remove the grill, take out the 6 slotted screws on the wrap-around front panel. Place the stirrer brake in the locked position and lift the instrument away from the grill.

Replacement Parts

The following parts may be ordered as replacements from YSI franchised dealers:

5541 Probe Service Kit
This kit contains a supply of membrane material, "O" rings, and glass vials.

5536 Plunger
This may be modified by the customer for use with sample volumes as low as 2 ml. — a ⅛" x ½" magnetic stirring bar (not furnished) is required.

5533 Oxygen Probe

5552 Standard Membrane Material

5937 High Sensitivity Membrane Material
This is .0005" Teflon membrane which will double the sensitivity of the system. It is useful for temperatures lower than 20°C and for evolution measurements.

Guarantee

Instrument — the Model 55 Oxygen Monitor 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.

Probe — The 5533 Oxygen Probe is similarly guaranteed for a period of six months.

Note:

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

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