# OPERATING MANUAL FOR THE U.S. GEOLOGICAL SURVEY MINIMONITOR, 1988 REVISED EDITION

Punched-Paper-Tape Model

By James H. Ficken and Carl T. Scott

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U.S. GEOLOGICAL SURVEY

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DEPARTMENT OF THE INTERIOR

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Use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

## CONVERSION FACTORS

The inch-pound units used in this report may be converted to metric (International System) units by the following factors.

| Multiply inch-pound unit | By | To obtain metric unit |
| --- | --- | --- |
| foot (ft) | 0.3048 | meter (m) |
| foot per second (ft/s) | 0.3048 | meter per second (m/s) |

### Additional Abbreviations and Symbols

| | |
| --- | --- |
| 1 mil | 0.001 in. |
| dc | direct current |
| DCP | data-collection platform |
| DO | dissolved oxygen |
| GOES | Geostationary Operational Environmental Satellite |
| HCl | hydrochloric acid |
| Hg | mercury |
| mg/L | milligrams per liter |
| MUX | multiplexer board |
| p | pressure |
| pots, trimpots | potentiometers |
| P | barometric pressure |
| S | solubility |
| $\mu$S/cm | microsiemens per centimeter |
| mm Hg | millimeters of Mercury |

# OPERATING MANUAL FOR THE U.S. GEOLOGICAL SURVEY MINIMONITOR, 1988 REVISED EDITION, Punched-Paper-Tape Model

By James H. Ficken and Carl T. Scott

## ABSTRACT

This manual describes the U.S. Geological Survey Minimonitor Water-Quality Data Measuring and Recording System. It also provides instructions for calibrating, servicing, maintaining, and operating the system.

The Survey Minimonitor is a battery-powered, multiparameter water-quality-monitoring instrument designed for field use. A watertight can containing signal conditioners is connected with cable and waterproof connectors to various water-quality sensors, which record data on a punched-paper-tape recorder. The device requires an external battery.

The manual further discusses operation and maintenance of various sensors and signal conditioners, including temperature, specific conductance, dissolved oxygen, and pH. It provides calibration instructions for each parameter, along with maintenance instructions. Sections of the report explain how to connect the Minimonitor to measure direct-current voltages, such as signal outputs from other instruments. In addition, it gives instructions for connecting a satellite data-collection platform or a solid-state data recorder to the Minimonitor.

The instructions include basic information for servicing the Minimonitor and troubleshooting some of its electronic components as well as a discussion of the use of test boxes to test sensors, isolate component problems, and verify calibration values.

## INTRODUCTION

The U.S. Geological Survey, under its authority to conduct water-resources surveys, investigations, and research, monitors certain water-quality constituents with automatic equipment. The data derived from monitoring activities are used to determine short-term and, in some cases, real-time fluctuations in the concentrations of these water-quality constituents.

The Hydrologic Instrumentation Facility (HIF) of the U.S. Geological Survey, in 1983, developed a system to effectively monitor data at relatively remote sites, some of which lack electrical utility service. HIF Operating Manual 6-83-02, the Survey Minimonitor, was published to enable field personnel to use the newly developed system. This manual, revised in 1988, incorporates changes made to the system and replaces HIF Operating Manual 6-83-02.

## Purpose and Scope

The purpose of this manual is to describe in some detail the Survey's Minimonitor Water-Quality Data Measuring and Recording System. Various components and parts of the system are described and directions are given for assembly and disassembly. Procedures are given for calibrating, servicing, and maintaining the system. Instructions are provided for proper operation of the equipment. Some troubleshooting procedures are included. No information has been provided in this manual on the digital input-output paper-tape recorder. Not covered is the selection of monitoring sites or the selection and installation of shelters, sensors, and equipment. U.S. Geological Survey Open-File Report 83-681, "Guidelines for Use of Water Quality Monitors," should be consulted for this information.

## General Description

The Minimonitor is a system designed to measure and record as many as four values of water-quality constituents or properties. An expanded version can measure as many as eight constituents or properties. A watertight can containing signal conditioners is connected with cable and waterproof connectors to various water-quality sensors. The system is composed of a battery-powered electronics package, a Leupold and Stevens (L&S) digital input-output 16-channel, paper-tape recorder, and sensors with or without extension cables having underwater connectors and, in some instances, a Geostationary Operational Environmental Satellite (GOES) data-collection platform (DCP) or other equipment. (Figure 1 shows a Minimonitor connection.) An external battery is required and when in operation, the unit turns itself on at every recording interval; scans, measures, and records the values of the constituents or properties on paper tape; and then, turns itself off until the next interval has elapsed. An internal crystal clock, which is user-settable from 1 to 79 minutes, controls the recording interval. Unlike the Survey Flow-Through Monitor, the sensor or sensors can be placed directly into the river if they are properly protected. This feature eliminates the need for a pump and a sample chamber. The Minimonitor system will function also with the sensors positioned in a sample chamber that has water pumped into it. The Minimonitor is available to measure temperature, specific conductance (conductivity), dissolved oxygen (DO) and pH, along with other acceptable voltage inputs from other instruments like the Ultrasonic Ranger. The Minimonitor is available on a rental basis from the HIF.

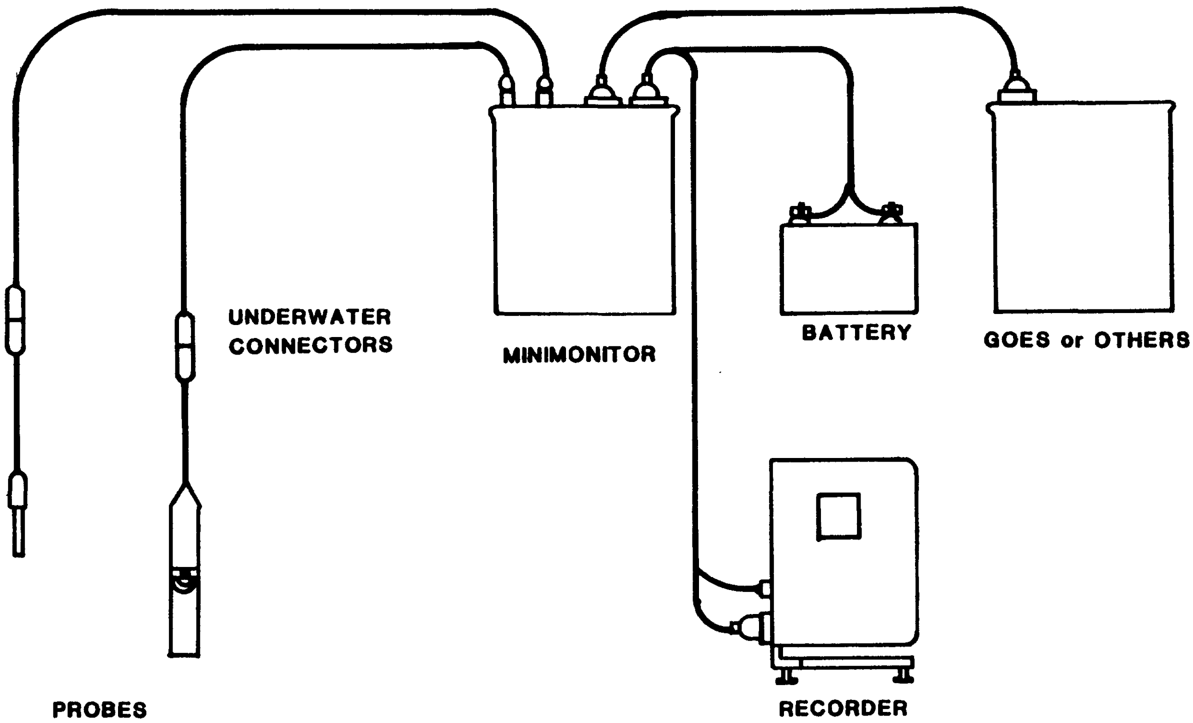



Figure 1.--Minimonitor connection.

## Specifications

Minimonitor specifications include the following:

- Number of available channels: 4; expandable to 8 on a special unit.
- Timer: Contained internally; accurate to within $\pm$ 4 minutes each month and provides any recording interval from 1 to 79 minutes.
- Recorder: External; L&S Digital input-output 16-channel, paper-tape recorder.
- Operating temperature range: -40 to 55 $^{o}$C.
- Battery type: External; 12-volt, dry-cell or lead-acid gel type with a minimum of 2-ampere, short-term, current capacity; two 6-volt batteries can be used in series. Do **not** use 15-volt batteries or 7.5-volt batteries in series because the actual voltage of these batteries can exceed 15 volts.
- Operating voltage range: 10 to 15 volts. **WARNING:** Voltages higher than 15 volts can damage the unit.

- Battery consumption: Less than a 1-ampere hour per month at a 1-hour recording interval with temperature and specific conductance.

- Current consumption:

  - In standby mode--250 microamperes
  - Recorder current (average)--1,300 milliamperes for 0.75 second
  - With the signal conditioners on (temperature and specific conductance)--100 milliamperes.

- Analog output: Compatible with data-collection satellite platforms; 0 to 5 volts from each channel; only on during scan-and-record cycle.

- Size: Electronics housed in a watertight container 10 inches high (15 inches high with cables plugged in) by 10.5 inches in diameter.

- Temperature: Range--0 to 50 °C; other ranges by special request. Sensor Size: 7.5 inches long by 0.75 inch in diameter.

- Specific conductance: Four ranges: 0 to 100, 0 to 1,000, 0 to 10,000, and 0 to 100,000 microsiemens; referred to 25 °C based on 1,000-microsiemen potassium-chloride solution; four-electrode method is used to reduce effects of fouling.
  Sensor Size: 10.5 inches long by 1.4 inches in diameter.

- Dissolved oxygen: Polarographic membrane sensor with stirrer; normally 2 ranges--0 to 10 and 0 to 20 milligrams per liter. Use of membranes other than 1-mil thickness can change range.

- pH: Uses an industrial-grade refillable combination electrode; ranges: 0 to 10 and 2 to 12 pH units. Sensor environment can significantly affect the accuracy of the acquired data.

- Voltage inputs:

  - Range--0 to 100 millivolts (minimum) to 0 to 10 volts (maximum)
  - Input impedance--1 to 5 megohms
  - Common mode input voltage range-- +7 to -4 volts
  - Differential input voltage-- -100 millivolts to +5 volts full scale.

  The voltage SIGNAL CONDITIONER has a relay that can be used to apply power to other instrumentation.

- Cables: Sensors come with a 10-foot cable terminated with an underwater connector. Extension cables in 100-foot sections are standard, other lengths are available.

## SERVICING INTERNAL COMPONENTS OF THE MINIMONITOR

Occasionally, the inside of the Minimonitor must be opened to change settings on switches, to change fuses on older models, to add or remove circuit boards, and to change the desiccant. The can must be closed carefully to prevent damage to components and to ensure proper operation of the monitor.

### Opening the Minimonitor

To prevent moisture from affecting the electronic circuitry, the Minimonitor should be opened only indoors under dry and warm conditions.

The following procedure is used:

1. Disconnect any cables from the top of the Minimonitor. Mark the sensor connectors and cables so they can be reinstalled correctly.

2. Remove the bolt or bolts that secure the locking ring.

3. Remove the locking ring from the top rim of the can.

4. Lift the cover and the electronics assembly from the can.

Figure 2, Minimonitor electronics assembly removed from can, shows the normal positioning of the circuit boards in the electronics assembly. The PROGRAMMER board is in the topmost slot and the multiplexer (MUX) board is in the bottom slot. SIGNAL CONDITIONER boards are positioned in the intermediate slots. The boards will be referred to as SIGNAL CONDITIONERS in the rest of this report.

The circuit boards are connected to each other, and to ZERO and SPAN potentiometers (called pots or trimpots in the rest of this report), and to connectors on the Minimonitor cover with both ribbon cables and 16-pin, dual in-line connectors that plug into sockets on the circuit boards.

### Internal Settings

#### Reasons for Internal Settings

The following items require the use of internal switches to set the desired

- recording interval;
- number of channels;
- delay times for the power-up, scan, and record cycles;
- specific-conductance range;
- dissolved-oxygen (DO) range; and
- pH range.

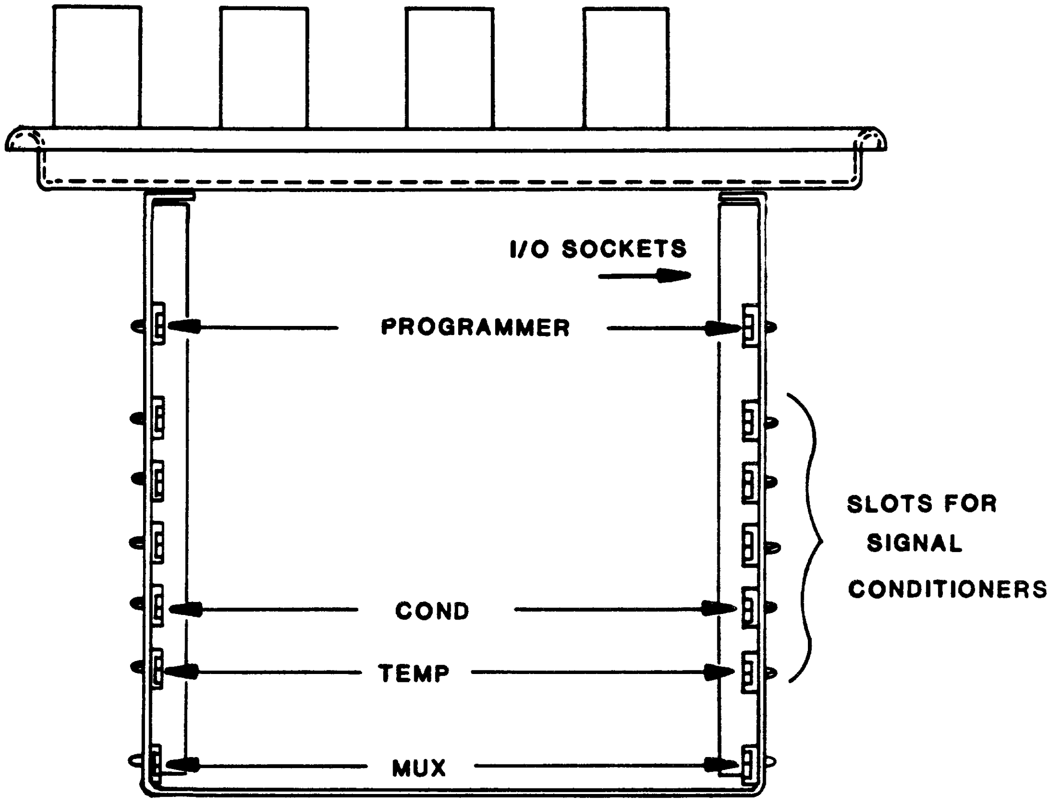



Figure 2.--Minimonitor electronics assembly removed from can.

Before the Minimonitor can be placed in operation, the electronics package must be programmed by internal switches for the number of channels to be recorded, the delay times, the recording interval, and the desired ranges on the SIGNAL CONDITIONERS of the constituents to be measured. These items were set before the monitor was shipped. To change the initial settings, open the Minimonitor as directed in the section entitled "Opening the Minimonitor."

**WARNING:** The internal wiring and circuits are not designed to withstand rough handling. Changes to internal settings are best made carefully indoors under dry, warm conditions, and with fresh desiccant added. Internal settings usually are changed in the field.

Internal settings required for operation of the Minimonitor are made on the PROGRAMMER board (fig. 3).

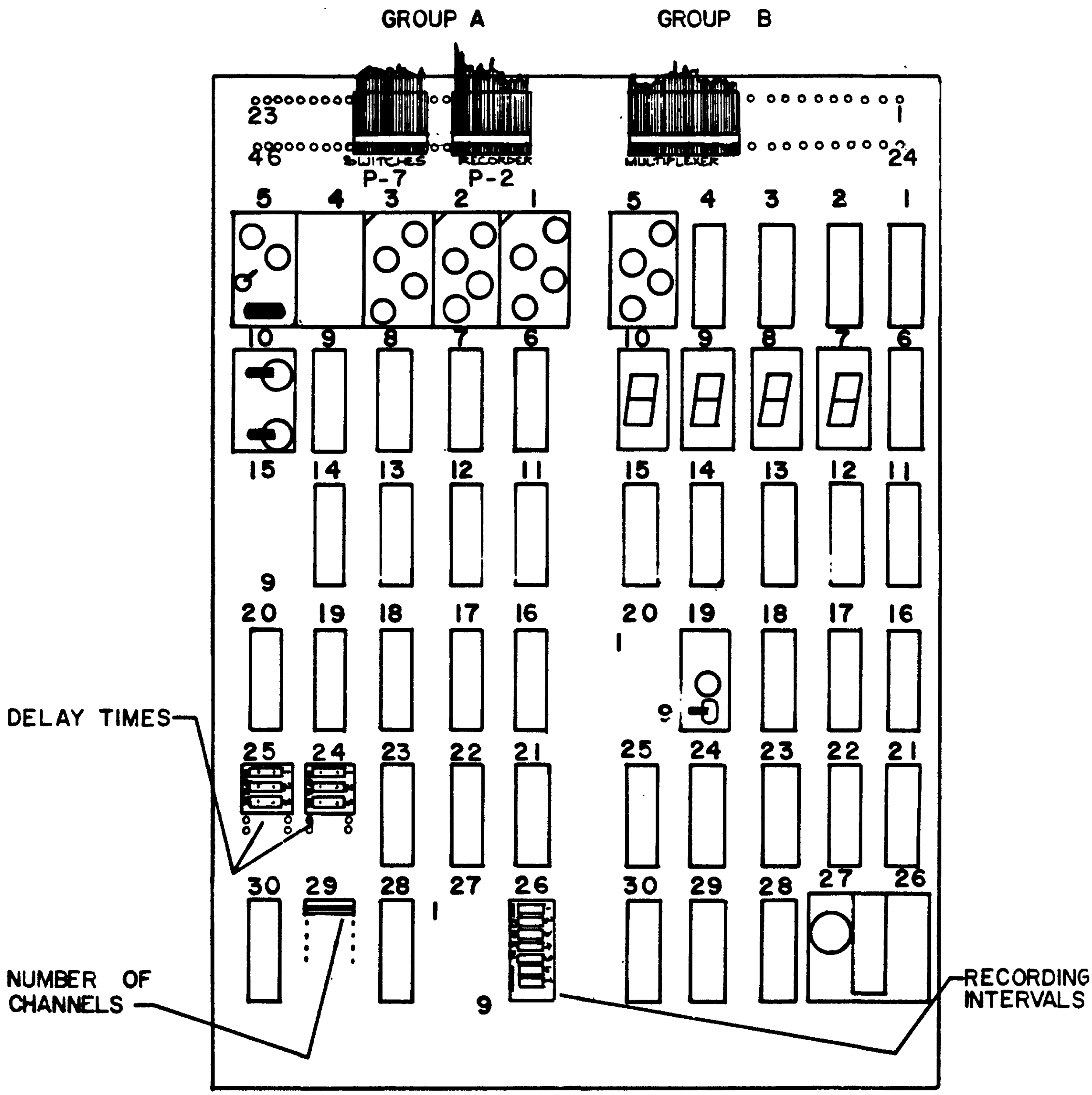



Figure 3.--Programmer board.

## Number of Channels

One setting of the internal switch programs the Minimonitor recording for the number of SIGNAL CONDITIONERS in the Minimonitor can. If the Minimonitor is set for the two SIGNAL CONDITIONERS, specific conductance and temperature, they are in slots in the electronics rack and the number of channels is two. Changing the number of SIGNAL CONDITIONERS requires resetting the number of channels.

The number of channels recorded is controlled by a shunt bar in socket 29A on the PROGRAMMER board. Put the shunt in row 1 to record channel 1; in row 2 to record channels 1 and 2; row 3 to record channels 1, 2, and 3; and so forth. To change the number of channels, lift the shunt bar from the card and reinstall the bar in the desired row. See the example in figure 4.

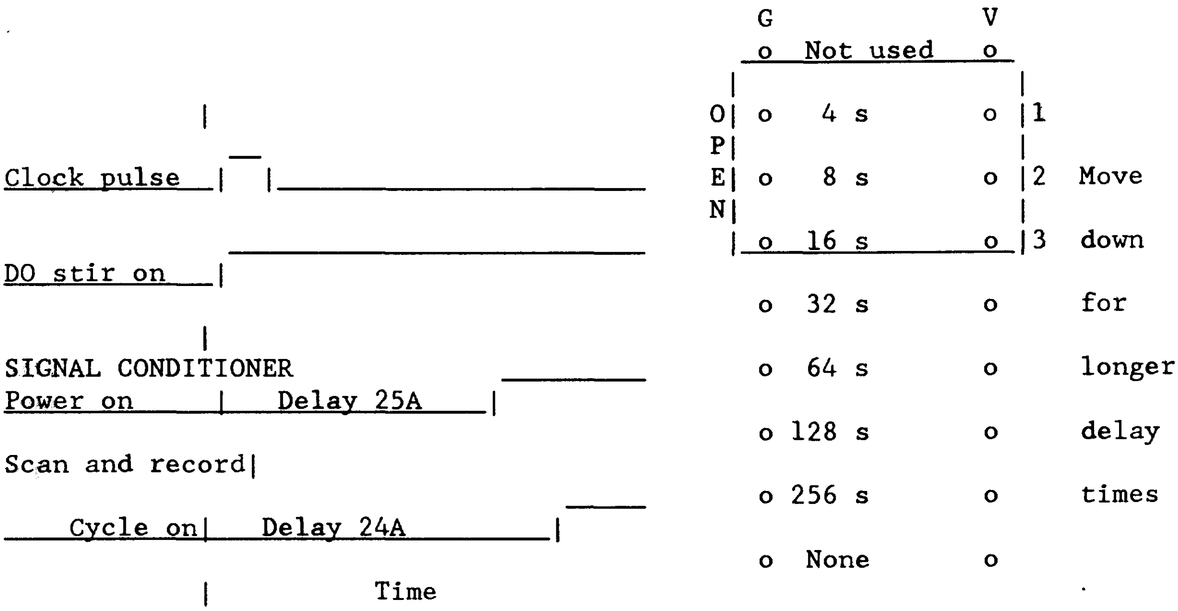
```
Row  1        o  __________  o
     2        o-|  SHUNT  |-o
     3        o              o
     4        o              o
     5        o              o
     6        o              o
     7        o              o
     8        o              o
```

Socket 29A

Figure 4.--Minimonitor set to record two channels.

## Delay Times

The Minimonitor has two delay times that may be set by the user. A clock pulse initiates the monitor scan-and-record cycle. The DO stir signal is turned on. After a time delay, set by the switches in 25A, SIGNAL CONDITIONER power is turned on. Next, the scan-and-record cycle begins; its starting time is determined by the switch settings in 24A. (See timing diagram, fig. 5.) The delay time of the scan-and-record cycle must be longer than the delay of the SIGNAL CONDITIONER power-on cycle. The delay time in either switch 24A or 25A equals the sum of the value of the closed switches as shown in figure 5. Only three switch closures are allowed in each socket. These three switches can be installed only in adjacent rows. If the desired delay cannot be obtained where the three-switch assembly is located, move the assembly to a different row in the socket.




Timing diagram

Switch values--socket 24A or 25A

Figure 5.--Timing diagram and switch values for socket 24A or 25A.

For a system with temperature and specific conductance, use the following delay times (fig. 6):

- A SIGNAL CONDITIONER power delay of 0 seconds set in 25A.
- A record delay of 4 seconds set in 24A.

Put the temperature SIGNAL CONDITIONER in channel 1 because this card stabilizes faster after power-up than the specific-conductance SIGNAL CONDITIONER.

Suggested delay times for other constituents are given in the sections entitled "Dissolved-oxygen range selection, calibration, sensor maintenance, and performance checks"; "pH range selection, calibration, and sensor maintenance"; "Voltage-input specifications, applications, and calibration"; "Ultrasonic Ranger specifications, installation, calibration, and water-stage calculations"; and "Operation of the Minimonitor with the LaBarge GOES data-collection platform."

```
  Time before SIGNAL
  CONDITIONER power                      Time before scan-and-
  is on.                                 record cycle starts.


  G            V                          G            V

  o  Not used  o__                        o   Not used o___
  |              |                        |                |
 O|o    OPEN   o |1                      O|o   CLOSED    o |1
 P|              |                       P|                |
 E|o    OPEN   o |2                      E|o    OPEN     o |2
 N|              |                       N|                |
  |o____OPEN___o_|3                       |o____OPEN_____o_|3

  o            o                          o            o

  o            o                          o            o

  o            o                          o            o

  o            o                          o            o

  o            o                          o            o

       25A                                     24A
```

**NOTE**: To close switches, press down on the numbered side opposite the side marked "OPEN."

Figure 6.--Switch settings for timing delays for a system with temperature and specific conductance.

## Setting the Recording Interval

The switches on socket 26A of the PROGRAMMER board set the recording interval. Each switch on 26A has a value in minutes as shown in figure 7. Close the switches so that the sum of all the closed switches equals the desired time interval. Closing the 8- and 4-minute switches at the same time will result in an illegal number.

Socket 26A

```
   ___________        ___________        ___________        ___________        ___________
  |o 1 min o  |1     |o CLOSE o  |1     |o CLOSE o  |1     |o OPEN   o |1     |o OPEN   o |1
  |           |      |           |      |           |      |           |      |           |
  |o 2 min o  |2     |o OPEN   o |2     |o OPEN   o |2     |o OPEN   o |2     |o OPEN   o |2
  |           |      |           |      |           |      |           |      |           |
  |o 4 min o  |3     |o CLOSE o  |3     |o CLOSE o  |3     |o OPEN   o |3     |o OPEN   o |3
 O|           |     O|           |     O|           |     O|           |     O|           |
 P|o 8 min o  |4    P|o OPEN   o |4    P|o OPEN   o |4    P|o OPEN   o |4    P|o OPEN   o |4
 E|           |     E|           |     E|           |     E|           |     E|           |
 N|o 10 min o |5    N|o OPEN   o |5    N|o CLOSE o  |5    N|o CLOSE o  |5    N|o OPEN   o |5
  |           |      |           |      |           |      |           |      |           |
  |o 20 min o |6     |o OPEN   o |6     |o OPEN   o |6     |o CLOSE o  |6     |o CLOSE o  |6
  |           |      |           |      |           |      |           |      |           |
  |o 40 min o_|7     |o OPEN   o_|7     |o OPEN   o_|7     |o OPEN   o_|7     |o CLOSE o__|7

   o None   o         o None   o         o None   o         o None   o         o None   o

  Switch Values         5 min              15 min             30 min             60 min
```

**NOTE**: To close switches, press down on the numbered side opposite the side marked "OPEN."

Figure 7.--Recording intervals.

## Setting Ranges on Signal Conditioners

When the Minimonitor can is open, the desired ranges may be set on SIGNAL CONDITIONERS. Ranges can be set on SIGNAL CONDITIONERS for measuring specific conductance, DO, pH, and voltage. To set the ranges, refer to the specific sections in the manual associated with range selection of the individual constituents desired.

## Changing Fuses

Two 0.5- and 1.5-ampere, AGC-type fuses are used to protect Minimonitor circuitry. When replacing fuses, be sure that the correct replacement sizes are used and are put in the proper place.

Older models have fuses, 0.5 and 1.5 ampere, located on the MUX board (fig. 8). This requires opening the Minimonitor to replace the fuses.

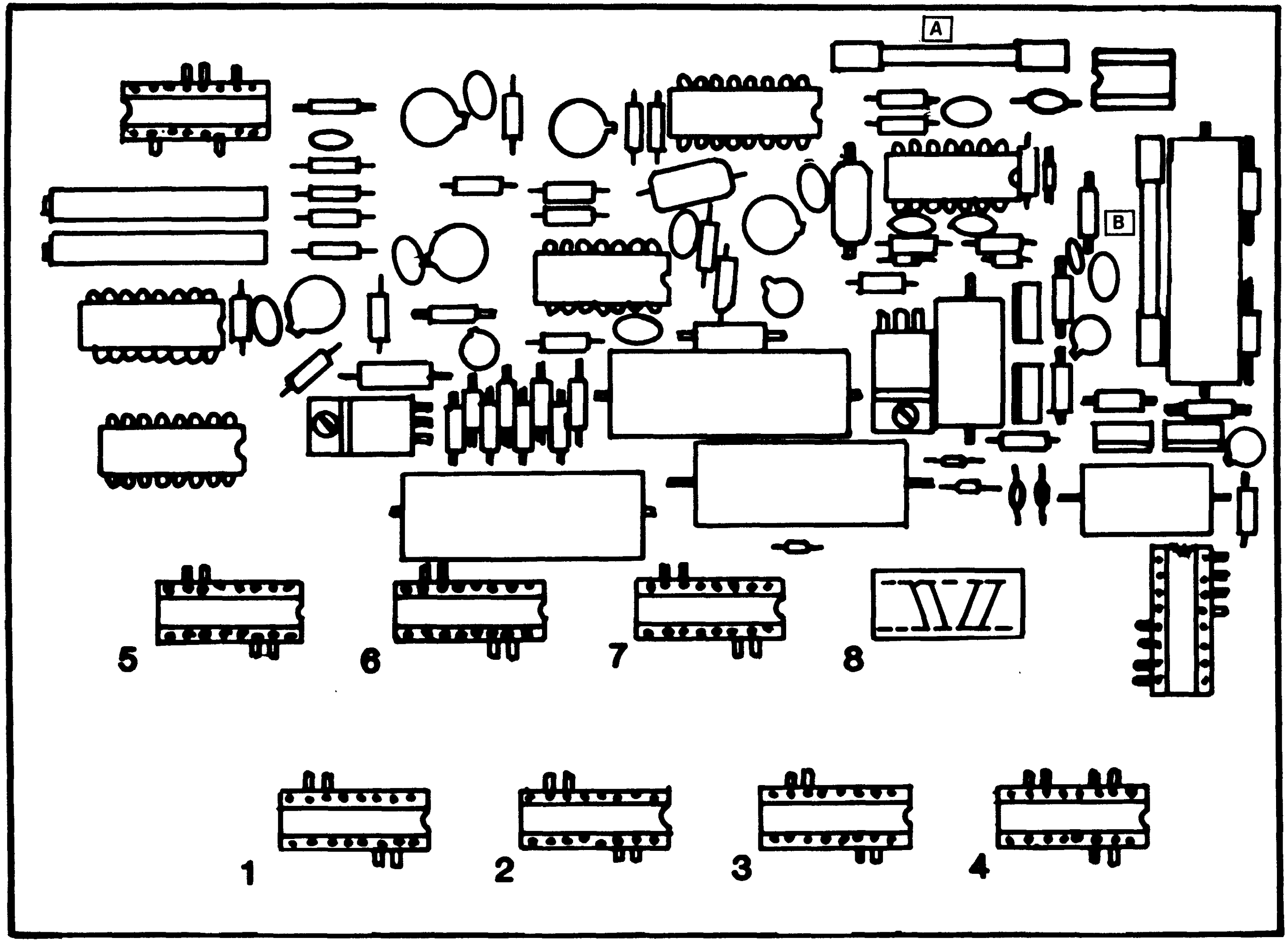



Figure 8.--Multiplexer board.
A-Fuse--1.5 ampere on older models only
B-Fuse--0.5 ampere on older models only
1 through 8--Signal-conditioner input sockets

Newer models have fuses located in waterproof fuse holders on the lid of the Minimonitor (fig. 9). Fuse holder caps must be unscrewed to replace the fuses. Screw the caps on tightly after replacing the fuses.

Do not substitute fuses of larger values than those indicated because this may result in serious damage to the Minimonitor.

**WARNING:** TURN OFF POWER WHILE REPLACING FUSES.

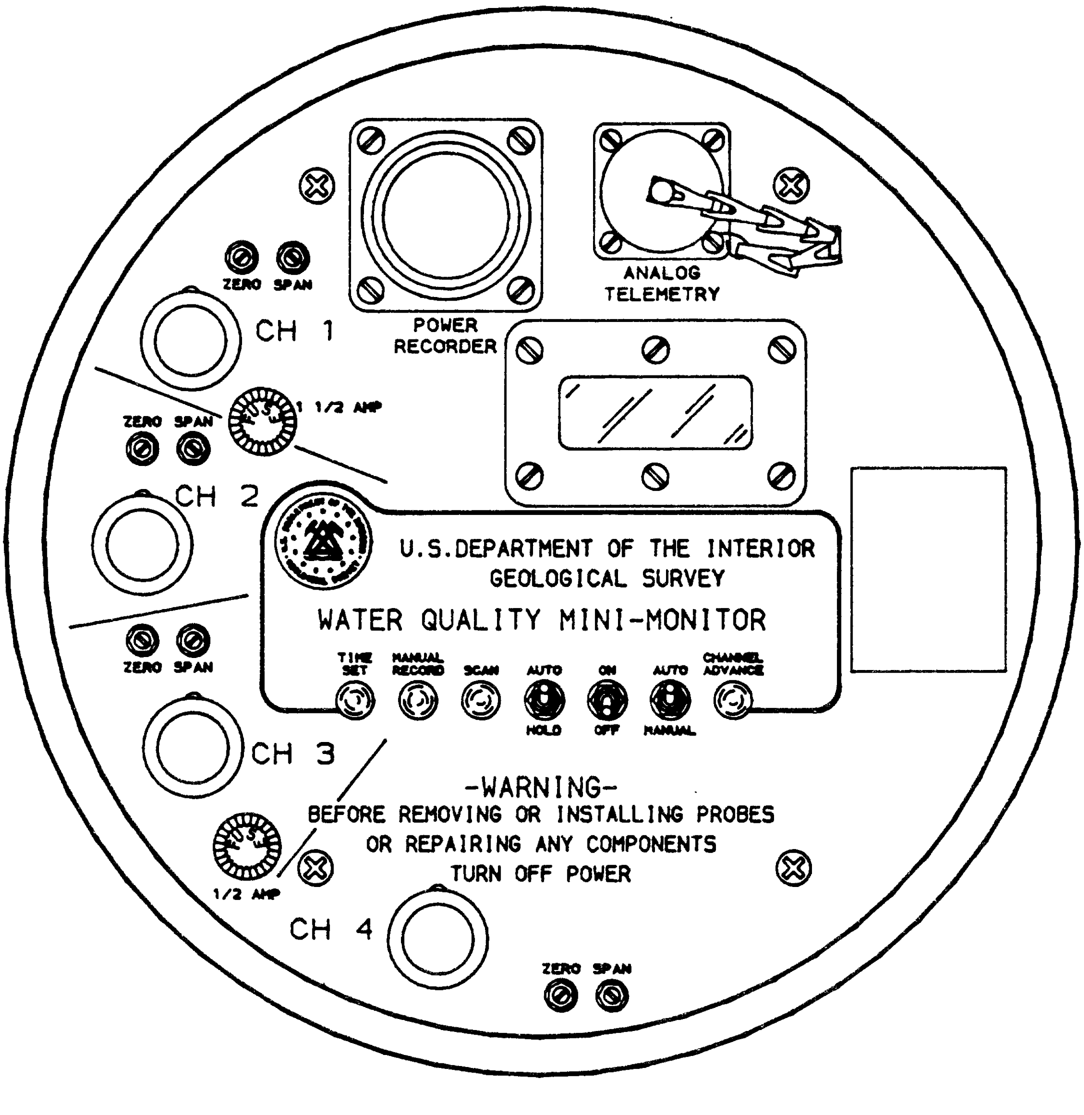



Figure 9.--Minimonitor front panel.

## <u>Battery-Check Feature</u>

The battery voltage may be read on the DISPLAY as follows:

1. Turn on the monitor.

2. Set the AUTO-MANUAL switch to the MANUAL position.

3. Use the CHANNEL ADVANCE switch to advance the monitor to the last channel.

4. Now press and <u>hold</u> down the CHANNEL ADVANCE switch.

To determine the battery voltage, add 007 to the DISPLAY value and divide the sum by 10. For example, a reading of 113 indicates 12.0 volts on the battery. A reading on the DISPLAY of less than 093 indicates that the battery voltage is too low and that incorrect data are being read. The battery voltage must not fall below 10.0 volts. The bottom board on the Minimonitor lid assembly is the MUX board (fig. 8). A battery test module normally is plugged into the 16-pin socket marked 8. To record the battery voltage, this battery test module must be removed from the number 8 socket and plugged into the next highest numbered socket after the last one used. For example, if channel 1 and channel 2 are being recorded, plug the module into the number 3 socket. Set the shunt bar in socket 29A on the PROGRAMMER board for an additional channel; in this case, channel 3. Battery voltage will be recorded in the channel 3 position on the paper tape. Calculate the battery voltage from the channel 3 DISPLAY in the same way as described above. In this case, holding the CHANNEL ADVANCE switch down after channel 3 will no longer indicate the battery voltage on the DISPLAY.

## <u>Removing or Adding Circuit Boards</u>

**NOTE:** The HIF will not be responsible for damage caused by improper connection of circuit boards. To ensure proper installation of circuit boards, return the unit to the HIF.

The following steps outline the procedure for adding or removing circuit boards:

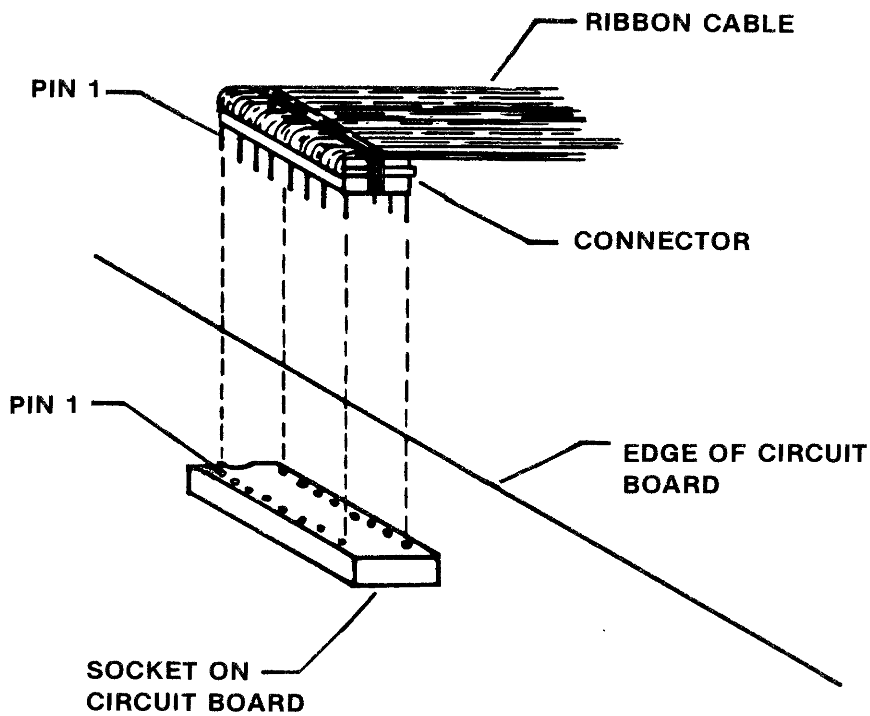
1. Turn off the power. Open the can as directed in the preceding section.

2. If a SIGNAL CONDITIONER is being replaced, disconnect the two connectors that are plugged into it. **Be very careful not to bend the pins on the 16-pin connectors.** Pry the connector loose with a small screwdriver before pulling on the connector. Wedge the screwdriver between the socket and the connector to loosen the connector.

3. Remove the board retainers and slide out the SIGNAL CONDITIONER. On the earlier assemblies, the circuit boards are mounted with screws through angle brackets that have to be removed in order to remove the SIGNAL CONDITIONER.

4. Slide the new SIGNAL CONDITIONER into the desired position. The board retainers may be mounted temporarily from the back side of the mounting screws. This provides a finger grip to aid in installation. First insert the edge of the circuit board with the socket labeled "SENSOR." The opposite edge with the socket labeled "MUX" will then be on the same side as the eight channel sockets on the MUX board. Replace the board retainers. On earlier assemblies, mount the new SIGNAL CONDITIONER by fastening the angle brackets to the mounting frame in the desired location.

5. Connect the socket on the SIGNAL CONDITIONER labeled "MUX" to the desired channel socket on the MUX board. The channel sockets are numbered 1 through 8. Use a ribbon cable assembly with a 16-pin connector on each end. Plug the ribbon cable connector into the socket on the circuit board as shown in figure 10.

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**WHEN PLUGGING A RIBBON CABLE CONNECTOR INTO A SOCKET ON A CIRCUIT BOARD, ALIGN PIN 1 ON THE CONNECTOR WITH PIN 1 ON THE SOCKET AS SHOWN IN THE ABOVE FIGURE. WHEN PROPERLY INSTALLED THE CABLE EXTENDS AWAY FROM THE CIRCUIT BOARD. BE SURE THAT EACH PIN IS STRAIGHT AND ALIGNED WITH ITS SOCKET HOLE BEFORE APPLYING PRESSURE TO PLUG IN THE CONNECTOR.**

**NOTE THAT PIN 1 ON THE SOCKET IS INDICATED BY THE NOTCH AT ONE END.**

Figure 10.--Connection of ribbon cable.

6. Plug the ribbon cable connector from the sensor connector on the cover into the socket on the SIGNAL CONDITIONER labeled "SENSOR." Plug in the connector as shown in figure 10. Be sure to connect the SIGNAL CONDITIONER to the sensor connector associated with the desired channel.* Mark each sensor connector on the cover to identify the constituent being measured. Earlier assemblies do not have ribbon cables from the sensor connectors. Instead, a bundle of wires from the trimpots and each sensor connector is soldered to a 16-pin connector. Plug in connectors so that the higher numbered pins on the connector are on the side of the socket closest to the edge of the circuit board.

7. Verify that the settings for the number of channels and the delay times on the PROGRAMMER are correct for the SIGNAL CONDITIONERS used.

***CAUTION:** Once the desired delay times and range have been set, prepare the DO sensor and stirrer in accordance with the Yellow Springs Instrument Company (YSI) instructions included in the section "Dissolved-oxygen range selection, calibration, sensor maintenance, and performance checks."

After the sensor and stirrer have been properly prepared, connect the sensor cables to the Minimonitor and calibrate, using the following precautions:

- Ensure that connectors are properly aligned and that the proper channel is being used. (If the SENSOR is connected to a channel having a different SIGNAL CONDITIONER, damage may result.)

- Ensure that adhesive labels to identify channels have been provided.

- Attach the labels to the connectors to help prevent misidentification and possible connection to the wrong channel.

## Desiccant

The Minimonitor contains packets of silica gel desiccant material, which prevents moisture buildup in the electronics package. When the monitor is opened for any reason, replace the old desiccant with dry desiccant. The old desiccant can be dried by heating it in an oven at 245 to 260 $^{o}$F for 12 hours. After drying, store the packets of desiccant in a sealed container to prevent the absorption of moisture from the air.

## Closing the Minimonitor

Set the cover assembly back into the can, being careful not to pinch any wires between the cover and the can. Check that the rubber seal in the lid rim is in the proper position. Replace the locking ring and fasten with the bolt or bolts. On models with a single bolt, the locking ring is put on the can by starting on one side and carefully working the ring around the edge of the can.

# CONNECTING THE MINIMONITOR FOR OPERATION

## Installing the Sensors

Because each site is different, only general suggestions on sensor mounting will be made. Consult U.S. Geological Survey Open-File Report 83-681, "Guidelines for Use of Water Quality Monitors," for more detailed information. Methods of mounting the sensors must be tailored to fit each particular site. Sensors may be protected from silting-in and from damage caused by debris, freezing, vandalism, or other causes. Sensors should be accessible under all river conditions.

The sensors may be held in place by a stainless- or galvanized-steel rod or bracket and anchored to the holding device with hose clamps of the same noncorrosive material. These sensors may be slid down the pipes. Mount the sensors so they can be removed easily for cleaning and calibration during any stream conditions. The cables may be routed to the gage house through a plastic pipe or conduit. The maximum length of cable from the sensors to the monitor is 1,000 feet. In cold weather, the rubber connectors become hard, making them difficult to pull apart.

## Sensor Cables and Connectors

Sensor cables and connectors are identical for all parameters, which allows interchangeability of these parts. However, it is possible to plug the wrong sensor into a SIGNAL CONDITIONER, causing damage to the sensor or the electronics. Mark the cables to help prevent improper connections. Many of the Minimonitors have the SENSOR CONNECTORS marked with special tape as follows: TEMP, COND, DO, PH. This marking tape is available upon request from the HIF warehouse. The connectors have an alignment marking on the outside body. When mating the connectors, align these marks and push the connectors together. Figure 11 shows the sensor cable connector.

**CAUTION:** Forcing the connectors together without aligning the marks can damage the connectors and may electrically harm the SIGNAL CONDITIONER or sensor. After the connector is properly mated, the locking sleeves can be screwed together. **NOTE:** A thin film of silicone grease, electrically nonconductive type, spread on the connector bodies helps the connectors work easier. Avoid getting grease on the pins.

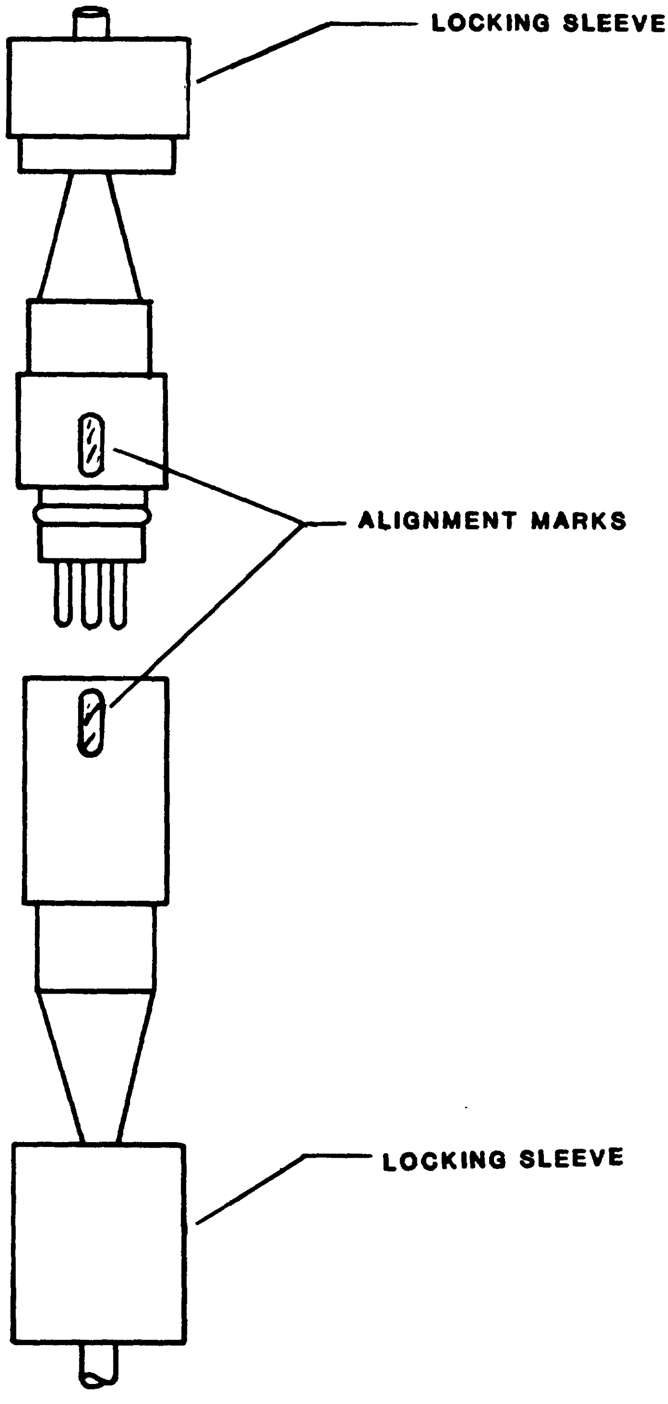



Figure 11.--Sensor cable connector.

## Final Connection of Cables

Complete the final connections as follows:

1. Connect the sensor cables to the monitor as described in the section entitled "Sensor Cables and Connectors." Check that the sensors are plugged into the channels that correspond to the matching SIGNAL CONDITIONER. Always turn off or remove power from the unit before installing or removing the sensors or other connectors.

2. Connect the power-and-recorder cable assembly (fig. 12) to the Minimonitor and to a Leupold and Stevens digital input-output recorder.

3. Make sure that the ON-OFF switch is toggled to OFF. Connect the power leads to a 12-volt dc power source. The monitor is now ready for operation.

## Power Source

Power the Minimonitor from a 12-volt, dry-cell, lead-acid battery or a dc power supply. The power source must be able to supply a minimum of 2 amperes for the time that the recorder runs. Two 6-volt, dry-cell batteries or rechargeable 12-volt, lead-acid batteries can be used. A solar panel may be used to charge the batteries. Contact the HIF for information.

**CAUTION:** Never use two 7.5-volt batteries or a 15-volt battery because the actual voltage of these batteries may exceed 15 volts and damage the monitor.

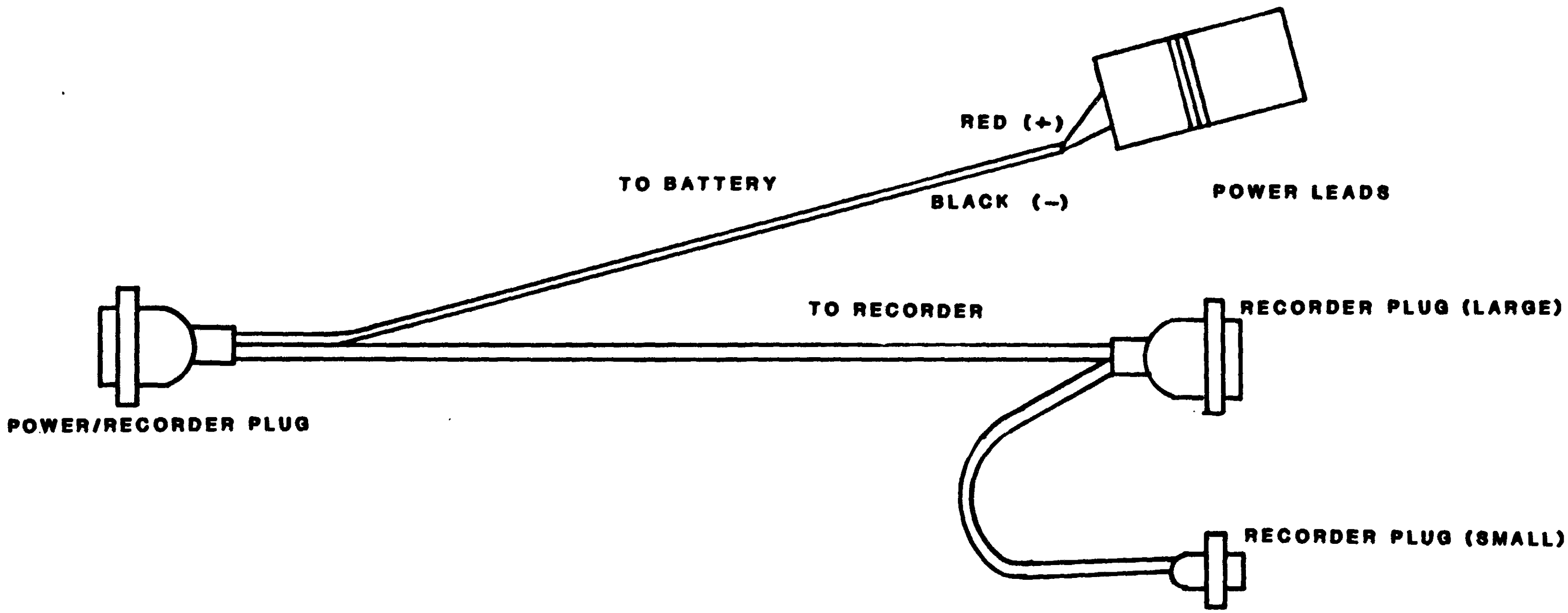



Figure 12.--Power-and-recorder cable assembly.

FUNCTION OF FRONT-PANEL SWITCHES, ADJUSTMENT POTS, AND CONNECTORS

Refer to figure 9, a drawing of the Minimonitor front panel.

Time Set.--Pressing this switch advances the clock 1 minute and holds the seconds at zero until the switch is released.

Manual Record.--Pressing this switch will cause the recorder to punch one line of tape if the AUTO-HOLD switch is in the AUTO position.

Scan.--Pressing this switch will cause a scan-and-record cycle if the AUTO-HOLD switch is in AUTO. The following sequence of events occurs:

1. DO stirrer turns on (if connected),
2. SIGNAL CONDITIONER power turns on,
3. the monitor records the data, and
4. the monitor returns to the standby mode.

This does not affect clock timing for the regular scan-and-record cycle.

Auto-Hold.--In the HOLD position, the monitor will not scan or record data. Turn this switch to AUTO before leaving the station.

On-Off.--In the OFF position, all power is disconnected from the monitor. Toggle this switch to OFF when changing cards or sensors.

Auto-Manual.--In the MANUAL position, the DISPLAY will light and the SIGNAL CONDITIONERS will be turned on. When leaving the station, leave this switch in AUTO or the batteries soon will be discharged.

Channel Advance.--Pressing this switch will advance the monitor to the next channel when operating in the MANUAL mode.

Zero.--Screwdriver adjustment for offset calibration of individual SIGNAL CONDITIONERS.

Span.--Screwdriver adjustment for gain calibration of individual SIGNAL CONDITIONERS.

Channel (CH) Connectors.--Waterproof, neoprene connectors for sensor cables; channels (CH) are numbered counterclockwise from 1 to 4 (or 8), starting from the 26-pin connector at the top. Numbering determines punching sequence on paper tape (first is 1, second is 2, and so on).

Power-and-Recorder Connector.--For connecting to a power source and to the Leupold and Stevens digital input-output recorder.

Analog-Telemetry Connector.--Provides 0- to 5-volt analog output for each channel when the SIGNAL CONDITIONER power is on. This connector may be used for interfacing to a DCP.

Display.--The Minimonitor has a four-digit DISPLAY mounted on the PROGRAMMER board and is viewed through the window provided on the Minimonitor cover. The farthest left digit indicates the channel number, and the right three digits indicate the data for that channel. Channel zero indicates the time elapsed since the last scan-and-record cycle, and channels 1 through 8 indicate the SIGNAL CONDITIONERS in sequence.

Fuse Holders.--Later models and some converted units have the 0.5- and 1.5-ampere fuses located in waterproof fuse holders. Older models of the Minimonitor have the fuses mounted on the MUX board, which requires opening the Minimonitor. Refer to the section of this manual entitled "Servicing Internal Components of the Minimonitor."

## SETTING THE TIME

When the monitor is in channel zero and the AUTO-MANUAL switch is set to MANUAL, the DISPLAY will show the minutes since the last scan-and-record cycle. Pressing the TIME SET switch advances the time 1 minute. Upon reaching the internally set recording interval, the clock will reset to 00, and a scan-and-record cycle will start unless the AUTO-HOLD switch is in the HOLD position. For example, on a 15-minute recording interval, the DISPLAY will show the numbers 00 to 14. When the DISPLAY is on 14 and the TIME SET switch is pressed, the DISPLAY will reset to 00 and the scan-and-record cycle will start. To set the time to the exact second, advance the DISPLAY 1 minute ahead of the actual time and hold the TIME SET switch down. When the minute displayed is reached in actual time, release the switch. The time is set. The display will be advanced one unit for every minute after the TIME SET switch is released. Because the monitor must go through a delay period before recording, the actual punches on the tape occur at a later time than the start of the scan-and-record cycle.

## TEMPERATURE CALIBRATION AND SENSOR MAINTENANCE

### Calibration Procedure

The standard temperature range is 0 to 50 °C. If another range is necessary, contact the HIF Field Service and Supply Section. Figure 13 shows the socket locations on the temperature SIGNAL CONDITIONER.

Zero degrees Celsius equals 000 on the display and 49 °C equals 980 on the display.

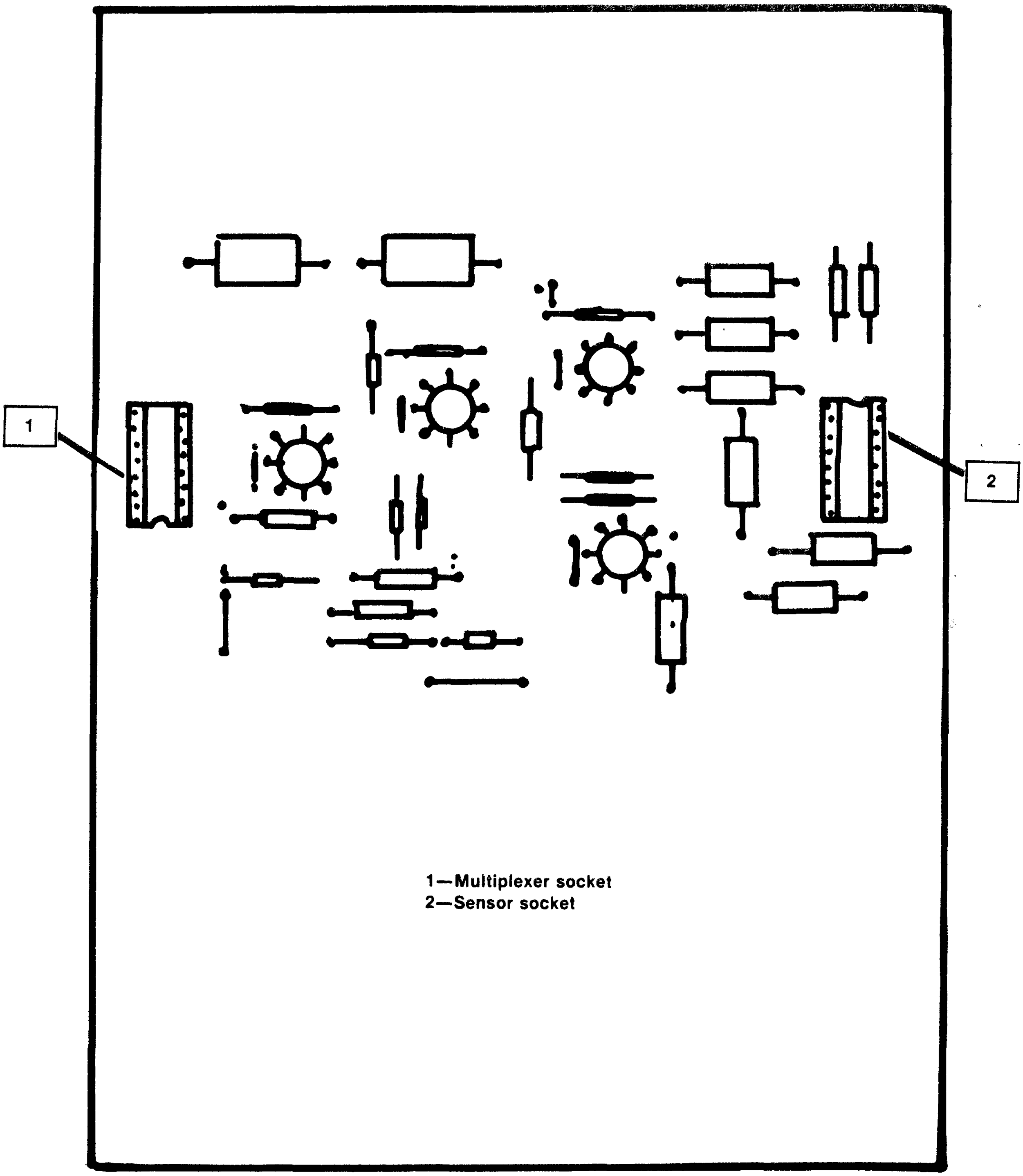



Figure 13.--Temperature signal conditioner.

Perform the following steps to calibrate the temperature signal conditioner:

1. Place the temperature sensor in a stirred cold solution as close to 0 °C as possible; an ice-and-water mixture works well. Place a thermometer, accurate to within 0.1 °C, in this solution.

2. Check that the sensor is plugged into the correct channel and turn on the monitor. Set the AUTO-MANUAL switch to MANUAL and advance the DISPLAY to the channel occupied by the temperature SIGNAL CONDITIONER.

3. Adjust the ZERO pot located above the sensor connector until the DISPLAY reading is from 000 to 001. An occasional 001 must be seen to ensure that the setting is not less than zero since negative values will read 000. Stirring the solution is recommended. Wait long enough for both readings to stabilize, read the thermometer, and record this reading.

4. Place the temperature sensor and the thermometer in a solution having a high, near-maximum temperature that will be measured. Stirring the solution is recommended. After both readings stabilize, adjust the SPAN pot until the DISPLAY reads 20 times the difference between the high- and low-temperature values.

5. With the sensors still in the high-temperature water, adjust the ZERO pot until the DISPLAY reads the proper value. The proper value is 20 times the actual temperature for a 0 to 50 °C range.

   **NOTE:** 0 °C = 000, 10 °C = 200, 20 °C = 400, 30 °C = 600, 40 °C = 800, and so forth.

6. Check the calibration by placing the sensor and the thermometer in a solution of about half the temperature of the previous high-temperature solution. If the two readings check, the calibration is accurate. An example follows.

| With Sensor In | Adjust | Until DISPLAY Reads |
| --- | --- | --- |
| 00.3 °C | ZERO | 000 to 001 |
| 36.0 °C | SPAN | (High temperature - low temperature) X 20 = 714 on DISPLAY |
| 36.0 °C | ZERO | (Actual temperature) 36 X 20 = 720 for 0 to 50 °C range |
| 21.0 °C | None | 420 (check-reading for 0 to 50 °C range) |

**NOTE:** DISPLAY readings can range from 000 to 999. Negative values less than 000 will register as 000. Values higher than 999 will show as 000, or 001, 002,..., 024. The DISPLAY will register no higher than 024. A DISPLAY reading of 024 indicates an over-range value.

Table 1 shows the relation between temperature values and Minimonitor display readings.

Table 1.--Relation between temperature values and Minimonitor display readings

| Temperature Value at Sensor (°C) | Minimonitor Display Readings 0 to 50 °C Range |
|---|---|
| 0.0 | 000 |
| 10.0 | 200 |
| 15.0 | 300 |
| 20.0 | 400 |
| 25.0 | 500 |
| 27.6 | 552 |
| 30.0 | 600 |
| 35.0 | 700 |
| 40.0 | 800 |
| 45.0 | 900 |
| 50.0 | 000 |
| 55.0 | 024 (over range) |

**NOTE:** DISPLAY readings can range from 000 to 999. Negative values less than 000 will register as 000. Values higher than 999 will show as 000, 001, 002,..., 024. The DISPLAY will register no higher than 024. A DISPLAY reading of 024 indicates an over-range value.

## Temperature Sensor Maintenance

Clean the temperature sensor by scrubbing with a soft-bristled brush and detergent solution. The rubber area at the top of the sensing portion of the sensor is easily damaged; do not use sharp or hard objects to clean the sensor. Films on the stainless-steel portion of the sensor that resist removal usually can be removed by soaking in a detergent-and-water solution.

If problems are encountered, contact HIF Field Service and Supply Section for assistance.

# SPECIFIC-CONDUCTANCE RANGE SELECTION, CALIBRATION, AND SENSOR MAINTENANCE

## Selecting the Specific-Conductance Range

Four specific-conductance ranges are available: 0 to 100, 0 to 1,000, 0 to 10,000, and 0 to 100,000 µS/cm. The desired range is selected by a set of switches on the specific-conductance SIGNAL CONDITIONER (fig. 14).

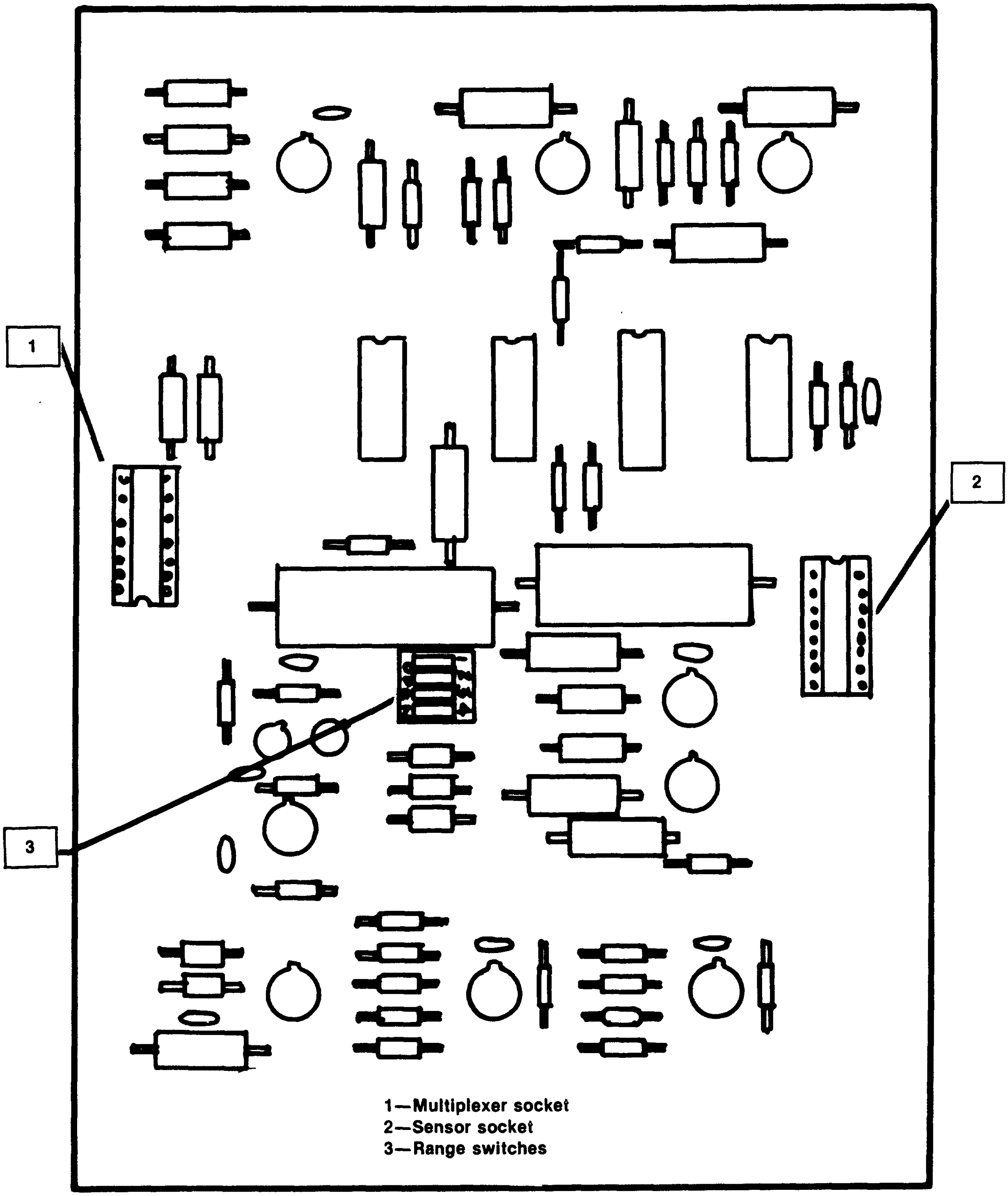



Figure 14.--Specific-conductance signal conditioner.

To set the switches, follow the steps listed.

1. Open the can according to instructions in the section of this manual entitled "Servicing Internal Components of the Minimonitor."

2. Locate the specific-conductance SIGNAL CONDITIONER. This board has a cable running from it to the sensor connector to which the specific-conductance sensor attaches.

3. Locate the switch assembly in the center of the card.

4. Use a ballpoint pen or a small screwdriver to select the switch closures (fig. 15) for the range desired.

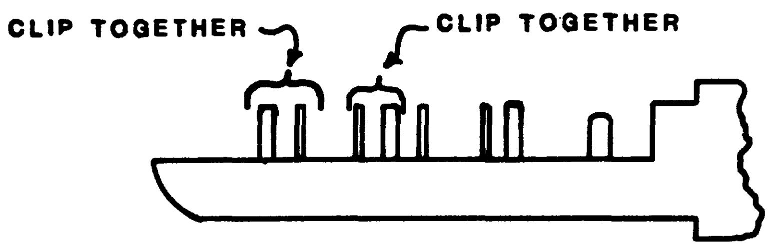



Figure 15.--Switch settings for different ranges.

If a very large specific-conductance range will be encountered, the use of two specific-conductance systems set to different ranges may be advantageous.

## Calibration Procedure

Once the desired range has been set, connect the sensor cables to the Minimonitor. The following items are needed to calibrate the specific-conductance signal conditioner. A cloth or paper towel, two clip leads, distilled water, and two known solutions--one near the maximum value selected and one about one-half the specific conductance of the first--will be needed for this procedure.

Perform the following steps to calibrate the specific-conductance signal conditioner:

1. Remove the shield on the specific-conductance sensor.

2. Dry the sensor completely with a cloth or a paper towel.

3. Attach one clip lead from the center electrode to an adjacent electrode. Attach the second clip lead from the outside electrode to the adjacent electrode. See figure 16, specific-conductance sensor.

| Switch (OPEN ←) | 0 to 100 microsiemens | 0 to 1,000 microsiemens | 0 to 10,000 microsiemens | 0 to 100,000 microsiemens |
|---|---|---|---|---|
| 1 | OPEN | OPEN | CLOSED | CLOSED |
| 2 | CLOSED | OPEN | OPEN | OPEN |
| 3 | OPEN | CLOSED | CLOSED | OPEN |
| 4 | OPEN | OPEN | OPEN | CLOSED |

Figure 16.--Specific-conductance sensor.

4. Turn on the monitor. Set the AUTO-MANUAL switch to MANUAL and sequence the monitor to the specific-conductance channel. The correct DISPLAY reading is 000 or 001. An occasional 001 must be seen to ensure that the monitor is not set below zero since negative readings register 000. If this 001 reading does not appear, adjust the ZERO pot located above the specific-conductance sensor connector until the proper value is seen.

5. Remove the clip leads and replace the shield on the sensor.

6. Place the sensor into a known standard solution that is near the maximum value expected.

7. With the monitor on and in the MANUAL mode, note the DISPLAY. After the reading has stabilized, adjust the SPAN pot located above the sensor connector until the DISPLAY reads the value of the test solution.

8. Calibration is complete. If you wish to verify that the system is calibrated correctly, rinse the sensor with distilled water and then rinse with a small portion of the second sample.

Place the sensor in a second known solution of about one-half the specific conductance of the first. If the DISPLAY reads this solution correctly, your calibration is accurate. An example follows:

A range of 0 to 10,000 μS/cm is desired and the range switch has been set accordingly. A standard solution having a value of 8,700 μS/cm at 25 $^{o}$C is available. In this range, 0 to 999 DIGITAL DISPLAY UNITS would equal 0 to 9,990 μS/cm. Therefore, the value of the standard solution, 8,700 μS/cm, would be indicated as 870 on the digital display if the specific-conductance signal conditioner were properly calibrated.

On other ranges, a digital display reading of 870 would indicate values of 87 μS/cm on the 0 to 100 range, 870 μS/cm on the 0 to 1,000 range, and 87,000 μS/cm on the 0 to 100,000 range.

Table 2 shows the relation between specific-conductance values and Minimonitor display readings.

Table 2.--Relation between specific-conductance values and Minimonitor display readings

| Specific-Conductance Value at Sensor (μS) | Minimonitor Display Readings (0-100 μS) | (0-1,000 μS) | (0-10,000 μS) | (0-100,000 μS) |
|---|---|---|---|---|
| 0 | 000 | 000 | 000 | 000 |
| 10 | 100 | 010 | 002 | 000 |
| 25 | 250 | 025 | 003 | 000 |
| 50 | 500 | 050 | 005 | 000 |
| 75 | 750 | 075 | 008 | 001 |
| 100 | 000 | 100 | 010 | 001 |
| 250 | 024(over range) | 250 | 025 | 002 |
| 500 | 024 | 500 | 050 | 005 |
| 750 | 024 | 750 | 075 | 008 |
| 1,000 | 024 | 000 | 100 | 010 |
| 2,500 | 024 | 024(over range) | 250 | 025 |
| 5,000 | 024 | 024 | 500 | 050 |
| 7,500 | 024 | 024 | 750 | 075 |
| 10,000 | 024 | 024 | 000 | 100 |
| 25,000 | 024 | 024 | 024(over range) | 250 |
| 50,000 | 024 | 024 | 024 | 500 |
| 75,000 | 024 | 024 | 024 | 750 |
| 100,000 | 024 | 024 | 024 | 000 |
| 150,000 | 024 | 024 | 024 | 024(over range) |

**NOTE:** DISPLAY readings can range from 000 to 999. Negative values less than 000 will register as 000. Values higher than 999 will show as 000, 001, 002,..., 024. The DISPLAY will register no higher than 024. A DISPLAY reading of 024 indicates an over-range value.

## Specific-Conductance Sensor Maintenance

Dirt or deposit buildup in the electrode area of the sensor can affect sensor response, so regular cleaning is necessary.

A brush and laboratory-type detergent will be needed.

1. Remove the shield from the conductance sensor. One or two screws will be found, depending on the sensor design. Slide the shield off carefully as any forcing may bend the electrode pins.

2. Clean the inside of the shield with a laboratory-type detergent and brush.

3. Rinse the shield thoroughly after cleaning.

4. Clean the body of the sensor in the same manner.

5. Reinstall the shield.

Care must be taken not to damage the insulating material surrounding the electronics of the sensor and the electrodes because premature failure of the sensor may result. If any dirt or deposits resist cleaning, allow the sensor to soak in a detergent-and-water solution and rescrub with the brush and detergent. Do not use objects such as screwdrivers, knives, or wire brushes to remove dirt or deposits from the sensor.

If any problems are encountered, contact HIF Field Service and Supply Section for assistance.

## DISSOLVED-OXYGEN RANGE SELECTION, CALIBRATION, SENSOR MAINTENANCE AND PERFORMANCE CHECKS

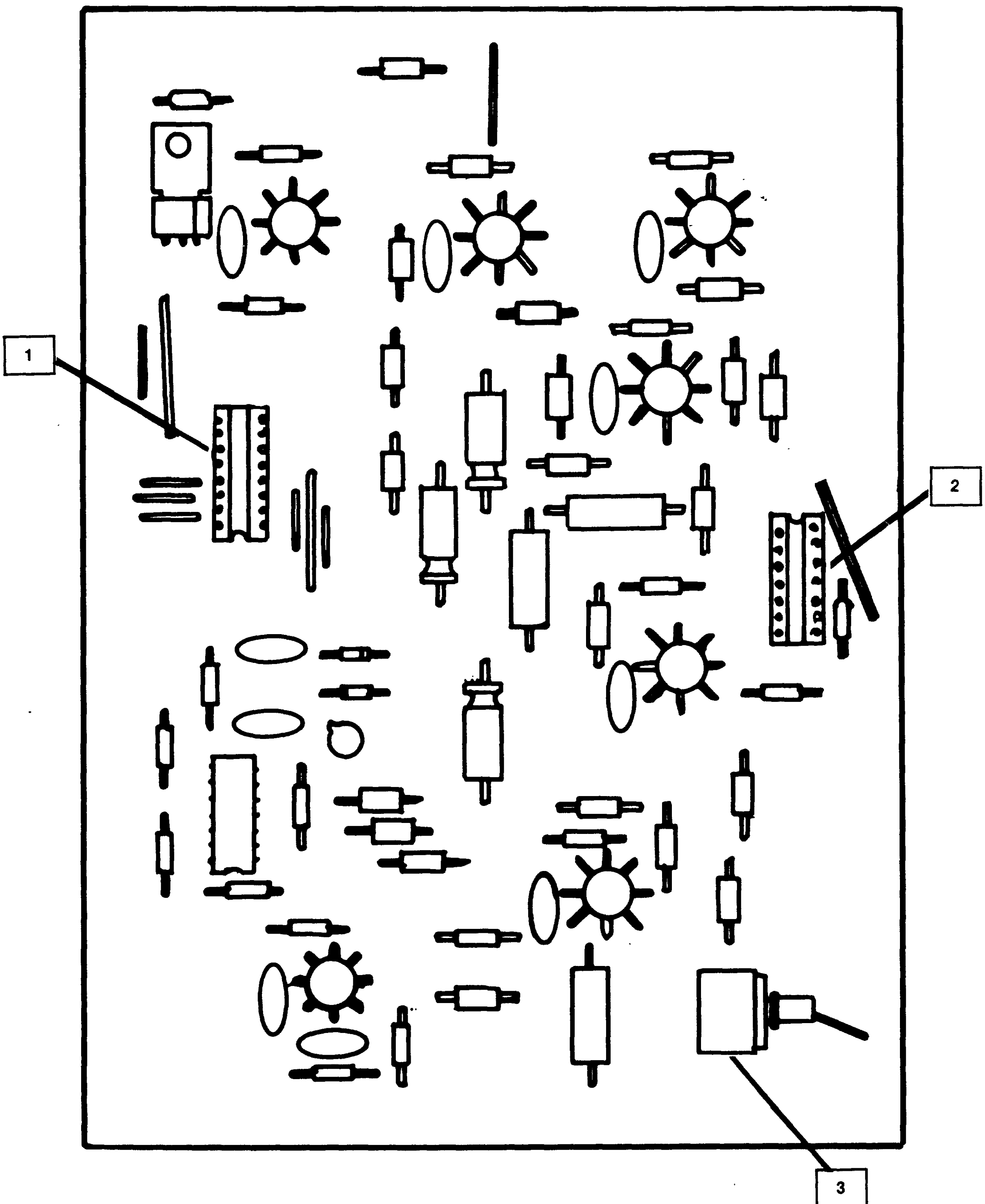
The DO measuring system uses a stirrer and DO sensor manufactured by the Yellow Springs Instrument Company (YSI) (1975, 1978, 1979). The operation and maintenance of these components are described in detail in the manufacturer's instructions, which are repeated with permission in the appendix. The DO SIGNAL CONDITIONER (shown in figure 17) has been designed by the Survey.

### Selecting Dissolved-Oxygen Range

The system has a two-range capability when the 1-mil-thickness plastic membranes provided with the units are used. These ranges can be extended by using membranes of other thicknesses available from YSI. Open the Minimonitor can to find a toggle switch located on the SIGNAL CONDITIONER board. The toggle positions marked HI and LO will provide the following ranges:

| Thickness of plastic membrane | | Switch position range (mg/L) | |
|---|---|---|---|
| (in) | (mil) | LO | HI |
| 0.0005 | 0.5 | 0 to 5 | 0 to 10 |
| .001 | 1 | 0 to 10 | 0 to 20 |
| .002 | 2 | 0 to 20 | 0 to 40 |

The membrane kit furnished with this system will have 1-mil (0.001 in) membranes.




**1—Multiplexer socket**
**2—Probe socket**
**3—Range switch**

Figure 17.--Dissolved-oxygen signal conditioner.

The DO measuring system operates in the following manner: When the Minimonitor ON-OFF switch is toggled to the ON position, 0.8-volt polarizing electrical potential is applied to the DO sensor at all times. At the start of a monitor-scan cycle, the DO stirrer comes on for a preselected length of time; then the SIGNAL CONDITIONERS are turned on for another selected length of time before the recording cycle begins. The length of time that the stirrer needs to be turned on depends upon the membrane thickness. Table 3 shows the preferred delay times to be set on the PROGRAMMER when operating a DO system. The times are based on experimental results obtained in still water.

Table 3.--Delay times for programmer when operating a dissolved-oxygen system

| Membrane thickness in mils | Time delays to set in seconds on the PROGRAMMER (Switch 25A) | (Switch 24A) |
|---|---|---|
| [a]1 | 40 | 48 |
| 2 | 112 | 128 |

[a]Standard with Survey system.

Refer to section, "Servicing Internal Components of the Minimonitor," for instructions on opening the can and setting the delay times on the PROGRAMMER.

Install the DO SIGNAL-CONDITIONER board following instructions provided in the section "Removing or Adding Circuit Boards."

## Calibration

The following steps detail the calibration procedure:

1. With the sensor and stirrer properly prepared and connected to the Minimonitor, turn the AUTO-HOLD switch to HOLD, the AUTO-MANUAL switch to MANUAL, and then the ON-OFF switch to ON. This will power the Minimonitor and turn on the DO stirrer. The DISPLAY also is lighted. Use of the CHANNEL ADVANCE switch advances the Minimonitor to the channel occupied by the DO SIGNAL CONDITIONER.

2. Submerge the sensor and stirrer in a container of water having zero DO. This water is prepared by stirring a small amount of sodium sulfite crystals into the water. About 4 grams for each liter probably will be more than sufficient. A pinch of cobalt chloride crystals may be added to hasten the reaction. Check the Minimonitor DISPLAY after a minute or two to see if the output value is changing. If the display reads 000, adjust the ZERO pot clockwise until the DISPLAY reads 001 or more. The DISPLAY value will decrease for a few minutes, and then stabilize. Keep observing the DISPLAY and keep adjusting the ZERO pot to keep the value about 001. After the reading stabilizes, adjust the ZERO pot until the reading is 001 or 000. Remember, the DISPLAY reading will not register negative values so the adjustment must be made by adjusting the value downwards toward 000 to 001 or higher.

3. Carefully wash the sensor and stirrer with water to remove all traces of the sodium sulfite solution; then place the unit in a container of water having a known DO concentration, or directly into the river or stream if the DO content is known. Adjust the SPAN pot until the monitor DISPLAY reads the proper value according to the range selected. Wait until the reading stabilizes to make the final adjustment. Table 4 shows the relation between range and monitor readings:

Table 4.--Relation between dissolved-oxygen concentrations and Minimonitor display readings

| Dissolved-oxygen value at sensor (mg/L) | Minimonitor display reading range 0 to 10 (mg/L) | Minimonitor display reading range 0 to 20 (mg/L) |
|---|---|---|
| 0.0 | 000 | 000 |
| 2.0 | 200 | 100 |
| 4.1 | 410 | 205 |
| 6.0 | 600 | 300 |
| 8.0 | 800 | 400 |
| 9.9 | 990 | 445 |
| 10.0 | 000 (full scale) | 500 |
| 12.0 | 024 (over range) | 600 |
| 14.0 | 024 ( do ) | 700 |
| 18.0 | 024 ( do ) | 900 |
| 19.9 | 024 ( do ) | 995 |

**NOTE:** DISPLAY readings can range from 000 to 999. Negative values less than 000 will register as 000. Values higher than 999 will show as 000, 001, 002,....to 024. The DISPLAY will register no higher than 024. A DISPLAY reading of 024 indicates an over-range value.

4. Table 5 shows the solubility of oxygen in water exposed to water-saturated air as a function of temperature and chloride concentration. The suggested method of determining DO is the Winkler method. Regardless of what method is used, do not remove the stirrer from the sensor. If air-saturated water is used, table 5 may be used to estimate the concentration of oxygen.

Table 5.--Solubility of oxygen in water exposed to water-saturated air as a function of temperature and chloride concentration

| Temperature (°C) | Chloride concentration in water (mg/L) | | | | |
|---|---|---|---|---|---|
| | 0 | 5,000 | 10,000 | 15,000 | 20,000 |
| 0 | 14.60 | 13.72 | 12.90 | 12.13 | 11.41 |
| 1 | 14.19 | 13.35 | 12.56 | 11.81 | 11.11 |
| 2 | 13.81 | 12.99 | 12.23 | 11.51 | 10.83 |
| 3 | 13.44 | 12.56 | 11.91 | 11.22 | 10.56 |
| 4 | 13.09 | 12.33 | 11.61 | 10.94 | 10.30 |
| 5 | 12.75 | 12.02 | 11.32 | 10.67 | 10.05 |
| 6 | 12.43 | 11.72 | 11.05 | 10.41 | 9.82 |
| 7 | 12.12 | 11.43 | 10.78 | 10.17 | 9.59 |
| 8 | 11.83 | 11.16 | 10.53 | 9.93 | 9.37 |
| 9 | 11.55 | 10.90 | 10.29 | 9.71 | 9.16 |
| 10 | 11.27 | 10.65 | 10.05 | 9.49 | 8.96 |
| 11 | 11.01 | 10.40 | 9.83 | 9.28 | 8.77 |
| 12 | 10.76 | 10.17 | 9.61 | 9.08 | 8.58 |
| 13 | 10.52 | 9.95 | 9.41 | 8.89 | 8.41 |
| 14 | 10.29 | 9.73 | 9.21 | 8.71 | 8.24 |
| 15 | 10.07 | 9.53 | 9.01 | 8.53 | 8.07 |
| 16 | 9.85 | 9.33 | 8.83 | 8.36 | 7.91 |
| 17 | 9.65 | 9.14 | 8.56 | 8.19 | 7.78 |
| 18 | 9.45 | 8.95 | 8.48 | 8.03 | 7.61 |
| 19 | 9.26 | 8.77 | 8.32 | 7.88 | 7.47 |
| 20 | 9.07 | 8.60 | 8.16 | 7.73 | 7.33 |
| 21 | 8.90 | 8.44 | 8.00 | 7.59 | 7.20 |
| 22 | 8.72 | 8.28 | 7.85 | 7.45 | 7.07 |
| 23 | 8.56 | 8.12 | 7.71 | 7.32 | 6.95 |
| 24 | 8.40 | 7.97 | 7.57 | 7.19 | 6.83 |
| 25 | 8.24 | 7.83 | 7.44 | 7.06 | 6.71 |
| 26 | 8.09 | 7.69 | 7.31 | 6.94 | 6.60 |
| 27 | 7.95 | 7.55 | 7.18 | 6.83 | 6.49 |
| 28 | 7.81 | 7.42 | 7.06 | 6.71 | 6.38 |
| 29 | 7.67 | 7.30 | 6.94 | 6.60 | 6.28 |
| 30 | 7.54 | 7.17 | 6.83 | 6.49 | 6.18 |
| 31 | 7.41 | 7.05 | 6.71 | 6.39 | 6.08 |
| 32 | 7.28 | 6.94 | 6.61 | 6.29 | 5.99 |
| 33 | 7.16 | 6.82 | 6.50 | 6.19 | 5.90 |
| 34 | 7.05 | 6.71 | 6.40 | 6.10 | 5.81 |
| 35 | 6.93 | 6.61 | 6.30 | 6.01 | 5.72 |

Table 5.--Solubility of oxygen in water exposed to water-saturated air as a function of temperature and chloride concentration[1] (continued)

| Temperature ($^{o}C$) | Chloride concentration in water (mg/L) | | | | |
|---|---|---|---|---|---|
| | 0 | 5,000 | 10,000 | 15,000 | 20,000 |
| 36 | 6.82 | 6.51 | 6.20 | 5.92 | 5.64 |
| 37 | 6.71 | 6.40 | 6.11 | 5.83 | 5.56 |
| 38 | 6.61 | 6.31 | 6.02 | 5.74 | 5.48 |
| 39 | 6.51 | 6.21 | 5.93 | 5.66 | 5.40 |
| 40 | 6.41 | 6.12 | 5.84 | 5.58 | 5.33 |
| 41 | 6.31 | 6.03 | 5.76 | 5.50 | 5.25 |
| 42 | 6.22 | 5.94 | 5.68 | 5.42 | 5.18 |
| 43 | 6.13 | 5.85 | 5.60 | 5.35 | 5.11 |
| 44 | 6.04 | 5.77 | 5.52 | 5.27 | 5.04 |
| 45 | 5.95 | 5.69 | 5.44 | 5.20 | 4.98 |
| 46 | 5.86 | 5.61 | 5.37 | 5.13 | 4.91 |
| 47 | 5.78 | 5.53 | 5.29 | 5.06 | 4.85 |
| 48 | 5.70 | 5.45 | 5.22 | 5.00 | 4.78 |
| 49 | 5.62 | 5.38 | 5.15 | 4.93 | 4.72 |
| 50 | 5.54 | 5.31 | 5.08 | 4.87 | 4.66 |

[1]At a total pressure of 760-mm Hg. Under any other barometric pressure, P, obtain the solubility S'(mg/L) from the corresponding value in the table by the equation:

$$S' = S\left(\frac{P - p}{760 - p}\right)$$

in which S is the solubility at 760-mm Hg and p is the pressure (mm) of saturated water vapor at the water temperature. For elevations less than 1,000 meters and temperatures below 25 $^{o}C$, p can be ignored. The equation then becomes:

$$S' = S\left(\frac{P}{760}\right) = S\left(\frac{P'}{29.92}\right)$$

where P' is the barometric pressure in inches Hg. Dry air is assumed to contain 20.90 percent oxygen. Calculations were made by Whipple and Whipple in 1911 and published in the Journal of the American Chemical Society, 33:362 (Franson, 392).

## Sensor Maintenance

If the system fails to perform acceptably, check the following:

| Problem | Resolution |
| --- | --- |
| Damaged or wrinkled membrane | Change membrane. |
| Fouled or coated cathode (gold) | Resurface as per instructions supplied with YSI 5675 sensor Service Kit (Not provided, available from local scientific supply houses) |
| Fouled anode (silver), blackening of anode or buildup of grayish precipitate in sensor | Soak 24 hours in 3-percent ammonia solution; rinse thoroughly with distilled water and retest |
| Damaged cable or connectors | Replace and retest |
| Broken stirrer diaphragm | Replace diaphragm |

Any questions regarding installation or operation can be referred to HIF Field Service and Supply Section.

Manufacturer's instructions for the stirrer and DO sensor are supplied in the appendix of this report.

## Sensor Performance Checks

The following checks can be made to determine sensor performance without using specialized equipment:

Checking sensor performance

1. Speed of response

   a. Prepare and calibrate the sensor.
   b. With sensor in air, read the DISPLAY.
   c. Immerse the sensor in a 25 $^{o}C$ oxygen-depleted sample. Samples may be prepared by adding approximately 1 gram of sodium sulfite to 0.5 liter of water.
   d. A good sensor will respond down-scale to 10-percent air saturation in 1 minute.

2. Background current

   After performing the speed-of-response steps, leave the sensor in the depleted sample for approximately 10 minutes. The reading will, in most cases, fall below 1 percent air saturation.

3. Calibration stability

   a. Carefully calibrate the sensor in moist air.
   b. Place the sensor in air-saturated water and allow the instrument to operate for 24 hours or longer.
   c. A good sensor will hold calibration plus 2 percent in 24 hours and plus 3 percent in 7 days.

4. Service

   If the sensor will not perform properly, see section entitled "Sensor Maintenance."

If these steps do not restore performance, the sensor may require replacement.

## pH RANGE SELECTION, CALIBRATION, AND SENSOR MAINTENANCE

The pH measuring system consists of a sensor assembly and a SIGNAL CONDITIONER designed by the U.S. Geological Survey. The sensor assembly contains a preamp and a combination pH-reference electrode. The standard pH sensor has a combination electrode with a refillable reference mounted directly on the sensor assembly.

The Minimonitor pH system can also accept most combination pH electrodes that are submersible and have standard dimensions of 0.5 inch by 6 inches.

To use pH electrodes other than those discussed here, contact HIF Field Service and Supply Section.

### Selecting pH Range

The system provides for two measuring ranges, 0 to 10 or 2 to 12 pH, selected by a toggle switch located on the pH SIGNAL CONDITIONER board (fig. 18, pH SIGNAL CONDITIONER). The LO position is 0 to 10 pH and the HI position is 2 to 12 pH. The shunt bar on the PROGRAMMER that controls the number of channels recorded must be moved to accommodate the pH system when it is added to a multichannel system. Refer to section entitled "Servicing Internal Components of the Minimonitor" for instructions on setting the number of channels.

Install the pH SIGNAL CONDITIONER board following instructions provided in section entitled "Servicing Internal Components of the Minimonitor."

Before resealing the can, the SIGNAL CONDITIONER electronics must be "balanced." Do not plug in the pH sensor at this time.

1. Set the toggle switch to the desired pH range. LO (0+010) is recommended.

2. Connect power to the Minimonitor and turn it on.

3. Set the AUTO-MANUAL switch to MANUAL.

4. Push the CHANNEL ADVANCE switch to DISPLAY the channel for pH.

5. Use a small screwdriver to adjust the balance pot (fig. 18) until the DISPLAY reads X700 if the range selected is LO (0 to 10) or X500 if the range selected is HI (2 to 12).

6. Turn off power and reseal the can.

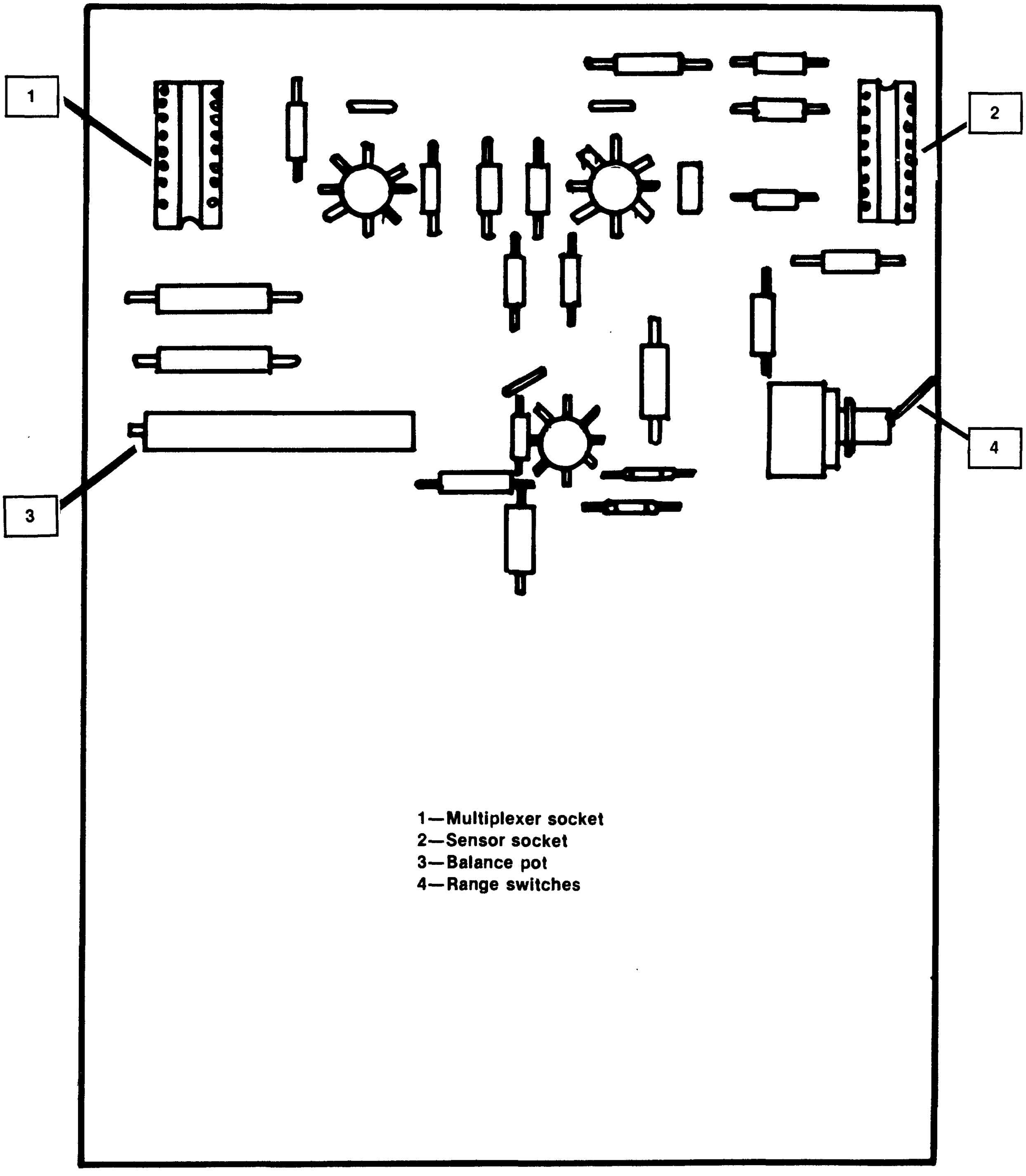



Figure 18.--pH signal conditioner.

## Calibration

Once the desired range has been set, prepare the pH sensor by following instructions provided in the section "Sensor Maintenance." After the sensor has been prepared, connect the pH sensor to the Minimonitor. Place the sensor in the 7.0 pH buffer. **NOTE: The wire that is down the side of the pH electrode is for grounding purposes and must be kept in the solution being monitored.** If the wire does not remain in the solution, erroneous results will occur. Allow the sensor to stabilize and adjust the ZERO pot so the DISPLAY reads 700 (0 to 10 range) or 500 (2 to 12 range). Place the sensor in a 4.0 pH buffer, or a 10.0 pH buffer if high pH values are expected. Adjust the SPAN pot until the DISPLAY reads 400 (in the 0 to 10 range), or 200 (in the 2 to 12 range) when using a 4.0 buffer. Adjust the DISPLAY to read 999 (in the 0 to 10 range) or 800 when using the 10.0 pH buffer. Check the DISPLAY reading in the 7.0 pH buffer. The value will change very little if the system is operating properly. Repeat the above process if the reading in the 7.0 buffer is not correct. The use of a pH buffer that has a pH value other than 7.0 will significantly increase the number of repetitions of the calibration process necessary to achieve calibration. Table 6 shows the relation between pH values and display readings.

Table 6.--Relation between pH values and Minimonitor display readings

| pH value at sensor | Minimonitor DISPLAY Reading: Range 0 to 10 pH | Minimonitor DISPLAY Reading: Range 2 to 12 pH |
|---|---|---|
| 0.0 | 000 | 000 (under range) |
| 1.0 | 100 | 000 ( do ) |
| 2.0 | 200 | 000 ( do ) |
| 3.0 | 300 | 100 |
| 4.0 | 400 | 200 |
| 5.0 | 500 | 300 |
| 6.0 | 600 | 400 |
| 7.0 | 700 | 500 |
| 8.0 | 800 | 600 |
| 9.0 | 900 | 700 |
| 9.5 | 950 | 750 |
| 10.0 | 000 | 800 |
| 11.0 | 024 (over range) | 900 |
| 12.0 | 024 ( do ) | 000 |
| 13.0 | 024 ( do ) | 024 (over range) |
| 14.0 | 024 ( do ) | 024 ( do ) |

**NOTE:** DISPLAY readings can range from 000 to 999. Negative values less than 000 will register as 000. Values higher than 999 will show as 000, 001, 002,..., 024. The DISPLAY will register no higher than 024. A DISPLAY reading of 024 indicates an over-range value.

## Sensor Maintenance

pH sensors require minimum maintenance. Simple guidelines follow:

- During storage, keep sensors near room temperature.

- Do not remove the cap on the tip of the sensor.

These caps are filled with a weak 7.0 pH buffer to keep the reference junction wet. Check the sensors in storage semiannually to assure that the cap retains moisture. The 7.0 pH buffer can be replaced with ordinary tap water if the buffer has evaporated. Keep the connector, located at the end of the sensor cable, clean and dry.

Cleaning the pH sensor is easy. The reference junction usually requires no maintenance. A coating covering the exposed part of the reference junction usually can be removed with detergent and a brush. Care must be taken not to break the glass bulb when cleaning the reference junction.

Glass pH electrodes can be cleaned in a number of ways. Scaling, persistent oils, and other stubborn coatings usually can be removed by soaking the reference in a 3 to 10 percent HCl solution for a few minutes and then rinsing it under tap water. Unusually heavy coatings may require more than one soaking. Simple cleaning of minor coatings often can be accomplished by directing a stream of clean water directly onto the glass. Wiping the glass with a clean, soft cloth may be permissible with new sensors. Care must be taken with this approach as the glass may break when mishandled.

## pH Sensor Preparation

Prepare the sensor as follows:

1. Examine the sensor for damage, paying particular attention to the electrode. Handle the sensor with care because the glass bulb is extremely fragile. If damaged, contact the HIF. Do not attempt to disassemble or repair the sensor assembly as further damage may result.

2. Check the glass bulb for air bubbles in the electrolyte. Hold the sensor vertically with the electrode-end down. If air is present, gently tap the lower end of the sensor (**not the electrode!**) against the heel of your hand until the bubbles are no longer present in the bulb. The sensor must not be inverted or bubbles may re-enter the bulb and cause erroneous measurements.

3. Soak the sensor for a minimum of 24 hours before calibration is attempted or drift may occur. Distilled water may be used, but a pH buffer of pH 4.0 or 7.0 units is preferred. The prepared sensor is ready to be connected to the Minimonitor. Align the waterproof plugs and sockets as shown in figure 11 and connect them to the proper channel. To make connector identification easier, use adhesive labels marked "pH."

## Refilling pH Reference

To refill the reference on the pH electrode, remove the slotted screw plug in the side of the electrode. Using distilled water and a squirt bottle, rinse the old reference solution out of the electrode. The reference solution used in the pH electrode is a liquid gel and is somewhat difficult to remove. Make sure all the old reference solution is washed out of the electrode, or problems may occur when the sensor is placed back into service. Using the solution supplied with the sensor, refill the reference, making sure no air bubbles are trapped inside. (To remove air, hold the sensor assembly with the electrode pointing down and gently tap the side with the heel of your hand.) Replace the plug, using thread-sealing tape on the threads.

## pH Sensor Shipping Procedure

When packing the pH sensor for shipment, please follow this procedure:

- Place the shipping cap over the end of the electrode. To prevent air from being forced into the reference electrode, fill the cap completely with tap water or buffer solution. Do not use distilled water. Electrodes shipped without this cap will dry out and sometimes cannot be salvaged.

- Please wrap the electrode end of the sensor with some cushioning material to prevent damage to the electrode. This is the most fragile part of the assembly and may be damaged during shipment.

## VOLTAGE-INPUT SPECIFICATIONS, APPLICATIONS, AND CALIBRATION

A VOLTAGE SIGNAL CONDITIONER (fig. 19) has been designed by the HIF to allow the Minimonitor to accept voltage and, in some cases, current signals from other instrumentation. In addition, the voltage SIGNAL CONDITIONER has relays available to provide electrical power from the Minimonitor, or other sources, to other instrumentation. Application of this power can be controlled by the Minimonitor timing circuits.

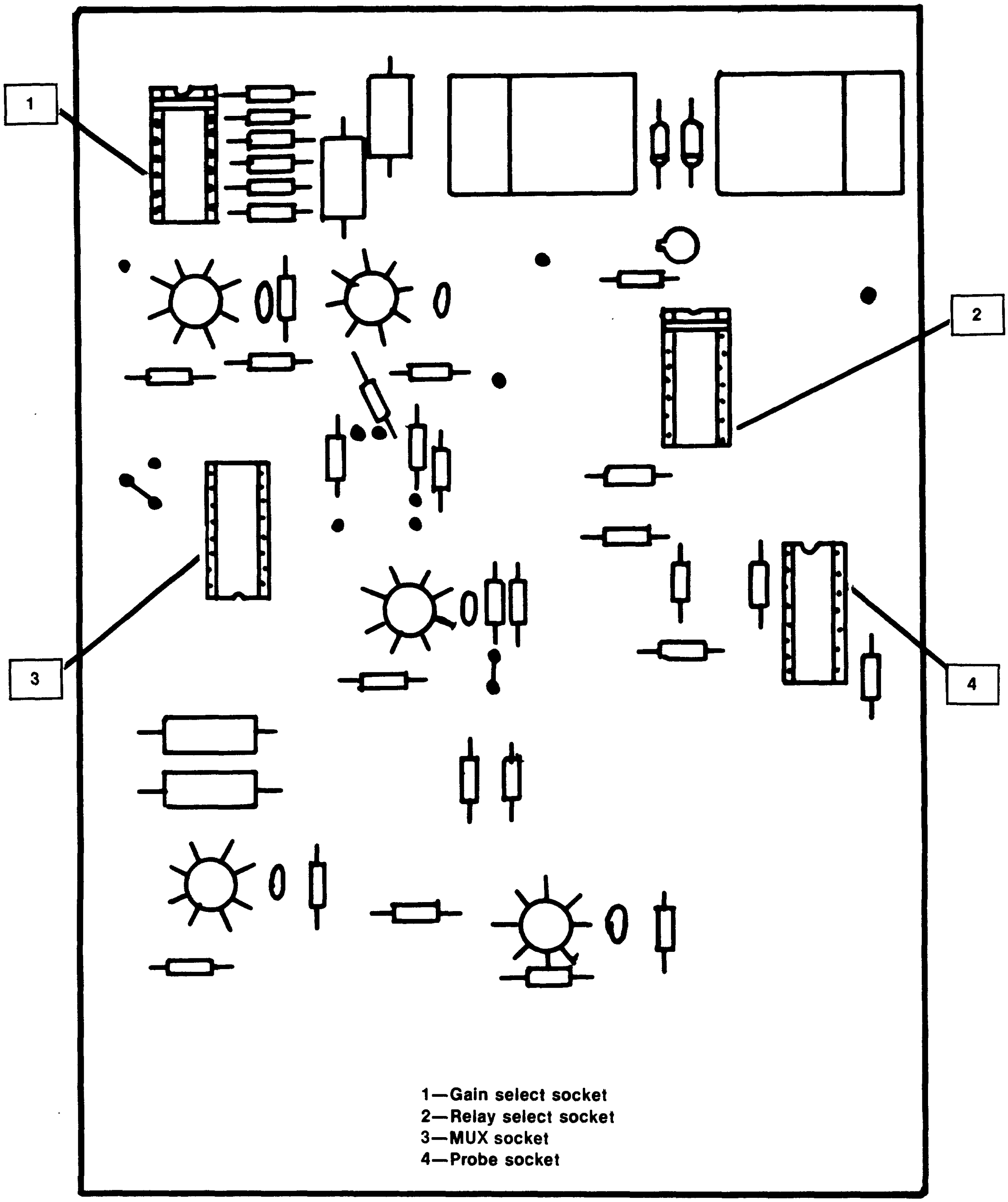



Figure 19.--Voltage signal conditioner.

Examples of some instruments that may be interfaced are

| | |
|---|---|
| Pressure transducers | DO meters |
| Turbidimeters | Ultrasonic Ranger |
| Meteorological sensors | Potentiometers |
| Specific-conductance meters | Bridges |
| pH meters | Metritape (Stage-measurement device) |

Almost any voltage-producing device can be interfaced, provided that its voltage output falls within the specifications of the voltage SIGNAL CONDITIONER.

## Technical Specifications

dc voltage inputs, full scale:

Maximum: 0 to 10 volts or more[1]
Minimum: 0 to 100 millivolts

Input impedance: 1 to 5 megohms

Common-mode input-voltage range: +7 to -4 volts
(Maximum input voltage that can be applied to either input)

Differential input voltage: 100 millivolt to 5 volts full scale

## Applications

Address questions concerning interfacing of the voltage SIGNAL CONDITIONER to any particular device or instrument to the HIF Field Service and Supply Section. Specifications of the device or instrument need to be provided to determine if the device will interface.

The Field Service and Supply Section will prepare the voltage SIGNAL CONDITIONER, making any necessary component adjustments to satisfy the needs of the user.

## Voltage Calibration

After the voltage SIGNAL CONDITIONER has been set up properly for the application, install it in the Minimonitor. See section entitled "Servicing Internal Components of the Minimonitor."

Exercise care in making the correct connections to the external devices or damage may result to the voltage SIGNAL CONDITIONER, the Minimonitor, and the external devices.

---

[1]Consult HIF for higher voltage inputs.

The power that is applied to the device through the relays on the voltage SIGNAL CONDITIONER will, under normal circumstances, be activated when the Minimonitor DO STIR signal comes on as shown in the section entitled "Delay Times." Delay times for the SIGNAL CONDITIONER and the scan-and-record cycles can be set with switch closures on sockets 25A and 24A on the PROGRAMMER BOARD.

Once the voltage SIGNAL CONDITIONER has been installed and the correct connections made, calibrate the Minimonitor as follows:

1. Turn the AUTO-HOLD switch to HOLD and the AUTO-MANUAL SWITCH to MANUAL and, then, the ON-OFF switch to ON. This will power up the Minimonitor and turn on the DO STIR signal. This will also power up the external device if it is connected to the SIGNAL CONDITIONER relay.

   The DISPLAY will be lighted. Use the CHANNEL ADVANCE switch to advance the Minimonitor to the channel occupied by the voltage SIGNAL-CONDITIONER system.

2. Provide a voltage signal from the external instrument or device representing a low or zero input and a voltage signal that represents a value close to full scale.

   If the device is a pressure transducer that provides 0 to 1 volt for a 0- to 10-foot water depth, the pressure transducer would be raised to just below the water surface to provide a voltage signal and then lowered to some known distance less than 10 feet below the surface to provide a voltage signal close to full scale. Adjust the ZERO pot for the low-voltage signal and the SPAN pot for the full-scale voltage signal.

3. Example:

   Pressure Transducer
   0 to 10 feet of water = 0 to 1 volt = 0 to 1,000 Minimonitor DISPLAY units.

| Pressure transducer | Depth (ft) | Voltage (V) | Adjust | Until DISPLAY reads |
|---|---|---|---|---|
| Low signal | 0.10 | 0.010 | ZERO | 000 |
| High signal | 9.50 | .950 | SPAN | 940 |
| High signal | 9.50 | .950 | ZERO | 950 |

If the low signal is not low enough, the ZERO pot will have insufficient range to make the DISPLAY read 000. In this case, either reduce the low signal or adjust the ZERO pot to make the DISPLAY read the equivalent to the low signal and the SPAN pot to read the equivalent to the high signal. Many trial adjustments will have to be made using this method.

4. Example:

A Minimonitor is interfaced to a turbidimeter.
Turbidimeter
0 to 1,000 JTU = 0 to 5 volts dc = 0 to 1,000 Minimonitor DISPLAY units.

| Turbidimeter | JTU | Voltage | Adjust | Until DISPLAY reads |
|---|---|---|---|---|
| Low signal | 0 | 0.00 | ZERO | 000 |
| High signal | 950 | 4.75 | SPAN | 950 |

5. Place the AUTO-MANUAL switch and AUTO-HOLD switch to AUTO. The Minimonitor is now calibrated.

   At the selected time interval, the Minimonitor will come on and power-up the external device and then wait the selected time intervals before turning on the SIGNAL CONDITIONER, scanning, and recording.

**NOTE:** DISPLAY readings of constituent values can range from 000 to 999. Negative values less than 000 will register as 000. Values higher than 999 will show as 000, 001, 002,..., 024. The DISPLAY will register no higher than 024. A DISPLAY reading of 024 indicates an over-range value.

## ULTRASONIC RANGER SPECIFICATIONS, INSTALLATION, CALIBRATION, AND WATER-STAGE CALCULATIONS

The Ultrasonic Ranger is a distance-measuring device that uses ultrasonic pulses to measure distances up to 35 feet from its sensor. The unit has been developed primarily to measure water stage. This section deals with the Ultrasonic Ranger when used with a Minimonitor.

The following components are necessary when the Ultrasonic Ranger is used with a Minimonitor:

- Ultrasonic Ranger with temperature sensor (fig. 20).
- Voltage signal conditioner (fig. 19) and ribbon cable connector if used on Minimonitor.
- Sensor cable (normally 100 feet).
- Minimonitor and recorder.
- Site, mounting brackets, shelter, power, and so forth.

The first three items above will be furnished by the HIF.

Figure 20.--Temperature-compensated Ultrasonic Ranger.

## Technical Specifications

| | |
|---|---|
| Operating Temperature: | -20 to +50 °C. |
| Range: | 35.5 feet maximum.<br>1 foot minimum. |
| Accuracy: | Approximately ±0.1 foot throughout the operating range depending on variations in air temperature in the column of air below the sensor. |
| Resolution: | About 0.05 foot. |
| Output voltage: | 0 to 4.88 volts, 15-milliamperes current maximum.<br>0 volts = 35.5 feet from sensor.<br>4.88 volts = 0.9 foot from sensor.<br>Rising water stage causes increasing output voltage. The output is linear within the operating range or 7.1 feet per volt. |
| Power required: | 11 to 15 volts dc; may be powered separately or with the same source used for companion equipment. |
| Power consumption: | 2.5 amperes for 1 millisecond during each pulse; 55 milliamperes time-averaged. |
| Cable length: | Up to 1000 feet. |
| Divergence angle: | 20 degrees; needs an unobstructed view of the sonic-beam water surface in a circle of about 13-foot diameter when the water surface is 35 feet directly below the sensor. |

| Distance below sensor (ft) | Diameter of field of view (ft) |
|---|---|
| 35 | 13 |
| 20 | 7.3 |
| 10 | 3.6 |
| 5 | 1.8 |

| | |
|---|---|
| Updating: | An initial value is given about 4 seconds after turn-on; then the measurement is updated about every 20 seconds. |
| Survey Minimonitor: | A voltage SIGNAL CONDITIONER is needed in the Minimonitor to operate the Ultrasonic Ranger. |

Range on Minimonitor: Water stage 0 foot = 000 DISPLAY reading.
Water stage 34.6 feet = 692[1] DISPLAY reading.

## Installation

The Ultrasonic Ranger needs to be suspended or mounted with the long axis vertical to the water surface above the unobstructed stream surface at a distance no greater than 35 feet. The Ranger will neither indicate nor measure distances greater than 35.5 feet. The unit may be suspended from a cable, but arrangements must be made to keep sway to a minimum. Position the Ranger's temperature sensor out of the sunlight to provide the best air-temperature measurement. The Ranger may be installed in a steel pipe to protect against vandalism, but the view from the bottom must be unobstructed. Refer to the "Divergence angle," in the preceding Technical Specifications of this section for the unobstructed view dimensions needed by the Ranger.

**CAUTION:** Protect the ultrasonic transducer on the bottom of the Ranger from damage by puncture or other shocks during shipping and transport. Avoid getting water into the transducer. **The transducer is not waterproof.**

Locate the Minimonitor in a shelter near the Ultrasonic Ranger to minimize the length and cost of the sensor cable. Use the standard Minimonitor sensor cable and connectors.

A voltage SIGNAL CONDITIONER that has been prepared especially by the HIF for the Ultrasonic Ranger is required. Do not install a voltage SIGNAL CONDITIONER for the Ultrasonic Ranger that has no label indicating preparation according to specifications.

Install the voltage SIGNAL CONDITIONER as instructed in the section "Servicing Internal Components of the Minimonitor." The SIGNAL CONDITIONER may be installed in any desired channel.

The Ultrasonic Ranger requires at least 4 seconds to provide a reading. If the Ultrasonic Ranger is used in channel 1 of the Minimonitor, a record delay of at least 8 seconds must be set on socket 24A. (See the section entitled "Delay Times.") If the Ultrasonic Ranger is used in channels 2, 3, or 4, the standard 4-second record delay provides sufficient time.

---

[1]This corresponds to a 0- to 50-foot range on the Minimonitor DISPLAY.

## Calibration

The Minimonitor-Ultrasonic Ranger system can be calibrated through the use of a piece of HIF-provided plastic foam and a piece of cardboard or other smooth surface. Access to the Ultrasonic Ranger is necessary.

1. On the Minimonitor, turn the AUTO-HOLD switch to HOLD, the AUTO-MANUAL switch to MANUAL, and then, the ON-OFF switch to ON. This action will power-up the Minimonitor and turn on the Ultrasonic Ranger. With the DISPLAY on, use the CHANNEL-ADVANCE switch to advance the DISPLAY to the channel occupied by the Ultrasonic Ranger.

2. Hold or tape a piece of plastic-foam sponge over the ultrasonic transducer at the lower end of the Ranger. This generates a full-scale reading. Adjust the ZERO pot associated with that channel on the Minimonitor lid until the DISPLAY reads 000. Full scale also can be achieved by pointing the Ranger at the sky. Wait at least 20 seconds for the value to stabilize.

3. Hold or tape a piece of cardboard or other sound-reflective material over the ultrasonic transducer at the lower end of the Ranger. The target must be closer than 0.9 foot from the end of the Ranger. After the value has stabilized, adjust the SPAN pot associated with that channel on the lid of the Minimonitor until the DISPLAY reads 692.

4. Repeat steps 2 and 3 until the desired readings are achieved and the system is calibrated.

Distance in feet from the Ultrasonic Ranger is calculated as follows:

### Minimonitor

$$\text{Distance in feet from Ranger} = 35.5 - \frac{\text{DISPLAY Reading}}{20}$$

$$\text{Distance in feet upwards from a plane 35.5 feet below the Ranger} = \frac{\text{DISPLAY Reading}}{20}$$

## Water-Stage Calculations

Correlation of the Minimonitor DISPLAY and RECORDER readings with water stage (gage height) is achieved in the following manner:

Calibrate the Ultrasonic Ranger and install it within 35.5 feet of the water surface at the lowest expected gage height. Subtract the DISPLAY reading after first dividing it by 20 from the closest outside gage-height reading. This is a constant value that is added to the DISPLAY reading after the DISPLAY reading is converted to feet.

$$\text{Minimonitor-Ultrasonic Ranger gage height, in feet} = \frac{\text{DISPLAY Reading + constant}}{20}$$

where the constant = gage datum outside gage - gage datum Ultrasonic Ranger.

On visits to the gaging station, the calibration is checked by reading the outside gage, reading the Minimonitor DISPLAY, dividing the value by 20, and adding the constant. The calculated gage height from the Ultrasonic Ranger will compare closely with the outside gage reading unless malfunctions occur.

If the stream gage height falls below the gage datum of the Ultrasonic Ranger, the DISPLAY will continue to show 000.

## OPERATION OF THE MINIMONITOR WITH THE LABARGE GOES DATA-COLLECTION PLATFORM

The Minimonitor has been designed to interface to the LaBarge data-collection platform. For operation with the platform, set the following switches to the closed or ON position on the PROGRAMMER card (fig. 3): 26A6, 26A7, 25A3, 25A4, 24A4, and 24A5. All other switches on 24A, 25A, and 26A are open. For more information, see the sections on "Delay Times" and "Setting the Recording Interval." These switch settings will cause the Minimonitor to come on once an hour, wait 48 seconds, turn on the SIGNAL CONDITIONERS, wait 48 seconds more, and record. See the timing diagram, figure 21. Delay times are shown in figure 22.

To connect the Minimonitor to other satellite data-collection platforms, please contact the Electronics group of the Field Service and Supply Section at the HIF for information.

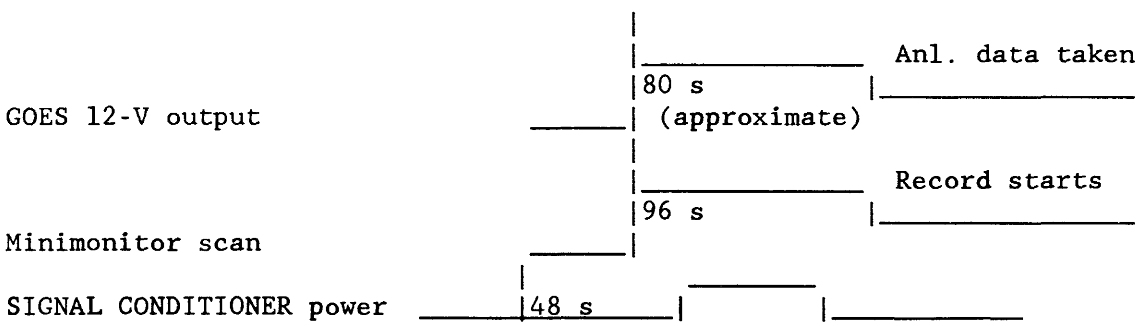



Figure 21.--Timing.

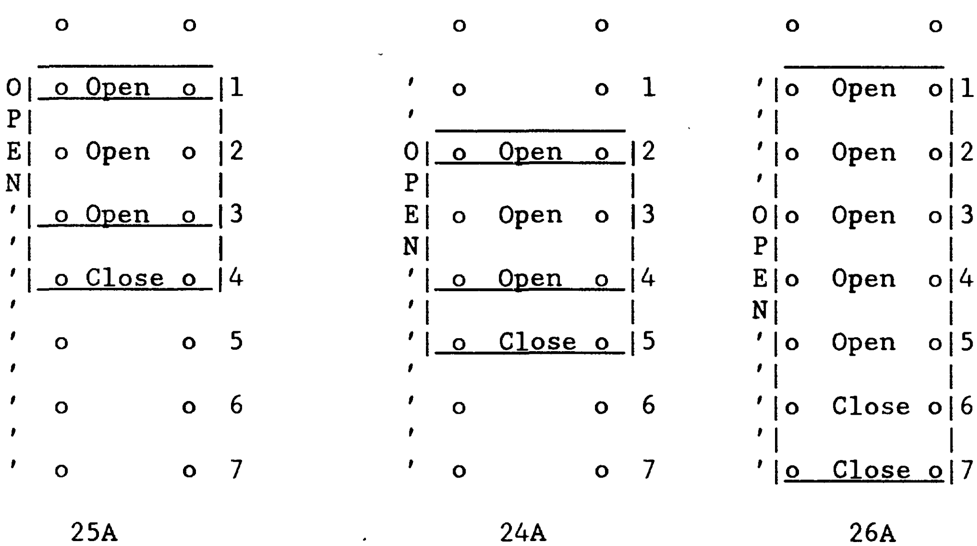



Figure 22.--Delay Times.

The 10-pin analog telemetry jack connects to the platform as follows:

| Minimonitor pin | Function | Platform pin |
| --- | --- | --- |
| A | Channel 1 out (0 to 5 volts) | j |
| B | Channel 2 out ( do ) | z |
| C | Channel 3 out ( do ) | m |
| D | Channel 4 out ( do ) | N |
| E | Channel 5 out ( do ) | AA |
| F | Channel 6 out ( do ) | T |
| G | Channel 7 out ( do ) | U |
| H | Channel 8 out ( do ) | n |
| I | Analog ground | P |
| J | 12 volts switched from platform | A |

After setting the monitor for the proper delays and hooking up the telemetry, perform the following test to verify that the system is working properly:

1. Set the platform on a 6-minute data-acquisition cycle.

2. Advance the Minimonitor through all of the channels and back to 0.

3. Set the Minimonitor time on the DISPLAY to 01.

4. When the 12 volts on the platform activate, the Minimonitor time will reset to 00. Approximately 80 seconds later, the platform will take in the analog data. Ninety-six seconds after the time resets, the scan-and-record cycle will start.

5. The sequence in step 4 will repeat every 6 minutes. One can verify the analog data by reading the data stored in the platform through the platform-test set.

6. When the test is complete, return the platform to its 1-hour data-acquisition time.

To put the system into operation, proceed according to the steps listed:

1. Set the platform to the correct time and set the platform data-acquisition time and Minimonitor recording interval to the same desired length.

2. Advance the Minimonitor through all of the channels and back to zero using the CHANNEL ADVANCE switch.

3. Set the Minimonitor time to 00 on the DISPLAY.

4. The Minimonitor will be triggered by the next data-acquisition cycle of the platform. This will keep the Minimonitor's clock synchronized with the platform's clock.

Table 7 shows the delay times for the programmer when operating on a LaBarge GOES platform when the Minimonitor has a DO system. This table applies when the Minimonitor is operated on a LaBarge GOES platform.

Table 7.--Delay times for programmer when operating on a LaBarge GOES platform with a dissolved-oxygen system on the Minimonitor

| DO Sensor Membrane thickness in mils | Time delays to set in seconds on the PROGRAMMER | |
|---|---|---|
| | Switch 25A | Switch 24A |
| 1 | 64 | 96 |
| [a]2 | 160 | 224 |

[a] For a 2-mil membrane, set the monitor record interval 2 minutes less than required. Example: For a 60-minute record interval, set the monitor record interval to 58 minutes.

## OPERATION OF THE MINIMONITOR WITH THE CR21 MICROLOGGER

The Minimonitor is modified at the HIF for operation with the Campbell Scientific CR21 Micrologger. Proceed according to the steps listed:

1. Remove the following components from the PROGRAMMER card (fig. 3):

   Four solenoid-drive transistor modules located in sockets 1A, 2A, 3A, and 5B, and the motor-drive module in socket 5A.

2. Change the chip in location 20A in the following manner:

   - o Remove chip (4013) from 20A; and
   - o bend chip-pin 9, <u>not</u> board-pin 9, up to the top of the chip and solder a wire between bent-up pin 9 and pin 14; and plug modified chip back into 20A.

3. Set delay times in locations

   25A--to 32 seconds

   24A--to 64 seconds

   26A--to 60 minutes.

The Minimonitor modification for use with the CR21 is done at the HIF. The Minimonitor is started by a signal from any one of four CR21 output control ports and the data is recorded 1 minute later by the CR21.

A special CR21 to Minimonitor interface (fig. 23) is used because the Minimonitor output voltage of 5 volts needs to be reduced to 2 volts. When used with the Minimonitor, no connection is made to the L (low) side of the

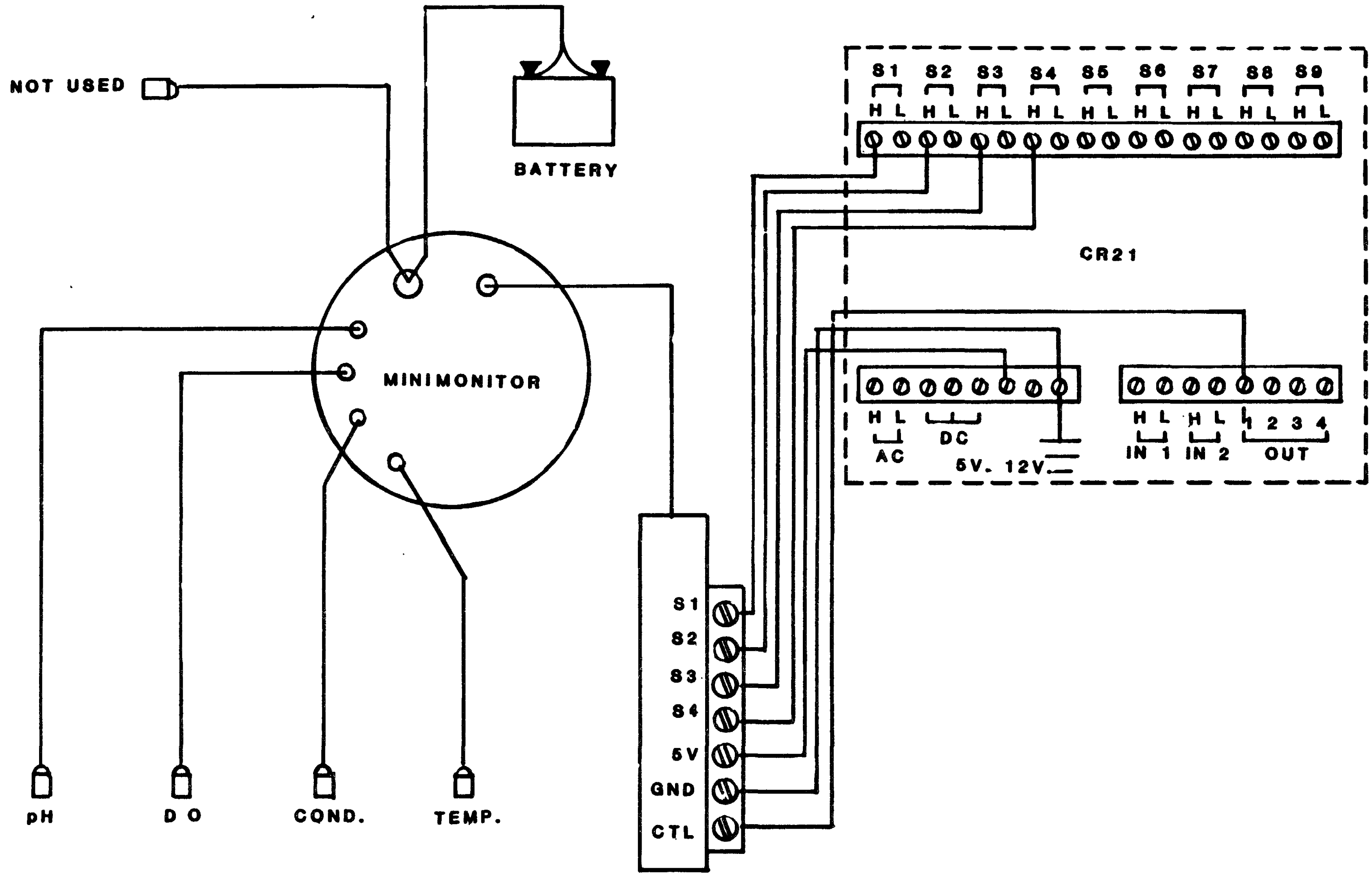



Figure 23.--CR21 to Minimonitor interface.

CR21 sensor inputs because they are 1 volt above the CR21 ground and will be forced to ground through the sensor. The interface is designed to allow the CR21, Minimonitor, and the A21 REL (relay) driver to use the same battery for power. A schematic is shown in figure 24.

The interface will accommodate up to 4 inputs from the Minimonitor through the analog-telemetry connector. The interface to CR21 connections are made with almost any type of wire that is 14 AWG, or smaller, by using screw-type connectors.

**NOTE:** Turn off the Minimonitor while any connections are being made.

**CAUTION:** Make no connections to the L (low) side of the CR21 sensor connectors. **NEVER** allow the 5-volt output voltage from the CR21 to go to ground. When this happens, all data and programs are erased.

## COMMON PROBLEMS AND TROUBLESHOOTING

### Common Problems

Some of the problems that may occur with the Minimonitor system follow:

#### Weak or Dead Battery

If the battery voltage drops below 10 volts, the Minimonitor system may malfunction and record erroneous values, and the recorder may cease operating. Always check the battery voltage first to ensure that the battery is not the source of a problem.

#### Blown Fuses

Two fuses, one on the main power supply and one on the negative power supply, are located in fuse holders in the front panel of the newer model monitors and on the MUX board of older models. When the main fuse is blown, the Minimonitor system is completely inoperable. If the negative fuse blows, parts of the Minimonitor will continue to operate. A blown fuse on the negative supply usually is apparent because the values shown on the DISPLAY are the same for all channels. The reading may even show a value of 024.

A short occurring in the specific-conductance sensor is a common cause of a blown negative fuse After a negative supply fuse has been replaced, unplug the specific-conductance cable before starting the Minimonitor. Turn on the Minimonitor with the specific-conductance cable unplugged. If the Minimonitor operates satisfactorily, then turn off the Minimonitor and plug in the specific-conductance cable; turn the unit on. If the negative supply fuse blows, the specific-conductance sensor is probably shorted.

Malfunctioning signal-conditioner boards may cause blown fuses. Remove all boards and if the Minimonitor operates satisfactorily, then replace the fuses one at a time until the problem board is found.

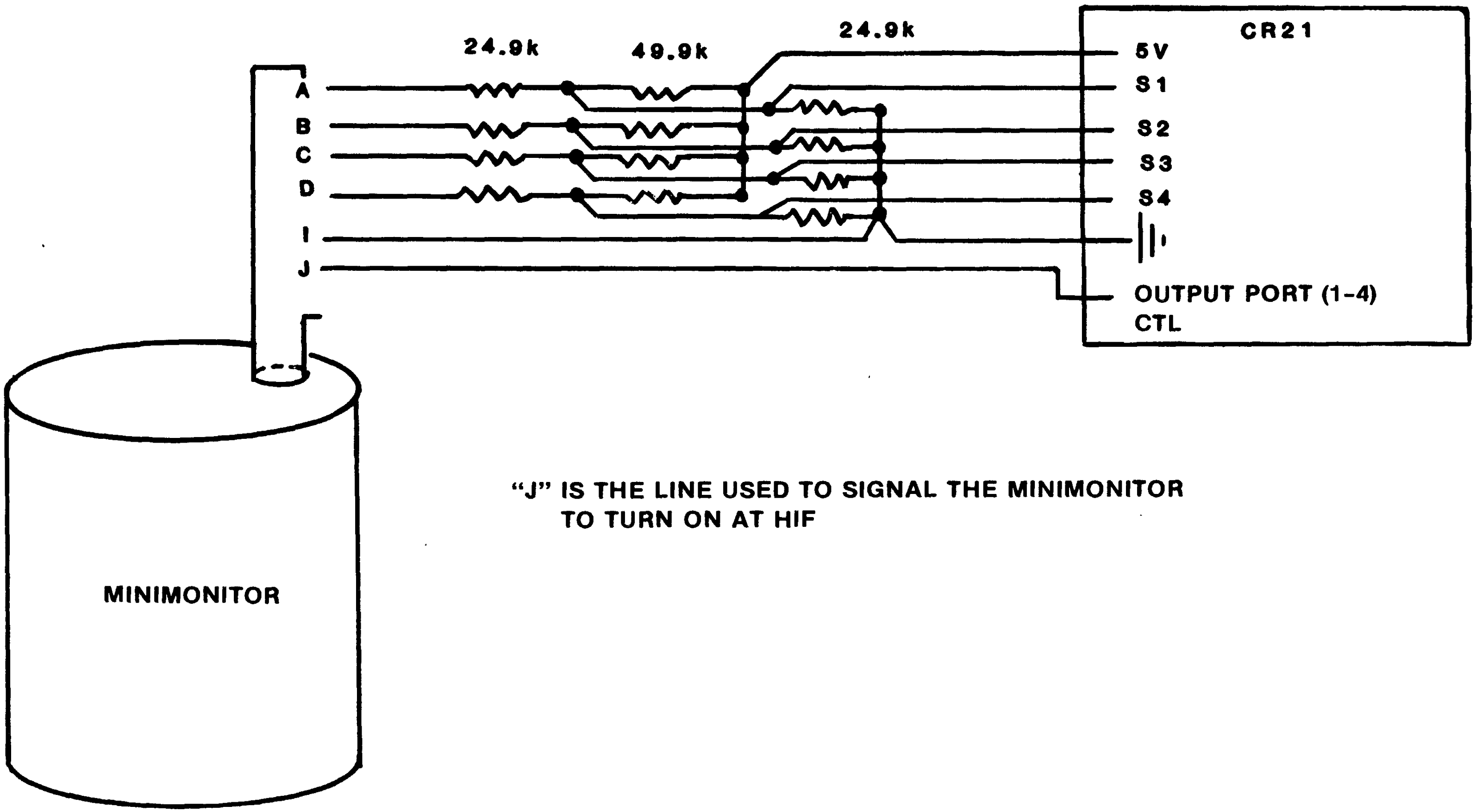



Figure 24.--CR21 to Minimonitor interface schematic.

### Sensor and Cable Connectors Misaligned

Carefully check to determine that sensor and cable connectors have not been improperly aligned and then forced together. This can happen when a new system is installed. If the cables are not plugged in properly, the sensors and SIGNAL CONDITIONERS will not be properly mated, causing malfunctions.

Cables occasionally are cut or abraded, or the underwater connectors leak. These problems usually appear as sensor problems.

### Recorder Malfunctions

On the punched-paper-tape recorders, problems associated with the paper-tape transport system are recorder problems not associated with the Minimonitor. These problems are associated with paper jams, torn tape, and the tape not advancing properly.

Problems associated with the Minimonitor, such as improper values, are difficult to isolate without replacement of the recorder.

### Sensor Failure

Failure of the sensors can usually be determined by replacing the sensor with a new sensor or by using test boxes.

### Electronic-Board Failures

These problems are not easy to isolate unless spare boards are available. Most DISPLAY and recorder and programming malfunctions associated with the Minimonitor can be attributed to the PROGRAMMER board. In some cases, failure of a SIGNAL CONDITIONER can be isolated by the use of test boxes. As a general rule, failure of a PROGRAMMER or MUX board will affect all channels; whereas, in many cases, the failure of a SIGNAL CONDITIONER will affect only that channel.

### Damage in Shipment

In many cases of Minimonitor malfunction, the unit has been jarred or damaged in shipment by rough handling. If a Minimonitor fails to operate when received, open and carefully inspect it for damage or loose connections. A wire may have come loose and replacement of the wire may cause the Minimonitor to operate satisfactorily.

## Troubleshooting

Repair and maintenance of the electronic circuitry in the Minimonitor normally are handled by the HIF. However, it is beneficial for the field personnel to be able to identify Minimonitor, recorder, or sensor failures and, by following instructions in other sections of the manual, be able to:

- Change blown fuses
- Add, remove, or change SIGNAL CONDITIONERS or other boards
- Set switches on electronic boards for delay times, channel selection, and ranges
- Change sensors, Minimonitor, or recorder.

After the problem has been identified and the faulty item isolated, replace the faulty item with a good or operational item and send the faulty item to the HIF for repair.

Ideally, field personnel have a spare Minimonitor, sensors, and recorder. When a malfunction occurs, the spare units can be exchanged until proper operation is achieved. The inoperative or faulty unit is sent to the HIF for repair. If numerous Minimonitors are being operated and serviced, the HIF recommends that a Minimonitor, recorder, and sensors be available as spares to minimize down-time and the subsequent record loss.

Changing Minimonitors, sensors, or recorders can be accomplished at the field location. If it becomes necessary to open the Minimonitor, move the Minimonitor to a warm, dry environment, preferably the office. Exercise extreme care to keep moisture out of the Minimonitor. Instructions are given in other sections of this manual.

If it is not possible to have Minimonitors, sensors, and recorders stocked as spares, the process of troubleshooting becomes more difficult and the station will be out of service during the time the faulty equipment is at the HIF for repair.

Test boxes that will help isolate sensor problems from Minimonitor problems are available from the HIF. Test boxes do not alleviate the need for spare sensors as these are necessary to replace the faulty sensors. If spare sensors are not on hand, additional record will be lost while waiting for new sensors to be shipped.

Test boxes are used in the following manner:

1. Calibrate the Minimonitor signal conditioners in the normal manner.
2. Shut off the Minimonitor and plug in test boxes in place of the sensors or sensor cables. A test box is needed for each type of sensor. A specific-conductance test box cannot be used to test, for example, temperature. This holds true for all types of sensors. Damage to the Minimonitor may result if test boxes are used on the wrong constituent.
3. Turn on the Minimonitor and sequence it through the channels. Note DISPLAY readings for each channel and for various switch positions on the test boxes. See instructions for operation of test boxes.

4. If a drift in calibration is noted on the next station visit after the sensors have been cleaned, the test boxes are again used to generate DISPLAY readings.

5. If these DISPLAY readings agree with those noted on the previous station visit, the problem is with the sensors. If the DISPLAY readings do not agree with those noted on the previous station visit, the problem is with the Minimonitor.

6. The signals generated by the test boxes are approximately equal to certain constituent values. These values can be established by noting the DISPLAY values generated by the test boxes when connected to the calibrated SIGNAL CONDITIONERS. The "calibrated" test boxes can then be used to calibrate a SIGNAL CONDITIONER to the approximate DISPLAY values that would be expected from a sensor when it is placed in a calibrating solution equal to the value of the "calibrated" test boxes.

## Instructions for Operating Test Boxes

The test boxes (figs. 25-29) are used to replace the sensors and to generate fixed values. These fixed values help determine if problems exist in the Minimonitor electronics or in the sensors.

### Operation of the test boxes

Calibrate the Minimonitor for each constituent before operating the test box. THIS IS IMPORTANT.

1. Turn off the Minimonitor and plug in the test boxes in their respective channels. **WARNING:** Make sure the test boxes are plugged into the proper channels; otherwise, damage may result to the electronic circuitry.

2. Turn on the Minimonitor and sequence it through the channels. Read and record the test values generated by the test boxes.

3. These values hold steady from station visit to station visit unless the calibration pots (zero and span) have been adjusted or the electronics have drifted or malfunctioned. Test values stay within +5 DISPLAY units of the original readings. Difference greater than this indicates problems in the electronics.

### Special instructions for each constituent

- Temperature.--Figure 26 shows the temperature test box. Three test values are generated, one for 0 $^{o}$C, one for 25 $^{o}$C, and one for 50 $^{o}$C. The values are approximate. Each test value is generated by successively toggling the switches from OFF to each test value. Use only one switch at a time.

Figure 25.--Minimonitor test box (typical).

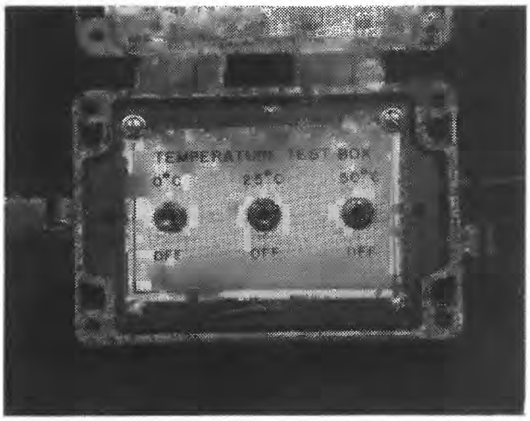



Figure 26.--Temperature test box.

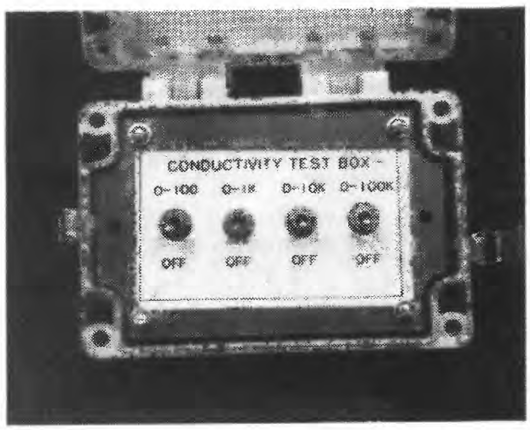



Figure 27.--Specific-conductance test box.

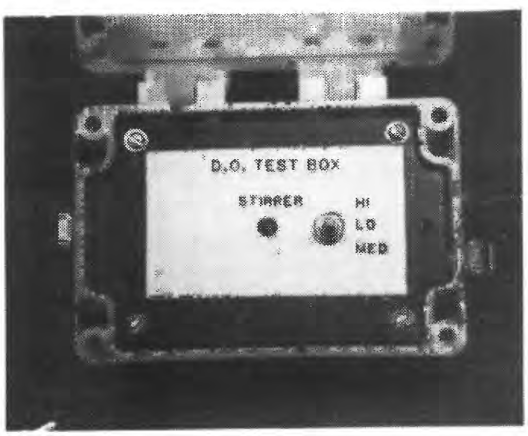



Figure 28.--Dissolved-oxygen test box.

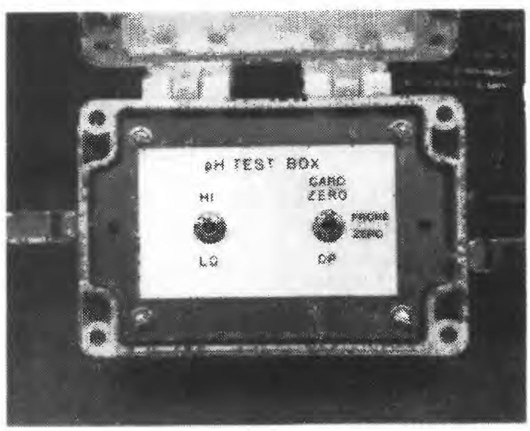



Figure 29.--pH test box.

- Specific conductance.--Figure 27 shows the specific-conductance test box. The OFF position represents zero specific conductance for all switches. Values of specific conductance can be set for any one of four ranges on the Minimonitor by use of a corresponding test switch on the test box. The 0 to 100 switch is used when the Minimonitor specific conductance has been set for the 0 to 100 $\mu$S/cm range and so on. Only one switch is used at a time.

- Dissolved oxygen.--Figure 28 shows the DO test box. The test switch has three positions: LO representing zero DO, MED representing about 10 mg/L DO, and HI representing about 20 mg/L DO. If using the 0-to-10 mg/L DO range, only the LO and MED switch positions can be used. An indicator light provided (STIRRER) will light when the Minimonitor activates the sensor stirrer motor. When the AUTO-MANUAL switch on the Minimonitor front panel (fig. 9) is in the MANUAL position, the light is on. When the switch is in the AUTO position, the light is off. The light also comes on immediately after the front panel SCAN switch is pressed and stays on until the recording cycle is complete.

- pH.--Figure 29 shows the pH test box. Two switches are provided. With the HI-LO switch in HI and the OP-ZERO switch in OP, a pH of about 10.0 units is generated. A LO switch position generates a pH of about 4.0 units. A pH of about 7.0 units is generated with the OP-ZERO switch in the CARD ZERO position. When the OP-ZERO switch is in the sensor ZERO position, a reading of sensor offset can be made.

Special notes

- If a suspicion exists that a cable has been damaged, the test boxes can be used to replace the sensors at the end of the cables after checks have been made at the Minimonitor. Test values are the same at the end of the cables as at the Minimonitor unless the cable has been damaged.

- The test boxes may be used to roughly calibrate the Minimonitor by generating test values instead of placing the sensors in solutions of known values. Follow instructions for the final calibrations.

## SHIPPING THE MINIMONITOR

If the Minimonitor and (or) the recorder need to be returned to the HIF for repair or shipped to another location, take precautions to prevent damage in shipment.

Pack the Minimonitor in a large carton with a minimum of 3 inches of packing such as Styrofoam or other shock-preventive material.

Considerable damage can occur to a Minimonitor shipped in a carton having little or no protective foam packing.

## REFERENCES CITED


Ficken, J.H., and Scott, C.T., 1983, Operating manual for USGS Minimonitor: Hydrologic Instrumentation Facility internal report 6-83-02, 71 p.

Franson, M.A., Ed., 1981, Standard methods for the examination of water and wastewater: American Public Health Association, Washington, D.C., p. 392-393.

Gordon, A.B., and Katzenbach, Max, 1983, Guidelines for use of water quality monitors: U.S. Geological Survey Open-File Report 83-681, 94 p.

Yellow Springs Instrument Co., Inc., 1975, Instructions for YSI 5700 series dissolved oxygen probes: Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio, 2 p.

----1978, Instructions for YSI model 5695 submersible stirrer: Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio, 3 p.

----1979, Instructions for YSI 5675 D.O. monitor service kit used with YSI 5739 dissolved oxygen probe: Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio, 2 p.

# APPENDIX

## INSTRUCTIONS FOR USE OF THE STIRRER AND DISSOLVED-OXYGEN SENSOR USED IN THE MINIMONITOR'S DISSOLVED-OXYGEN MEASURING SYSTEM AND DISCUSSION OF MEASUREMENT ERRORS

Yellow Springs Instrument Company, Inc., Yellow Springs, Ohio, is the manufacturer of the stirrer and dissolved-oxygen (DO) sensor referenced on page 17 in this report and has granted permission to the U.S. Geological Survey to reproduce instructions for these devices in this report.

# INSTRUCTIONS FOR YSI MODEL 5695 SUBMERSIBLE STIRRER

## GENERAL DESCRIPTION

The YSI Model 5695 Submersible Stirrer is designed to be used with the YSI Model 56 Dissolved Oxygen Monitor and Model 5739 Dissolved Oxygen Probe (See Figure 1.)

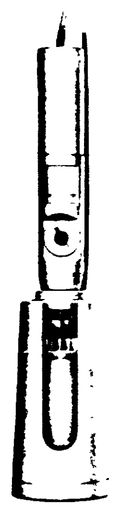


**Figure 1**
**YSI Model 5739 Dissolved Oxygen Probe Mounted in YSI Model 5695 Submersible Stirrer**

It should be used whenever the existing sample velocity is less than one foot per second. The stirrer creates a turbulent sample flow over the probe's sensor membrane. The turbulent flow removes the oxygen-depleted sample and continuously provides a fresh sample to the probe.

The 50' cable supplied with the stirrer also provides electrical connections between the Model 56 Dissolved Oxygen Monitor and the Model 5739 Dissolved Oxygen Probe. Therefore, if the Model 5740 Probe Cable is currently installed with the probe, it must be removed when the stirrer is in use.

## SPECIFICATIONS

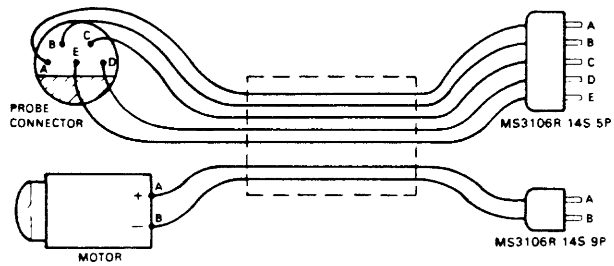
**Power**: 12.5 ±2 VDC, 4 mA

**Cable Length**: 50' (15 m) standard; lengths to 250' are available.

**Motor Life**: 10,000 hours typical

## INSTALLATION AND OPERATION

1. If the probe is attached to a Model 5740 Probe Cable, remove the cable.
2. Remove the sensor guard from the probe.
3. Screw the probe into the stirrer until it bottoms out — about three turns
4. Connect the cable to the probe and the monitor.




5. Place the probe with stirrer into the sample to be measured and turn the monitor to STIR. Check to be sure the stirrer is operating
6. If there is any question about the adequacy of the stirring action, move the operating probe/stirrer up and down in the water at about one foot per second. Observe the dissolved oxygen reading — if it increases while the probe is being moved, stirring speed is probably too slow. Check the impeller, diaphragm, and power supply voltage for possible problems. (See battery pack instructions in the Model 56 Instruction Manual for checking voltage.)

## MAINTENANCE

The dimension between the end of the probe and the stirrer impeller is critical for proper stirring. (See Figure 3.) If

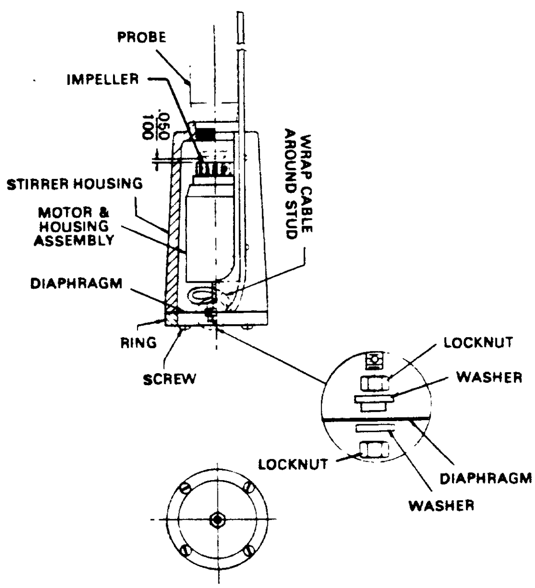



**Figure 3**
**Component Diagram**

necessary to achieve proper spacing, the diaphragm on the bottom of the stirrer can be removed and the impeller and motor assembly raised or lowered by adjusting the locknuts on the motor assembly mounting screw. The motor and housing assembly is sealed at the factory; do not tamper with it.

If the impeller is grossly damaged with one or more broken blades, continued use is not recommended and the motor and housing assembly should be replaced.

## GUARANTEE

All YSI products carry a one-year unconditional guarantee on workmanship and parts, exclusive of batteries. Damage through accident, misuse, or tampering will be repaired at a nominal charge.

If you are experiencing difficulty with any YSI product, it may be returned to an authorized YSI dealer for repair, even if the guarantee has expired. If you need factory assistance for any reason, contact:

Service Department
Yellow Springs Instrument Co., Inc.
P.O. Box 279
Yellow Springs, OH 45387 U.S.A.
Phone: (513) 767-7241
Telex: 20-5437

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# INSTRUCTIONS FOR YSI 5700 SERIES DISSOLVED OXYGEN PROBES

The probes described in this instruction sheet are designed for direct use with YSI Models 51B, 54ABP, 54ARC and 57 Dissolved Oxygen Meters. The probes can also be used with discontinued YSI Models 51A, 54BP and 54RC Dissolved Oxygen Meters when the YSI 5735 Cable Adaptor is employed (See Accessories).

## I. PRINCIPLE OF OPERATION

Each YSI 5700 Series Probe is a complete polarographic system in itself. A thin permeable membrane stretched over the sensor isolates the sensor elements from the environment, but allows gases to enter. When a polarizing voltage is applied across the sensor, oxygen that has passed through the membrane reacts at the cathode, causing a current to flow.

The membrane passes oxygen at a rate proportional to the pressure difference across it. Since oxygen is rapidly consumed at the cathode, it can be assumed that the oxygen pressure under the membrane is zero. Hence, the force causing the oxygen to diffuse through the membrane is proportional to the adsolute pressure of oxygen outside the membrane. If the oxygen pressure increases, more oxygen diffuses through the membrane and more current flows through the sensor. A lower pressure results in less current.

## II. SPECIFICATIONS

Cathode — Gold
Anode — Silver
Membrane — .001" FEP Teflon (.0005" FEP Teflon available)
Electrolyte — Half saturated KCl
Temperature Compensation — (See instrument specifications)
Pressure Compensation — effective to 1/2% of reading over a 100 psi range (230 ft. water)
Response Time — 90% DO value in 10 seconds
Polarizing Voltage — 0.8 volts nominal
Probe Current — Air at 30°C = 19 microamps nominal
Nitrogen at 30°C = .15 microamps or less

## ACCESSORIES AND REPLACEMENT PARTS

YSI 5986 — Diaphragm Kit
YSI 5775 — Membrane and KCl Kit, Standard — includes 2 each 15-membrane packets (.001" thick standard FEP Teflon membranes) and a 30 ml bottle KCl with Kodak Photo Flo.
YSI 5776 — Membrane and KCl Kit, High Sensitivity — includes 2 each 15-membrane packets (.0005" thick FEP Teflon membranes) and a 30 ml bottle KCl with Kodak Photo Flo.
YSI 5945 — "O" ring pack — contains replacement "O" rings for all YSI 5700 Series Probes.

Detachable cable:

| | |
|---|---|
| YSI 5740-10 | 10' cable |
| YSI 5740-25 | 25' cable |
| YSI 5740-50 | 50' cable |
| YSI 5740-100 | 100' cable |
| YSI 5740-150 | 150' cable |
| YSI 5740-200 | 200' cable |

YSI 5735 — Cable Adaptor to mate YSI 5700 Series Probes with discontinued YSI Models 51A, 54BP and 54RC Dissolved Oxygen Meters.
YSI 5486 — Beater Boot Assembly for YSI 5720 Probe.

## III. YSI 5739 DISSOLVED OXYGEN PROBE

The YSI 5739 probe, with built-in lead weight, is an improved design that replaces the discontinued YSI 5418, 5419, 5718 and 5719 probes. (See Figure 1.)

The complete probe consists of the YSI 5739 probe body plus a YSI 5740 detachable cable. The detachable cable is a convenience feature that facilitates changing cable lengths and replacing damaged cables or probes. The probe and cable assembly is held together with a threaded retaining nut. The connection is not designed for casual disconnection and should only be disconnected when necessary.

To disconnect the cable unscrew the retaining nut and slide it down the cable to expose the connector. Pull gently on the cable and connector until the connector comes away from the probe body.

To reassemble, inspect the connector and "O" ring for cleanliness. If the "O" ring is frayed or damaged remove it by squeezing it in the groove causing it to bulge, then roll it out of the groove and off the connector. A replacement "O" ring is supplied with the cable.

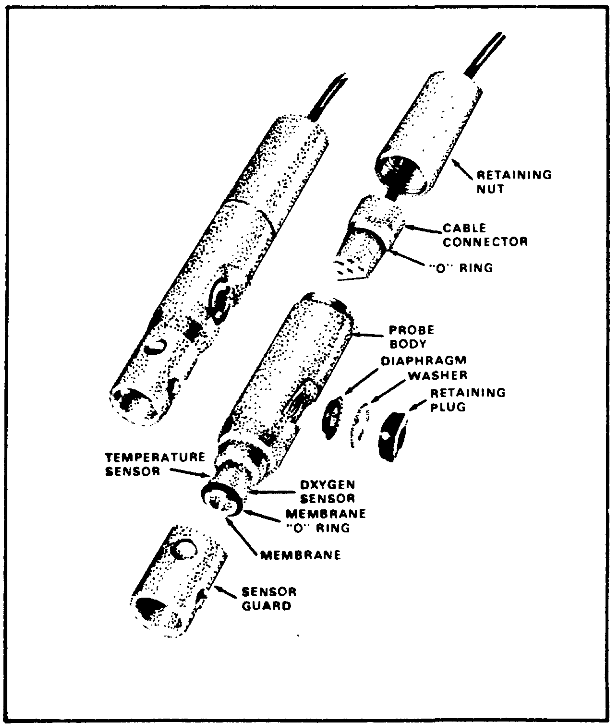


Figure 1

Push the connector into the probe body, rotating it until the two halves mate. A light coating of vaseline or silicone grease on the "O" ring will make reassembly easier. Air trapped between the connector halves which may cause them to spring apart slightly, is normal. Screw on the retaining nut, **hand tight only**. NOTE: If erratic readings are experienced, disconnect the cable and inspect for water. If present, dry out and reconnect, replacing the "O" ring, if necessary.

## PRESSURE COMPENSATION

The vent on the side of the probe is part of a unique pressure compensating system that helps assure accurate readings at great depths of water. Pressure compensation is effective to 1/2% of reading with pressures to 100 psi (230 ft. water). The quantity of air bubbles trapped under the membrane determines how serious the pressure error will be, which is why proper preparation of the probe is essential. The system is designed to accommodate a small amount of trapped air and still function properly, but the amount should be kept to a minimum.

The compensating system normally does not require servicing and should not be taken apart. However, if electrolyte is leaking through the diaphragm or if there is an obvious puncture, the diaphragm must be replaced. Large accumulation of salt crystals around the diaphragm plug may be due to a poorly tightened plug or dirt underneath the diaphragm. Cleaning the parts in water and retightening may be tried before diaphragm replacement. A spare is supplied with the probe. Using a coin unscrew the retaining plug and remove the washer and the diaphragm, flush any salt crystals from the reservoir, install the new diaphragm (convolution side in), replace the washer, and screw in the retaining plug.

## PROBE SCHEMATIC

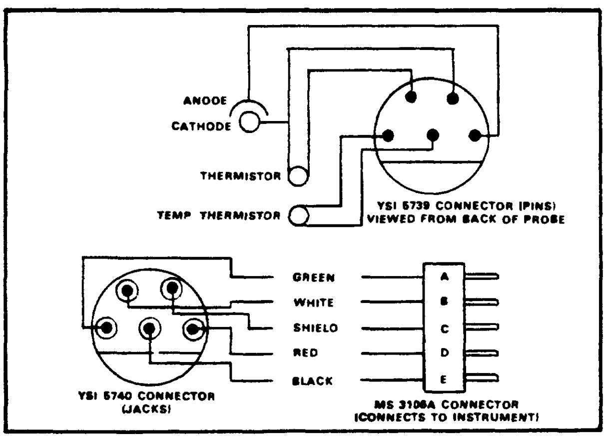


Figure 2

## IV. YSI 5720 B.O.D. BOTTLE PROBE

The YSI 5720 B.O.D. Bottle Probe replaces the discontinued YSI 5420A B.O.D. Bottle Probe for measuring dissolved oxygen and temperature in standard B.O.D. bottles. It is provided with an agitator for stirring the sample solution, available in models for 117VAC (95-135VAC, 50/60 Hz) or 230VAC (190-250VAC, 50/60 Hz) operation. (See Figure 3.)

When using the probe, plug the agitator power supply into line power and the probe plug into the instrument. With the agitator turned off place the tapered probe end into the B.O.D. Bottle and switch agitator "ON" with switch on top of probe. The probe should be operated with a minimum of trapped air in the B.O.D. bottle. A slight amount of air in the unstirred region at the top of the bottle may be neglected, but no bubbles should be around the thermistor or oxygen sensor.

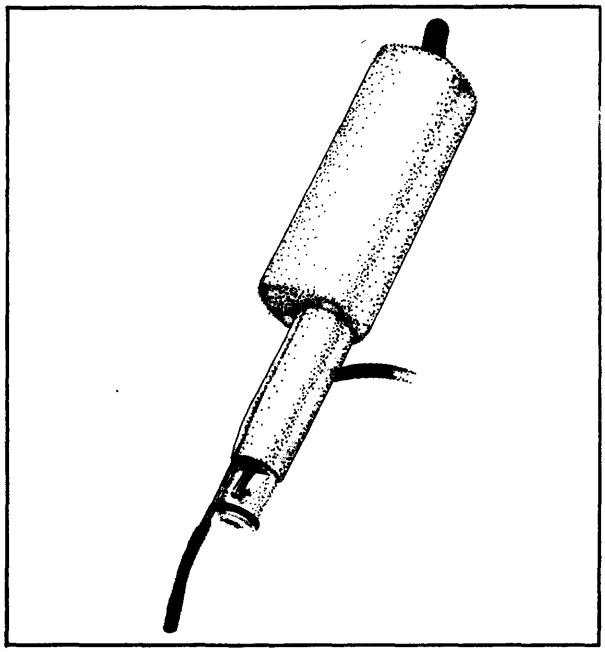

Figure 3

## STIRRER BOOT

The probe uses a flexible stirring boot to transmit motion from the sealed motor housing to the sample. If the boot shows signs of cracking or other damage likely to allow leaking into the motor housing, the boot must be replaced.

In fresh water applications boot life is normally several years, but this may be shortened by exposure to hydrocarbons, moderate to strong acids or bases, ozone, or direct sunlight. For maximum life rinse the boot after use in contaminated samples. (See Figure 4.)

Boot replacement is as follows:

1. Pull off old assembly and clean shaft.
2. Slide on new assembly making sure the back spring is on the grooved area of the shaft. A small amount of rubber cement may be used.
3. Check that there is sufficient clearance between the tip and the end of the shaft to permit turning without binding.

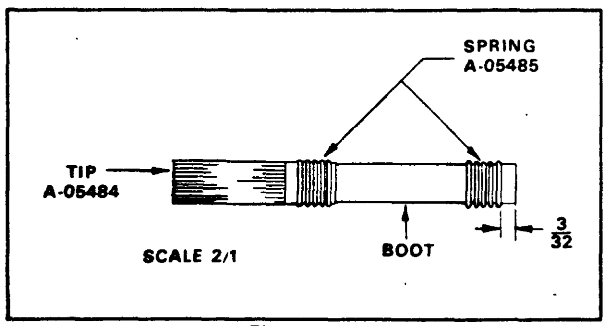


Figure 4

## V. YSI 5750 B.O.D. BOTTLE PROBE

The YSI 5750 B.O.D. Bottle Probe replaces the discontinued YSI 5450 B.O.D. Botte Probe. It is similar to the YSI 5720 B.O.D. Bottle Probe, except that it does not have a stirrer. Agitation of the sample must be provided by other means, such as a magnetic stirrer. (See Figure 5.)

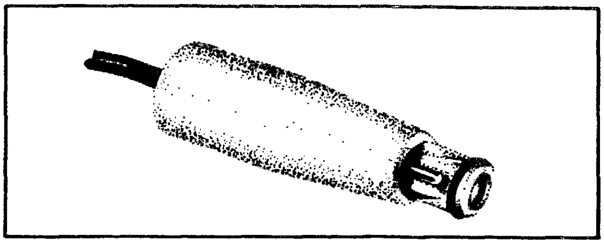

Figure 5

## VI. PROBE PREPARATION AND CARE

1. Prepare the electrolyte by dissolving the KCl crystals in the dropper bottle with distilled water. Fill the bottle to the top.
2. Unscrew the sensor guard from the probe (YSI 5739 only) and then remove the "O" ring and membrane. Thoroughly rinse the sensor with KCl solution.
3. Fill the probe with electrolyte as follows:
   ALL PROBES ARE SHIPPED DRY — YOU MUST FOLLOW THESE INSTRUCTIONS
   A. Grasp the probe in your left hand. (See Figure 6.) When preparing the YSI 5739 probe the pressure compensating vent should be to the right. Successively fill the sensor body with electrolyte while pumping the diaphragm with the eraser end of a pencil or similar soft, blunt tool. Continue filling and pumping until no more air bubbles appear. (With practice you can hold the probe and pump with one hand while filling with the other.) When preparing the YSI 5720 and 5750 probes, simply fill the sensor body until no more air bubbles appear.
   B. Secure a membrane under your left thumb. Add more electrolyte to the probe until a large meniscus completely covers the gold cathode. NOTE: Handle membrane material with care, keeping it clean and dust free, touching it only at the ends.
   C. With the thumb and forefinger of your other hand, grasp the free end of the membrane.
   D. Using a continuous motion **STRETCH** the membrane **UP, OVER**, and **DOWN** the other side of the sensor. Stretching forms the membrane to the contour of the probe.
   E. Secure the end of the membrane under the forefinger of the hand holding the probe.
   F. Roll the "O" ring over the end of the probe. There should be no wrinkles in the membrane or trapped air bubbles. Some wrinkles may be removed by lightly tugging on the edges of the membrane beyond the "O" ring.
   G. Trim off excess membrane with scissors or sharp knife. Check that the stainless steel temperature sensor is not covered by excess membrane.
4. Shake off excess KCl and reinstall the sensor guard.
5. A bottomless plastic bottle is provided with the YSI 5739 probe for convenient storage. Place a small piece of moist towel or sponge in the bottle and insert the probe into the open end This keeps the electrolyte from drying out. The YSI 5720 and 5750 probes can be stored in a B.O.D. bottle containing about 1" of water.
6. Membranes will last indefinitely if properly installed and treated with care during use. The result of poor membrane application or damage is erratic readings. The cause of erratic behavior can be loose, wrinkled or fouled membranes (by algae for example), or bubbles in the probe from electrolyte loss. If any of these signs occur it is good practice to thoroughly flush the reservoir with new KCl and replace the membrane.
7. "Home brew" electrolyte can be prepared by making a saturated solution of reagent grade KCl and distilled water, and then diluting the solution to half strength with distilled water. Adding two drops of Kodak Photo Flo per 100 ml of solution assures good wetting of the sensor, but is not absolutely essential.
8. The gold cathode should always be bright and untarnished. To clean, wipe with a clean lint-free cloth or hard paper NEVER USE ANY FORM OF ABRASIVE OR CHEMICAL Rinse the sensor several times with KCl, refill, and install a new membrane.
9. Some gases contaminate the sensor, evidenced by discoloration of the gold. If the tarnish cannot be removed by vigorous wiping with a soft cloth, lab wipe, or hard paper, return the probe to the factory for service.
10. $H_2S$, $SO_2$, Halogens, Neon, and CO are interfering gases. If you suspect erroneous readings, it may be necessary to determine if these are the cause.
11. If the probe has been operated for extended periods with a loose or wrinkled membrane the gold cathode may become plated with silver. In this event return the probe to the factory for refinishing.

## VII. GUARANTEE AND REPAIR

All YSI products carry a one-year unconditional guarantee on workmanship and parts, exclusive of batteries. Damage through accident, misuse, or tampering will be repaired at a nominal charge, if possible, when the item is returned to the factory or to an authorized YSI dealer.

If you are experiencing difficulty with any YSI product, it may be returned for repair, even if the guarantee has expired. YSI maintains complete facilities for prompt servicing of all YSI products.

Yellow Springs Instrument Co., Inc.
Service Department
P.O. Box 279
Yellow Springs, Ohio, 45387, U.S.A.
Phone: 513-767-7241

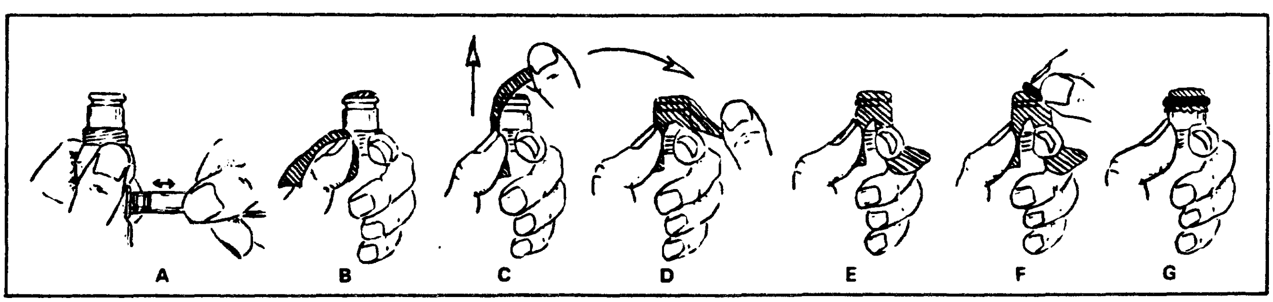


Figure 6

# INSTRUCTIONS FOR YSI 5675 D.O. MONITOR SERVICE KIT USED WITH YSI 5739 DISSOLVED OXYGEN PROBE

**GENERAL DESCRIPTION**

The YSI 5675 D.O. Monitor Service Kit contains supplies for preparing YSI 5700 series dissolved oxygen probes for extended time interval dissolved oxygen monitoring.

The kit contains two 15-membrane packets of 0.002"-thick FEP, half-sensitivity membranes, one 30 ml bottle of KCl crystals for preparation of electrolyte, and a special probe contouring tool.

The half-sensitivity membranes alter the probe's operating characteristics, making the probe more suitable for extended interval use. The probe contouring tool alters the normal 5700 series D.O. probe electrode surface finish for optimum use with the half-sensitivity membranes. The tool also functions as a probe cleaning device to remove accumulated silver deposits from the probe's cathode following extended interval probe use. Cathode cleaning is normally required after 2000 hours of probe use or whenever silver is visible on the gold cathode.

**PROBE SPECIFICATIONS**
**(when prepared with YSI 5675 Service Kit):**

Cathode: Gold

Anode: Sintered silver

Membrane: 0.002"-thick FEP Teflon

Electrolyte: 0.5 Saturated KCl with Photoflo®

Pressure Compensation: Effective 0.5% of reading to 100 PSI

Response Time: 60 seconds to 90%

Polarizing Voltage: 0.65

Probe Current: 7.5 μA in air @ 760 mmHg, typical @ 25°C; less than 0.05 μA in nitrogen

Liquid Flow Rate Across Membrane For Accurate D.O. Readings: 1-5 feet/second

Probe Calibration Stability: Calibration shifts less than 3% of reading per week of operation in water following warm up at 0-30 °C; ± 5% at 30-45 °C.

Thermistors: (2) YSI 44004

**USING THE YSI 5675 MONITOR SERVICE KIT**

For optimum monitoring performance, prepare your YSI D.O. probe with one of the half-sensitivity membranes included in the YSI 5675 Service Kit. For optimum stability, contour and clean the probe's gold sensing surface with the sanding tool included in the service kit. These instructions detail both operations:

1. Prepare the electrolyte provided in the service kit by dissolving the KCl crystals in the dropper bottle with distilled water. Fill the bottle to the top.
2. Unscrew the sensor guard from the probe and remove the "O" ring and membrane. Thoroughly rinse the sensor with distilled water.
3. Prepare the probe for use with the half-sensitivity membrane.

- Lightly pencil an "X" across the probe's gold sensing surface. (See Figure 1.)
- Wet the specially contoured sanding tool.
- Hold the sanding tool's abrasive face uniformly against the probe's sensing surface (see Figure 2) and slowly rotate the tool in a circular fashion until all traces of the pencil mark are removed.
- Use the tool to slightly radius the outer edge of the probe face. (See Figure 3.)
- *Rinse probe surface with distilled water to remove all particles.*

**NOTE:** If a probe has been in use for some time and the gold cathode appears tarnished or shows a slight silver ring on the inner edge, it should be restored by sanding as described in Step 3.

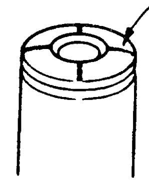


**Figure 1 — Penciled X on the probe surface**

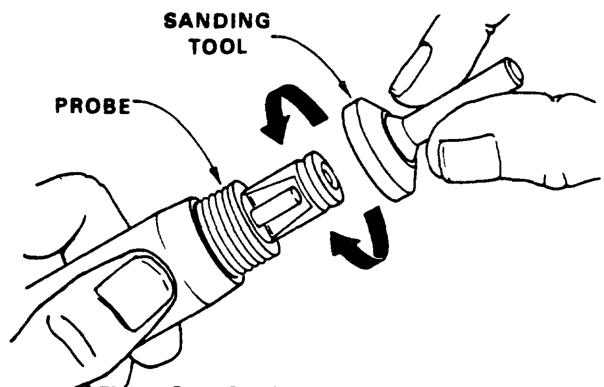


**Figure 2 — Sanding the probe surface**

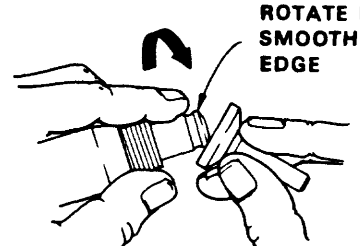


**Figure 3 — Smoothing the edge**

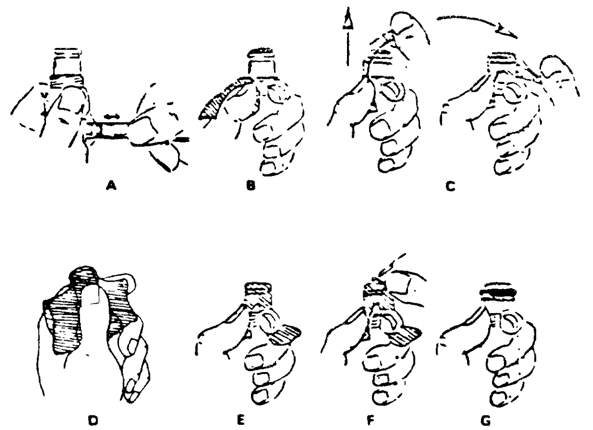

**Figure 4 — Putting the membrane on the probe**

4. Fill the probe with electrolyte. (See Figure 4.):
   - Grasp the probe in your left hand . . . the pressure compensating vent should be to the right.
   - Fill the sensor body with electrolyte while pumping the diaphragm with the eraser end of a pencil or similar soft, blunt tool.
   - Continue filling and pumping until no more air bubbles appear. (With practice you can hold the probe and pump with one hand while filling with the other.)
5. Secure a half-sensitivity membrane under your left thumb. Add more electrolyte to the probe until a large meniscus completely covers the gold cathode. (Figure 4B).

   **NOTE:** Handle membrane material with care . . . keep it clean and dust free . . . touch it only at the ends.
6. With the thumb and forefinger of your other hand, grasp the free end of the membrane.
7. Using a continuous motion, *stretch* the membrane Up, OVER and DOWN the other side of the sensor. Stretch DOWN until the membrane "cap" forms smoothly over the "O" ring groove.
8. Secure the end of the membrane under the forefinger of the hand holding the probe. (Figure 4E.)
9. Roll the "O" ring over the end of the probe There should be no wrinkles in the membrane or trapped air bubbles Some wrinkles may be removed by lightly tugging on the edges of the membrane beyond the "O" ring. (Figure 4F.)
10. Trim off excess membrane with scissors or sharp knife Check that the stainless steel temperature sensor is not covered by excess membrane (Figure 4G.)
11. Shake off excess KCl and reinstall the sensor guard.
12. A bottomless plastic bottle is provided with the YSI 5739 probe for convenient calibration. Place a small piece of moist towel or sponge in the bottle and insert the probe into the open end. This keeps the electrolyte from drying out.

Membranes will last indefinitely, depending on usage Average replacement is 2-4 weeks. However, should the electrolyte be allowed to evaporate and an excessive number of bubbles form under the membrane or the membrane becomes damaged, thoroughly flush the reservoir with KCl and install a new membrane. Also replace the membrane if erratic readings are observed or calibration is not stable.

User-made electrolyte can be prepared by making a saturated solution of reagent grade KCl and distilled water and then diluting the solution to half strength with distilled water. Adding two drops of Kodak Photoflo® per 100 ml of solution assures good wetting of the sensor.

**GUARANTEE**

All YSI products carry a one-year unconditional guarantee on workmanship and parts, exclusive of batteries. Damage through accident, misuse, and tampering will be repaired at a nominal charge.

If you are experiencing difficulty with any YSI product, it may be returned to an authorized YSI dealer for repair, even if the guarantee has expired. If you need factory assistance for any reason, contact:

Service Department
Yellow Springs Instrument Co., Inc.
PO Box 279
Yellow Springs, OH 45387 USA
Phone: (513) 767-7241
Telex: 20-5437

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## DISCUSSION OF DISSOLVED OXYGEN

Following is a discussion of measurement errors that the Yellow Springs Instrument Company provides with its Model 56 DO Monitor. Not all of the errors apply to the Minimonitor, especially those associated with instrument-component errors. However, the discussions of all errors are included to better understand the propagation of errors.

### Instrument Component Errors

- Recorder linearity
  Error = +0.5 percent of full scale of measurement range.

- Range-to-range error
  Switching from 0 to 100 percent to the 10 ppm range.
  Error = 0
  Switching from 10 ppm range to the 0 to 5 or 0 to 20 ppm range.
  Error = +1 percent of reading

- Temperature coefficient (zero setting)
  Error = +0.05 percent for each degrees Celsius difference from 25 °C of the full-scale value of the measurement range.

### Nonideal Sensor Behavior

- Background signal varies with sensor temperature. See sensor background error below.

- Temperature-compensation uncertainty
  Error = 0 if readings are taken at the calibration temperature.

  Error = +1 percent of reading if readings are taken with +5 °C of the calibration temperature.

  Error = +3 percent of reading for all other conditions.

Sensor Background Error

| Error ppm | Error 0 to 100 percent | Temperature (C°) |
|---|---|---|
| 0.28 | 1.9 | 0 |
| 0.14 | 1.2 | 10 |
| 0.07 | 0.8 | 20 |
| 0.04 | 0.6 | 30 |
| 0.02 | 0.4 | 40 |

**NOTE:** Use of the YSI STANDARD membranes reduces these errors by 50 percent.

## Sensor-Calibration Uncertainty

- Barometric pressure effect.--If normal barometric pressure is assumed (+0.5 inch or 12 mm(Hg))
  Error = 1.7 percent of reading

- Altitude effect.--If altitude is estimated +500 feet,
  Error = +1.8 percent of reading

  **NOTE:** The two errors above are eliminated if accurate true barometric-pressure data are available.

- Calibration drift with time.--Calibration may drift +3 percent of reading over a 7-day period in 0- to 30-$^{\circ}$C samples. In 30- to 45-$^{\circ}$C samples, calibration may drift +5 percent. Actual drift during a run can be checked by a postmeasurement-calibration check.

  **NOTE:** In the discussion of measurement errors, YSI uses concentrations of DO expressed in ppm. For all practical purposes, concentrations expressed in ppm are equivalent to mg/L.

## Example of a Typical Error Calculation

The following example represents a typical error calculation for a 1-week period of data collection.

DATA: Instrument calibrated with a 20-$^{\circ}$C sensor on the 0 to 100 percent air saturation range, elevation estimated at 2000 feet ±500 feet, normal barometric pressure presumed. Readings taken on the 0- to 10-ppm scale. Highest sample temperature 25 $^{\circ}$C. Lowest sample temperature 15 $^{\circ}$C. Ambient instrument air temperature: from 10 to 30 $^{\circ}$C. Error calculated for a reading of: 6 ppm at 21 $^{\circ}$C.

| Description | Calculation | | Error ppm |
|---|---|---|---|
| Linearity | +0.005 by 10 ppm | = | 0.05 |
| Range to range | 0 | = | - - |
| Temperature Coefficient (zero) | (25 to 10 $^{\circ}$C) by 0.0005 by 10 ppm | = | 0.08 |
| Background | at 20 $^{\circ}$C | = | 0.07 |
| Temp. comp. | 0.01 by 6 ppm | = | 0.06 |
| Barometer | 0.017 by 6 ppm | = | 0.10 |
| Altitude | 0.018 by 6 ppm | = | 0.11 |
| Drift | 0.03 by 6 ppm | = | +0.18 |
| | Maximum possible error | | 0.65 ppm |

It is unlikely that errors will sum to produce the maximum possible error. It is more likely that some errors will oppose others to produce a statistical error approximating a root-mean-square error of about one-half the maximum possible error, or about 0.3 ppm.

# ERRATA

The warning on page 6 of Open-File Report 88-491, "Operating manual for the U.S. Geological Survey Minimonitor, 1988 revised edition, punched-paper-tape model," should read as follows:

**WARNING:** The internal wiring and circuits are not designed to withstand rough handling. Changes to internal settings are best made carefully indoors under dry, warm conditions and with fresh desiccant added. Internal settings usually are **not** changed in the field.