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Techniques of Water-Resources Investigations
of the United States Geological Survey

Book 8 Chapter A2

INSTALLATION AND SERVICE MANUAL FOR U.S. GEOLOGICAL SURVEY MANOMETERS

By J. D. Craig

Book 8
Instrumentation

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PREFACE

The series of manuals on techniques describes procedures for planning and executing specialized work in water-resources investigations. The material is grouped under major subject headings called "Books" and further subdivided into sections and chapters. Section A of Book 8 is on instruments for measurement of water level.

The unit of publication, the Chapter, is limited to a narrow field of subject matter. This format permits flexibility in revision and publication as the need arises. Chapter A2 deals with installation and servicing of U.S. Geological Survey manometers.

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INSTALLATION AND SERVICE MANUAL FOR U.S. GEOLOGICAL SURVEY MANOMETERS

By J. D. Craig

ABSTRACT

The purpose of this manual is to describe the installation, operation, and maintenance of the bubble-gage manometers currently (1982) used by the U.S. Geological Survey. Other applications of these devices, such as the long manometer and differential manometer, are discussed, and accessories available for them are described.

The bubble gage (water-stage manometer with gas-purge system) described in the Installation and Service Manual, October 1962, has been extensively modified and developed into the STACOM (stabilized and temperature compensated) device. This chapter is the manual for the STACOM unit and an update of the manual for the screw-type bubble gage. A parts list is included for both units.[1/]

GENERAL DESCRIPTION OF THE MANOMETERS

The manometers operate on the principle that a difference in pressure between ends of the manometer displaces the free surface of a liquid-mercury column. Displacement of the liquid mercury develops a head sufficient to balance the pressure. The pressure-cup reservoir on the manometer is driven by a servo motor, actuated by a float switch, to a position that develops a sufficient height of mercury to balance the pressure. The float switch operates within a narrow lead band and actuates the motor until a null position is developed when the pressure is balanced. Activitation of the float switch is a direct consequence of movement of the free surface of mercury when pressures across the manometer change as a result of variations in stream level. A counter displays the stage (height), in feet of water, which is recorded on an analog or digital recorder or both. The manometer assembly converts the pressure in the sensing element of the gas-purge system to a shaft rotation, which drives the stage-indicating and recording mechanisms.

Pressure transmitted through the manometer tubing to the pressure-cup reservoir is developed at a bubble orifice placed in the stream. When a gas is supplied through the tubing and bubbles freely into the stream through an orifice at a fixed elevation, pressure in the tubing is equal to the pressure head at the bubble orifice. Minor differences due to variation in the weight of gas and friction of the flowing gas in the connecting tubing result in small errors in the pressure. The gas-purge system provides a means of transmitting the pressure head of water above the orifice to the manometer. The dynamic purge provided by the continuous formation of bubbles avoids discrepancies of locked-system temperature effects. This principal is utilized to transfer pressure head caused by stream stage to the recording equipment in the gaging station, which is installed at a location above expected flood levels.

The servo-control unit provides the amplification necessary for the sensitive float

[1/] Part numbers in this manual refer to drawing dated Oct. 21, 1971, for STACOM, and Sept. 1, 1959, for screw type.

switch to control operation of the motor. Amplification is needed because pressure on the float-switch contacts otherwise is too light to provide enough electric current to operate the motor. Such sensitivity is required to detect changes in mercury level of only a few thousandths of an inch. The servo-control unit also provides a delay circuit to dampen pressure surges that often result from surface waves or water-velocity disturbances. The circuit locks the manometer drive during punching of the paper tape on the digital recorder. The delay circuit also eliminates undesirable "painting" of analog-recorder charts and contributes to longer periods of satisfactory operation.

Recording equipment used with the manometer can be any type of analog or digital water-stage recorder. Those units with suitable sprocket ratios or jack shafts can be chain driven by the manometer unit. The two drive sprockets regularly furnished are designed to permit coupling to the Leupold & Stevens digital recorder, the Leupold & Stevens continuous recorder Model A-71, and the Fischer & Porter digital recorder Series 1542.

THE STACOM MANOMETER

The U.S. Geological Survey manometer (bubble gage) was first introduced in 1956, but fewer than 100 were installed in the next several years. The manometer would have failed and been forgotten except for the men in a few field offices who were determined to make it work because it was the only viable alternative to a stilling well.

Frustration and disappointment prevailed until 1961, when a more reliable mercury-wetted servo control was introduced. Although far from perfect, this control improved operation and allowed more detailed analysis of other manometer problems. Thus, during 1961-67, several accessories for improved operation were offered, used, and subsequently required on procurements of new manometers.

During 1963-67, several commercial versions of all-solid-state servo controls were tried with fair to poor results. However, in 1968 an in-house-designed, ramp-start, solid-state servo control was introduced that significantly improved record collection. In fact, the new control unit avoided a decision to adopt a much more expensive and complicated pickup system that had been designed to eliminate nagging problems with "loss of sensitivity."

Through the development years, the hydrographers responsible for record collection suggested a multitude of devices or changes. Although many of these suggestions were not feasible or economical, the general tone of the complaints was considered very carefully. Consequently, design of a new manometer that would satisfy the complaints and further improve operation was begun in 1969, and testing was done in 1971.

The new U.S. Geological Survey STACOM manometer is the first significant model change since introduction of the bubble-gage manometer in 1956. The word STACOM is derived from the two words--STAbilized and temperature COMpensated. This title will also clearly distinguish it from the original screw-type manometer.

The threaded shaft has been replaced either with a cable belt and sprocket-drive system (earlier STACOM models) or a roller chain (later STACOM models). The motor-drive assembly is pivoted and can

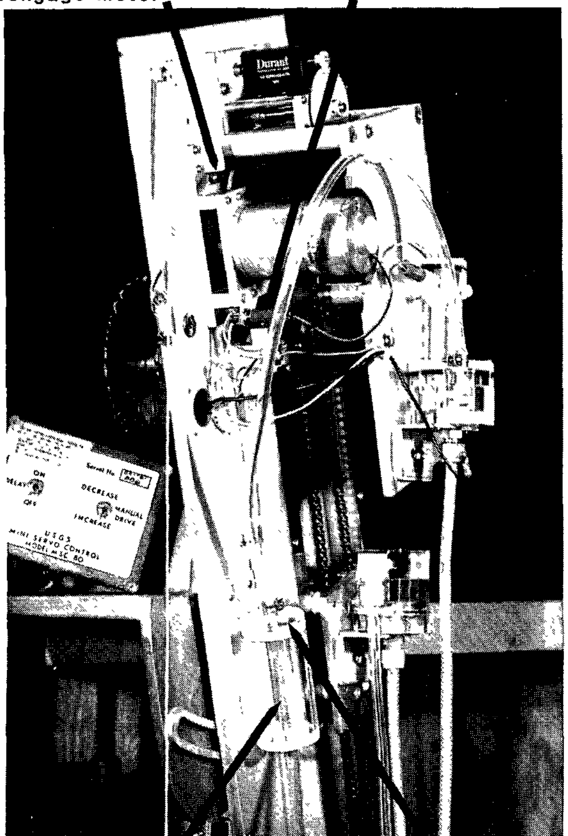


Figure 1.--STACOM manometer drive system.

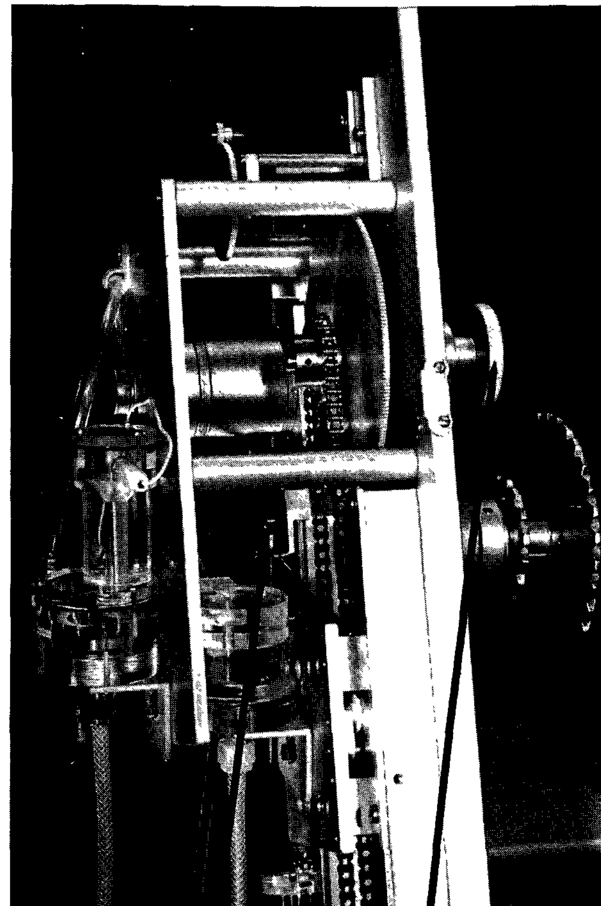


Figure 2.--Pressure reservoir traverse system.

be uncoupled by loosening one screw (fig. 1) and moving the platform to the left until the motor-drive gear is disengaged. The pressure reservoir (moving cup) can then be caused to traverse the entire vertical distance quickly with a few turns of the hand knob (fig. 2) at the rear of the manometer backplate.

The counter remains synchronized throughout this traverse, so any datum that had been established is not lost. Guide rails direct the path of the pressure reservoir. Less power is required by the new drive system to move the reservoir due to lower friction and, more importantly, less variation in friction.

Temperature Compensation

All uncorrected mercury manometers of the type used by the Geological Survey have an error of 0.01 percent per degree Fahrenheit change in temperature due to changes in specific gravity of the mercury with temperature. Unless high heads and rapid changes in temperature occur, this error is probably not noticed, as it is corrected for gradually during regular visits to the station when the manometer is reset to the outside gage reading. When a high degree of accuracy is required, the error can be reduced to less than 0.001 percent per degree Fahrenheit by adding an optional correcting device to the STACOM manometer.

The ambient-temperature-correcting device varies the angle of the manometer with the vertical in direct proportion to the temperature change. To prevent affecting the base datum, the two mercury reservoirs must be perfectly alined front to rear (fig. 2), so that both subscribe identical arcs about the pivot point at manometer zero. To check for accuracy of reservoir alinement, the counter must remain at zero throughout the full excursion of manometer-angle adjustment with the pressure reservoir open to the atmosphere. (This requirement prevents the original manometers from being modified in a practical way to compensate for temperature errors.)

The temperature-correcting device is a self-contained servo package (fig. 3) that samples the manometer backplate temperature each minute, corrects the manometer angle if necessary, and then shuts off until the next minute. The device has a visual counter readout in degrees Celsius and operates from two 6-volt lantern batteries for a year or more. The temperature-correcting device is recommended only for models designed for stage changes of 75 feet or more.

The preceding discussion reveals that manometer angle (when measuring water head with gas purge) is really a function of temperature; therefore, the most commonly used angle adjustment index should be engraved on the fold-out arm in degrees of temperature.

This angle determination is accomplished with a fold-out arm and plumb bob with string (fig. 4), both fastened at predetermined points on the manometer backplate. With the arm extended and the plumb bob in place, the string hangs across the temperature index (fig. 5), which is calibrated with marks at 5-degree-Fahrenheit intervals (degrees Celsius if automatic temperature correction is used). On a standard manometer, a manually adjusted screw is used (fig. 6) to set the angle to whatever the local average ambient temperature is estimated to be. Obviously one or more seasonal changes can be made to decrease errors due to extreme temperature changes. On 1981 later and models, a level bubble has been added to the upper left-hand corner on the backplate to set the gage (the same as the screw-type

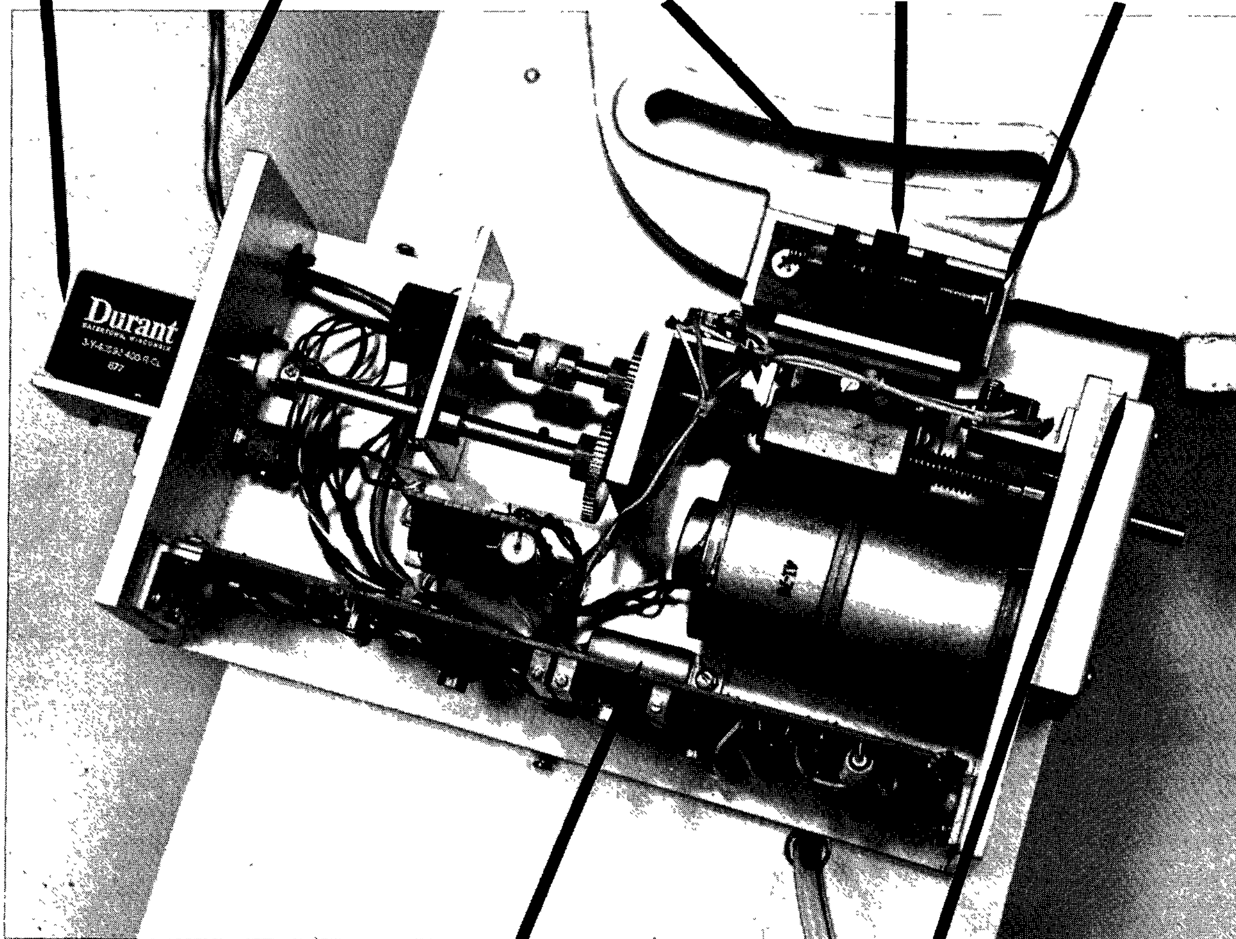


Figure 3.--Temperature servo with cover removed (rear view of manometer).

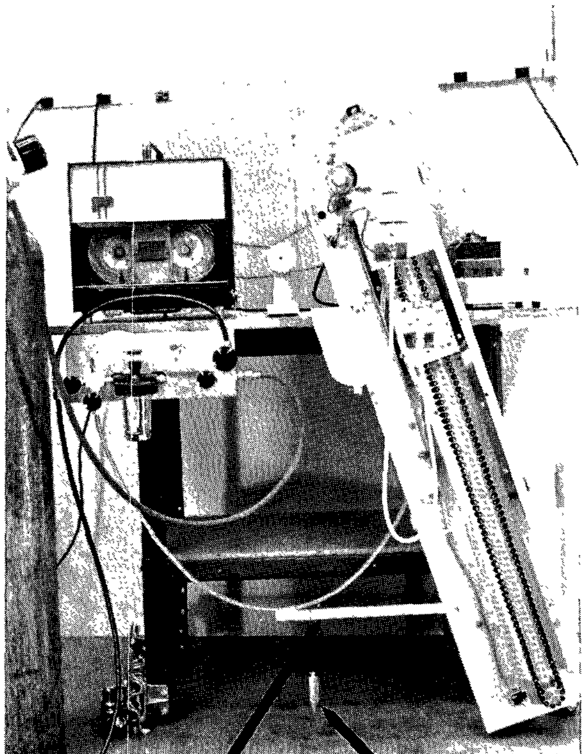


Figure 4.--Fold-out arm and plumb bob.

gage) at 17°40', which represents 67°F.

When the automatic angle-correcting device is installed, the angle is set to agree with the visual counter temperature reading of the unit, which should be the average ambient temperature at that time. On later visits, the angle can be checked occasionally to see that it continues to agree with the counter readout.

Float-Switch Reservoir and Mercury Overflow

In recognition of the mercury-contamination risk to the environment and to eliminate an aggravation, a method is provided for catching the mercury if the system is accidentally, or otherwise, purged. To accomplish this, it was first necessary to design the "O"-ring-sealed float-switch reservoir to provide an outlet for the mercury (fig. 7). Note that the float is smaller, the contact chamber is smaller, the contact spacing is adjustable externally, the mercury reservoir is smaller, and venting to the atmosphere is accomplished through the overflow reservoir. The rather devious inlet to the overflow reservoir prevents mercury droplets from splashing out during a sometimes violent purge. By removing this overflow reservoir (fig. 1) from the backplate and inverting in an elevated position, the mercury can be poured back into the system. The return path should be carefully examined and the tube or reservoir tapped as necessary to insure that all significant droplets have returned. Somewhat violent mercury purging may damage the pivots and bearings and, therefore, should always be avoided if possible. The straightin side contacts are purposely bent slightly to one side so that the effective contact spacing can be varied easily by turning the outside stainless-steel hex nut (fig. 7).

With the float switch sealed, a second gas-purge system can be attached at the reservoir outlet in place of the overflow reservoir, and the manometer can be used as a differential pressure device.

Miscellaneous

There are four tapped holes on the right-side track of the movable mercury reservoir that are to be used if accessory rail sections (fig. 8) are to be installed for mounting adjustable-stage microswitches or a peak-detection slider. The reservoir

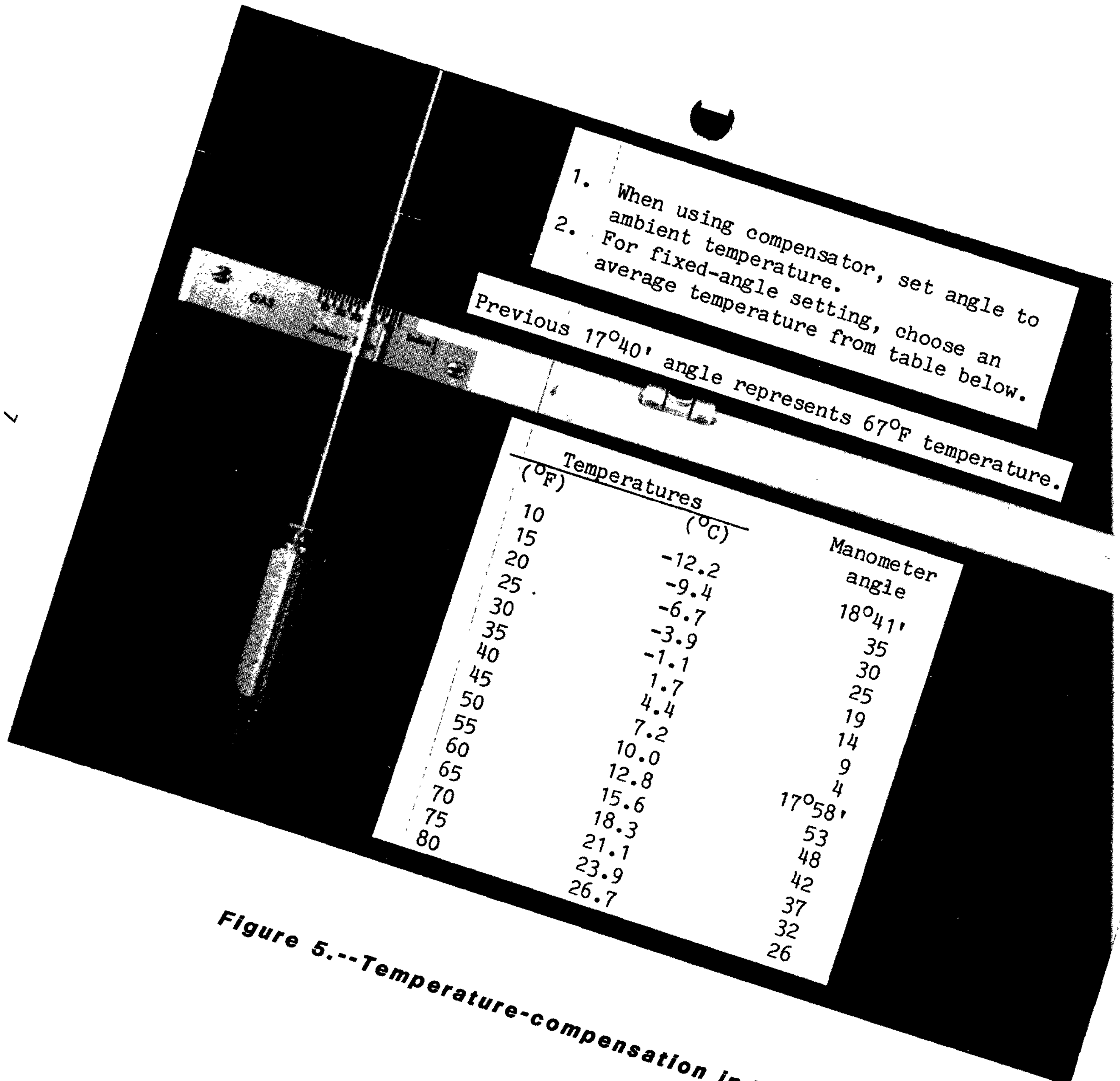


Figure 5.--Temperature-compensation index.

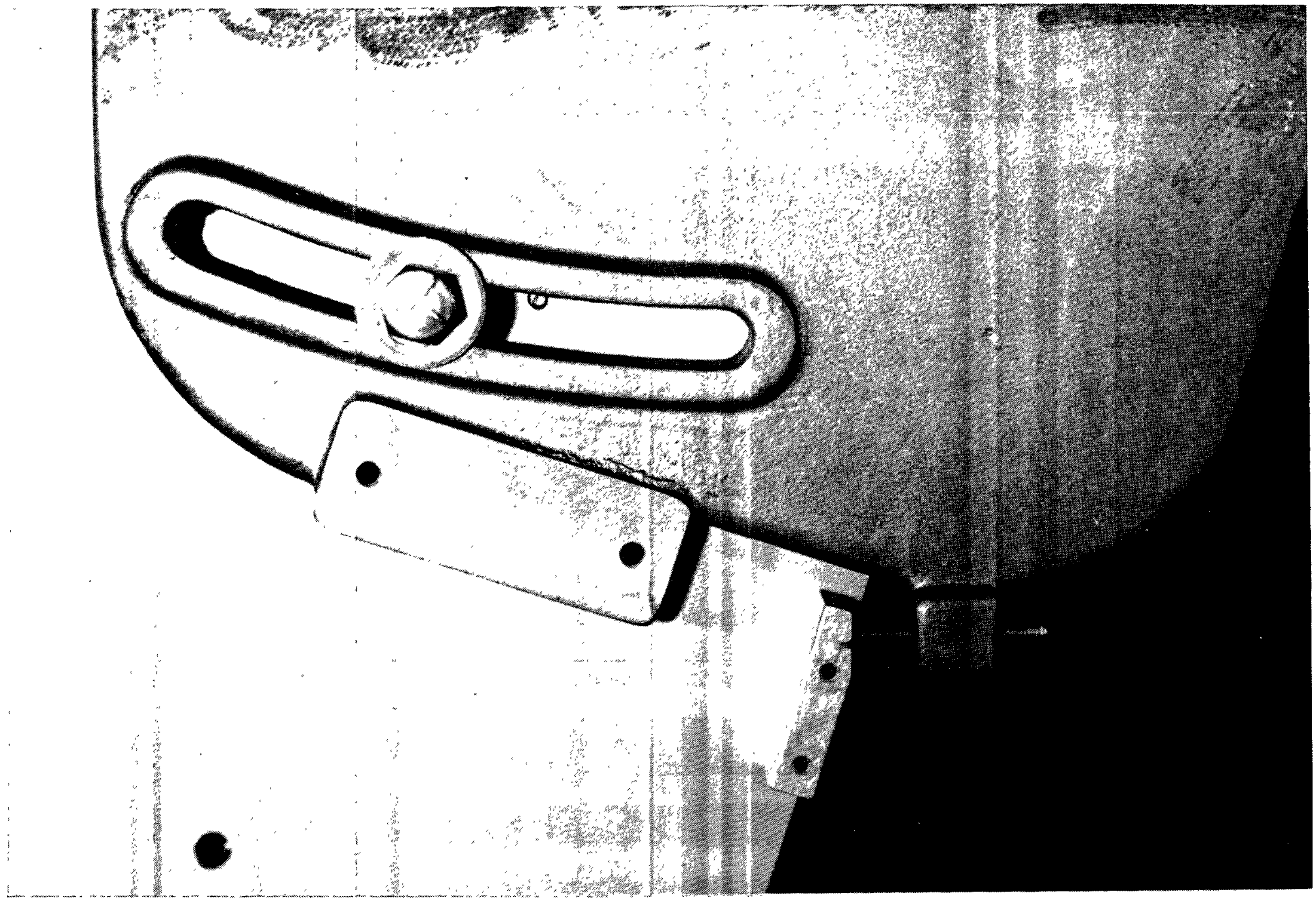


Figure 6.--Manual angle-adjustment screw.

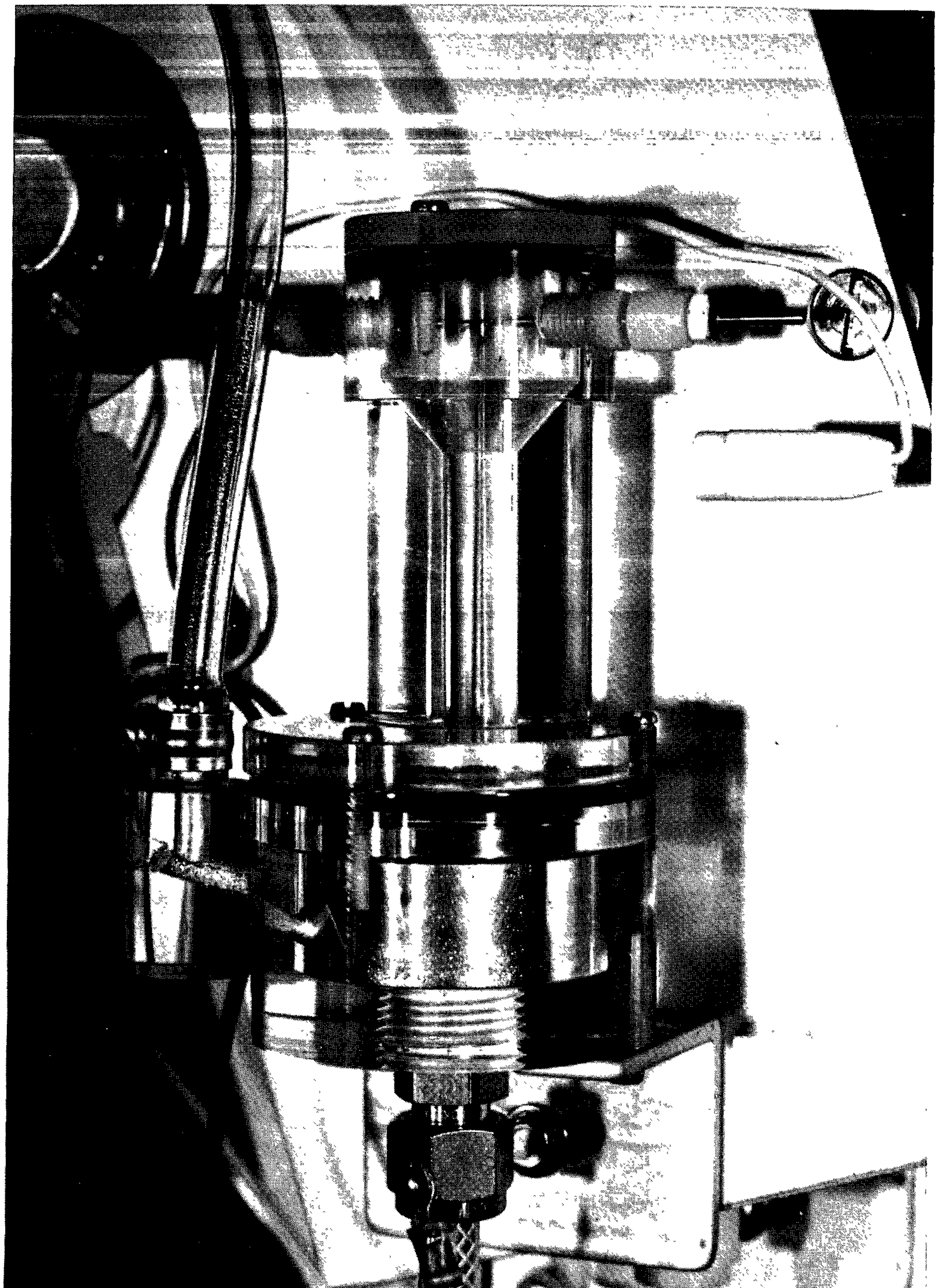


Figure 7.--Float-switch reservoir.

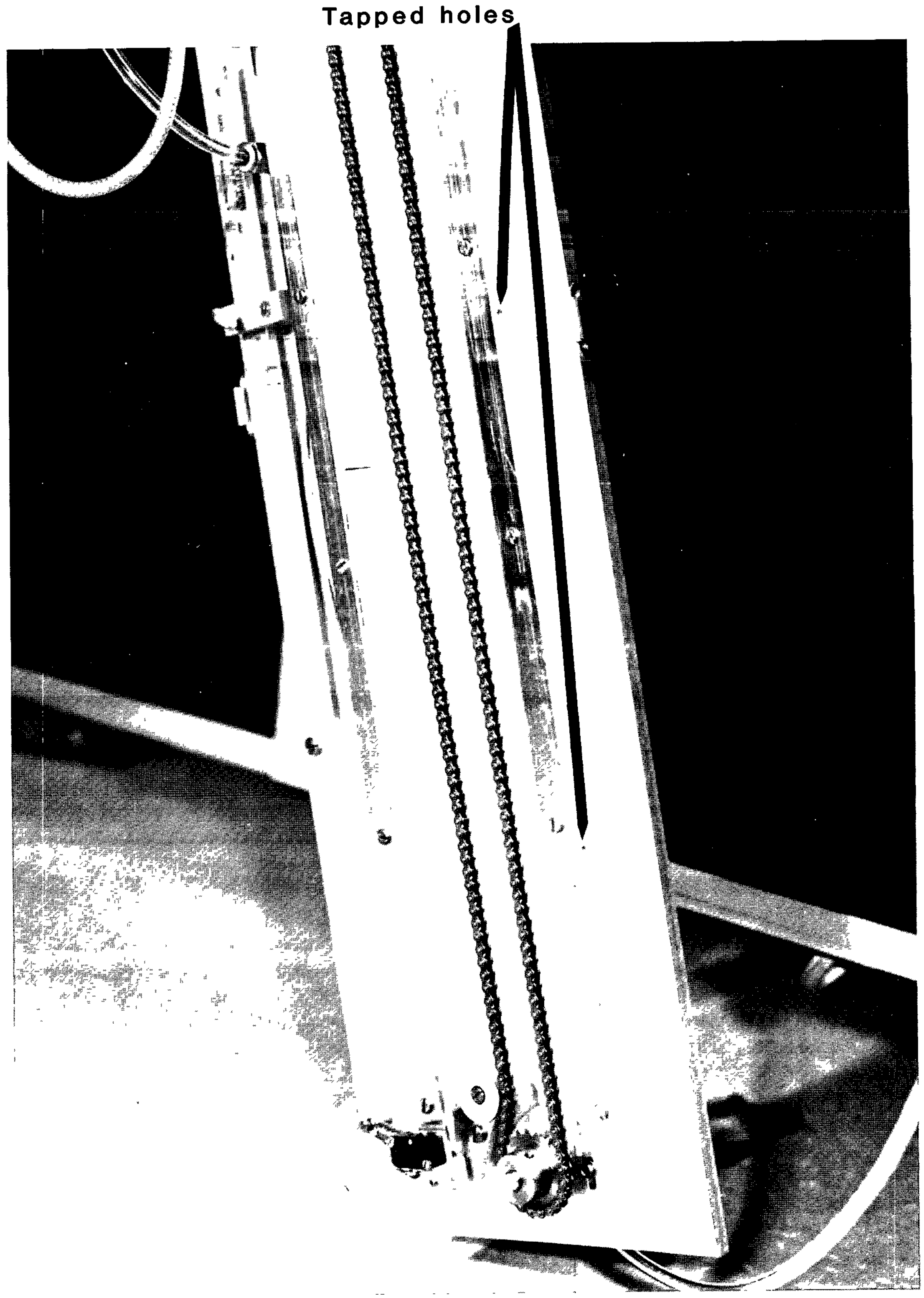


Figure 8.--Accessory switch rail section.

carriage plate also has tapped holes for mounting the switch-activator arm of whatever length or configuration is necessary. The regular left-hand-track limit switches are also adjustable (fig. 2), which means that the manometer can control its own travel and can also control any external device on-off at any predetermined stage.

The electrical connector on the manometer backplate is attached to an adaptor plate, which, in turn, covers a through hole large enough to accommodate the next larger size fitting. Tapped holes to attach such a fitting provide for field conversion to a more complex system in the future, if needed. Other through holes with hole plugs allow the passing of switch leads at any time. The motor connect is now a prepolarized single phone plug (fig. 1), which simplifies phasing of motor rotation.

The manometer cover is now a two-piece arrangement (fig. 9), and normally only the top half needs to be removed for servicing. Large viewing windows are on the front and side for cursory inspection of the condition of the float-switch reservoir, and a topside window is provided for counter readout.

It is possible to convert screw-type manometers to catch purged mercury as with the new manometer.

The above description of equipment shows that there are three subsystems:

1. The Gas-Purge System (fig. 10)
2. The Manometer Assembly (fig. 10)
3. The Servo-Control Unit (fig. 11)

The complete installation also includes a suitable recorder unit. To properly diagnose malfunction of the stage-measuring device, symptoms should be isolated into one of the three (or four) subsystems.

Purging Gas

Nitrogen is used as purging gas because it is cheap and readily available in most localities, it will not freeze and clog tubes, it is completely inert and safe, and it has very nearly the same weight as air. Compensation for weight variations that result from pressure are necessary for the recorder to follow variations in stage accurately. The density of river water also varies with temperature and with chemical and silt content, which causes errors in any pressure-sensing equipment used to record water levels.

Under standard conditions, water is approximately 900 times as heavy as nitrogen; therefore, errors due to variations in weight of the gas will be small. The manometer assembly can be adjusted to compensate for all errors that vary linearly with stage. The only other error due to variation in the weight of the gas is caused by temperature. Because nitrogen at atmospheric pressure has very nearly the same weight as air and because the weight of the atmosphere also varies with temperature, it is only the effect of a difference in average temperature of nitrogen in the bubble tube and temperature of the air that needs be considered.

For example, if the recording equipment is mounted 100 feet above the bubble orifice in the river with 2 feet of water over the orifice and if the average temperature of the gas in the bubble tube is constant at 40°F. While the air temperature increases from 40° to 70°F then the

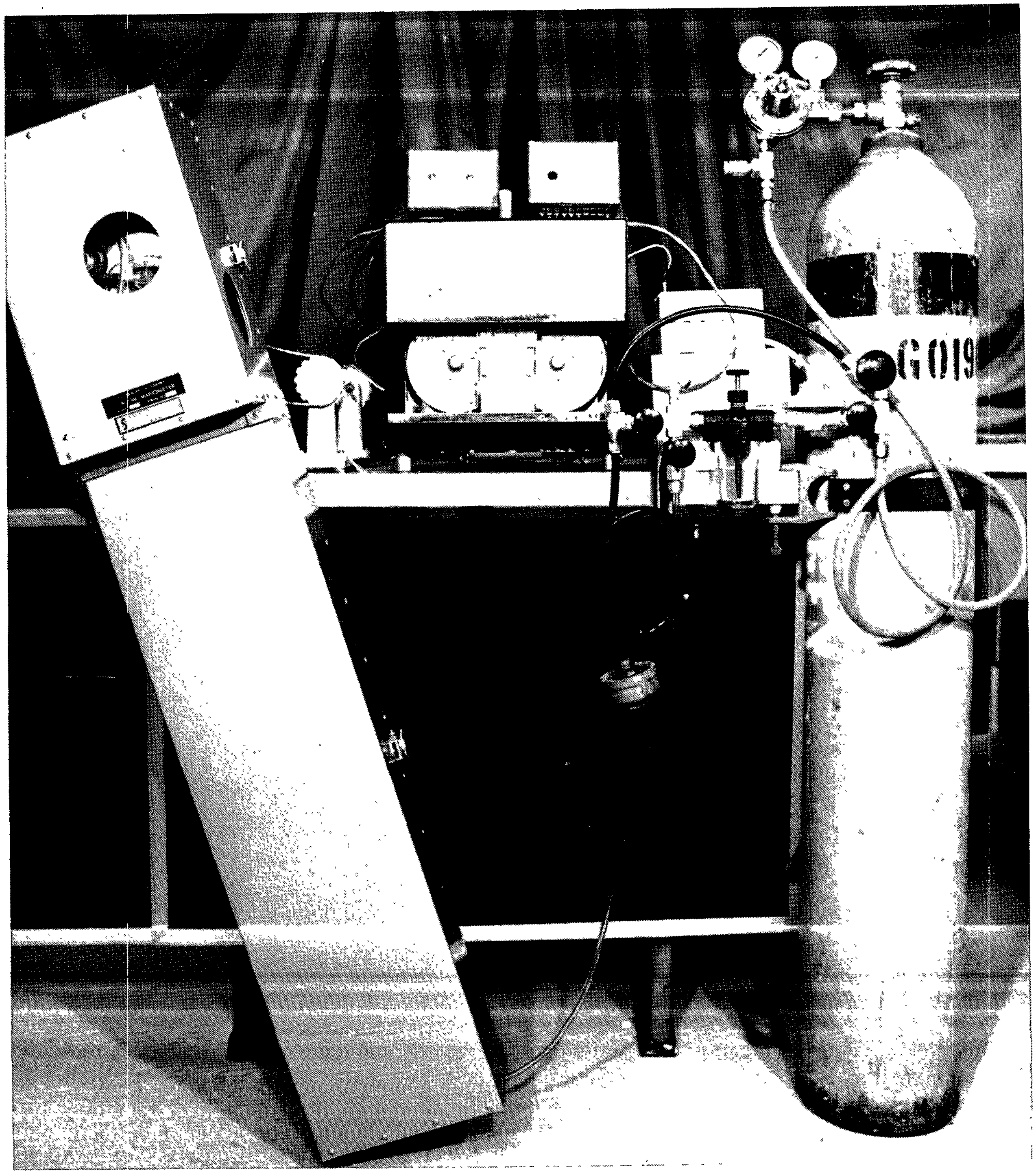


Figure 9.--Two-piece cover.

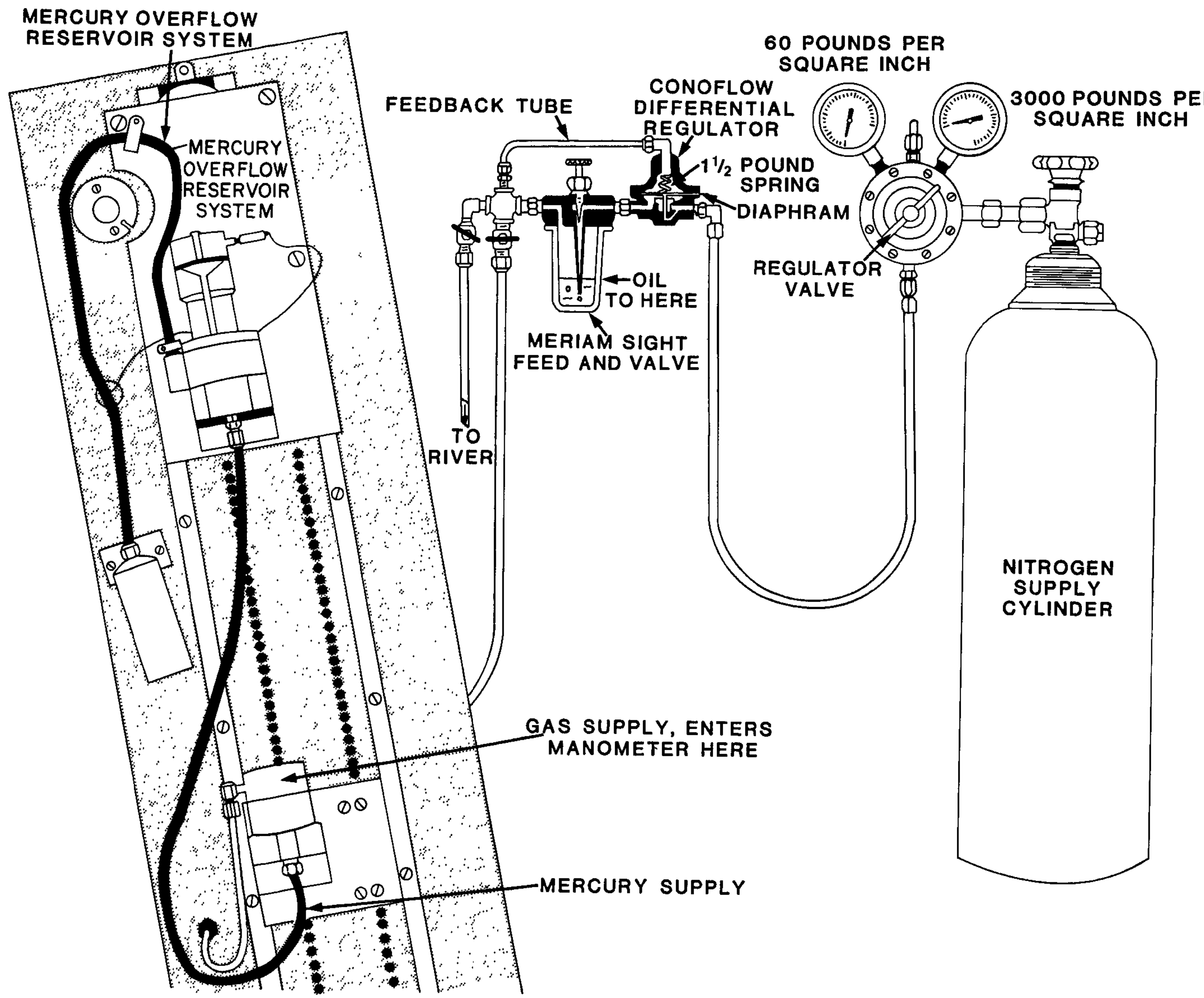


Figure 10.--Manometer assembly and gas-purge system.

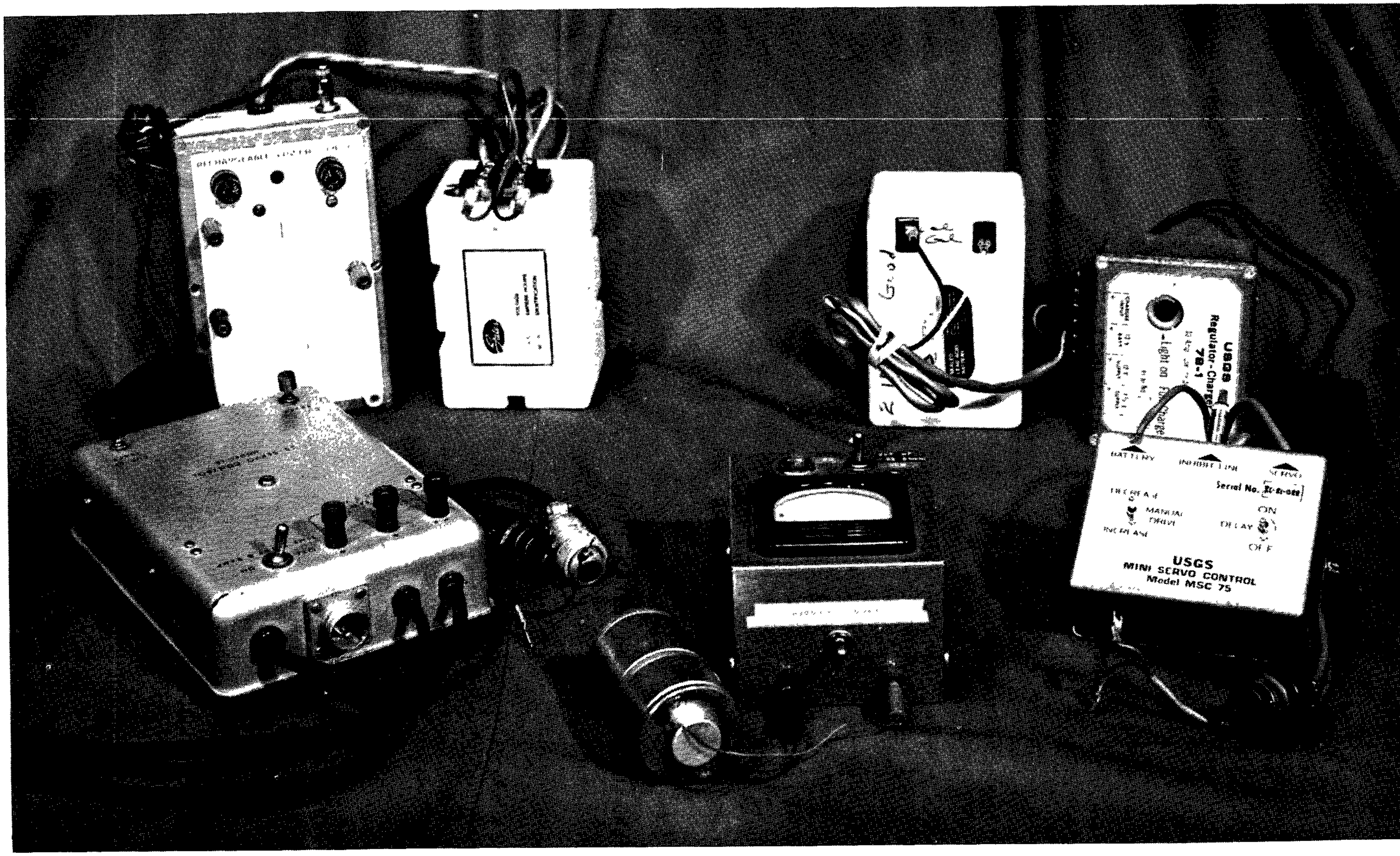


Figure 11.--Servocontrol unit.

error in the recorded level would be less than 0.01 foot. This error would decrease with the river stage and with the height of the equipment. For the usual height of equipment, this would not seriously affect the accuracy at low water, where greater accuracy is desired.

Density Effects

Any pressure-sensing system for recording water levels will be subject to errors due to variations in the density of water with temperature and with chemical and silt content. Stilling wells are not completely free of these effects because the water in the well may not have the same temperature or silt content as water in the river. Density-produced errors are usually quite small and, as they are proportional to stage, are, therefore, negligible at low water. The manometer can be adjusted for the effect of average silt concentrations, insofar as silt content varies directly with stage. The density of water does not vary appreciably with temperature from the freezing point to 60°F, but above 60°F, the variation is more rapid. At 90°F, for example, the relative density of water is 0.995. Density variations with chemical content in freshwater streams are not large enough to be significant.

Mercury, the heaviest liquid suitable for manometers, is used to keep manometers as short as possible. As the specific gravity of mercury is approximately 13.6, the effective vertical height of the manometer is 1/13.6 times the head of water to be measured. Thus, the manometer must be 13.6 times as sensitive to the mercury level as the accuracy desired in recording the water level (0.005 foot of water is equivalent to 0.0044 inch of mercury).

Manometer Angle

The manometer is installed at an angle of 17°40′ from the vertical at a temperature of 67°F. The angle is adjustable to compensate for temperature effects by use of the built-in index calibrated in degrees. From tests, the error caused by temperature change was empirically determined to be less than 0.01 percent per degree Fahrenheit. Angular adjustment may be made to compensate for an average, say seasonal, temperature that is different from 67°F. An automatic temperature correcting servo package is recommended as an accessory on long manometers to minimize errors due to temperature variations (fig. 3).

Power Consumption

Because this equipment usually must operate for long periods from dry batteries, the power consumption has been held to a minimum. At 6 volts (or 7 $\frac{1}{2}$ volts) the reversible motor draws about 200 milliamperes (1.2 watts) only while repositioning the manometer and recorder. The sensing and delay circuits draw currents of only a few milliamperes, and, with contacts open, the current is only a few microamperes.

DETAILED DESCRIPTION

Gas-Purge System

The gas-purge system (fig. 12) is the most complex and critical subsystem of the STACOM manometer. An understanding of its

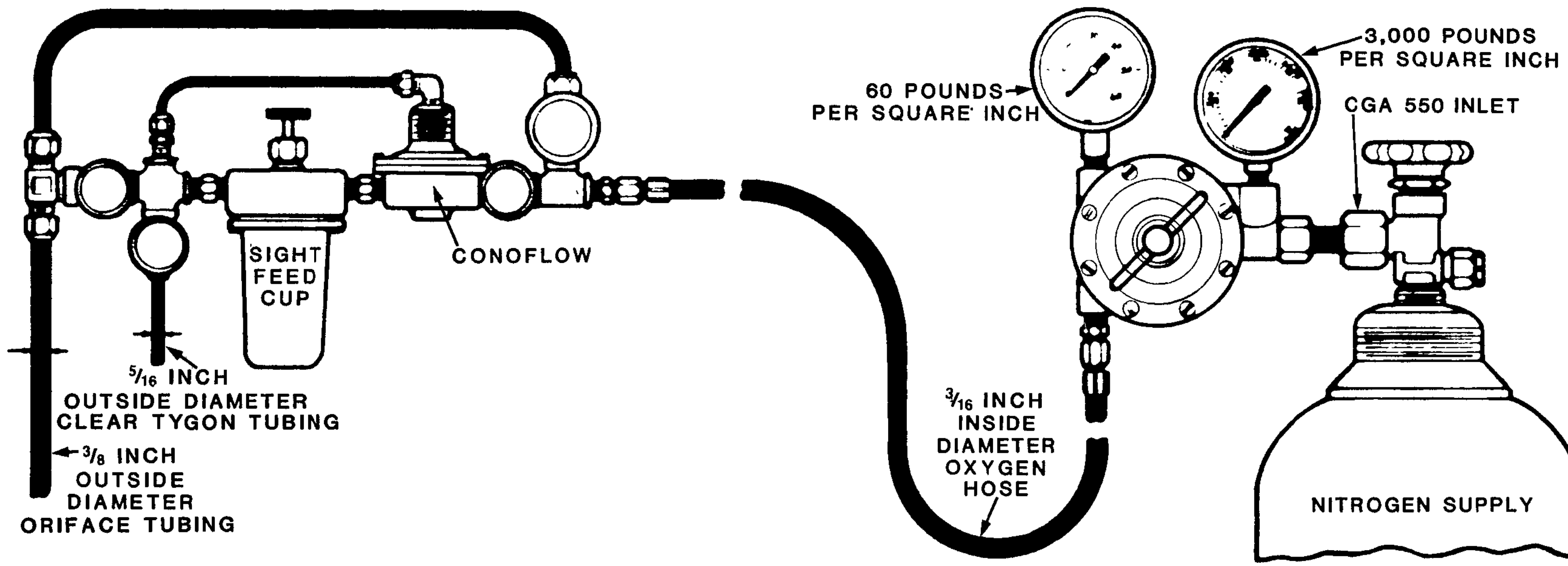


Figure 12.--Gas-purge system.

function and proper installation is essential to operate the manometer satisfactorily.

Gas cylinder

Nitrogen is used as the purging gas, and it should be "dry" if the climate is such that moisture in the gas would freeze and clog the bubble tubes. Nitrogen is dry because of the methods used in its production, but some slight moisture may be introduced if the compressors are water lubricated (W.P. nitrogen). Oil-pumped (O.P.) nitrogen is, therefore, recommended, where available, but nitrogen designated as "super dry" or "extra dry" may also be used. Most nitrogen is referred to as liquid pumped. CO_2 can be used and in some locations reduces orifice clogging from calcification; compressed air can also be used.

A 114-cubic-foot-size cylinder will operate most bubble-gage installations for a year or more. A normally operating gage will cause a pressure drop of about 100 psi of nitrogen per month. Smaller or larger cylinders can be used as desired, depending on the required feed rates and accessibility of the gage site.

Cylinder regulator

The cylinder regulator furnished with the STACOM manometer is a single-stage model with a cylinder-pressure reading to 4,000 psi maximum and a feed-pressure reading to 60 psi maximum. Some regulators are supplied with female threads compatible with O.P. nitrogen cylinders equipped with CGA 550 fittings. The CGA 550 fitting has male, left-hand threads, 0.904-inch diameter, 14 per inch. After 1978, the National Standard was changed to the CGA 580 fitting with female threads on the cylinder and male threads on the regulator. If the regulator and cylinder fittings are not compatible, the cylinder supplier may change the nipple and nut on the regulator so it will fit directly on the valve. While in service, the connection of the regulator to cylinder valve is subjected to continuous pressure up to 2,000 psi. Even a small leak in this connection, or in the regulator, would rapidly exhaust the cylinder. Avoid using adaptor fittings from the cylinder to the regulator that will increase the probability of gas leaks.

Constant-differential regulator and sight feed

The constant-differential regulator with sight feed is a Conoflow gas-purge assembly, DH41-1088, illustrated in figure 12. The diaphragm of this regulator acts on a soft-seated plug to admit just enough gas to maintain a pressure drop of 3 psi across the needle valve.

Dow-Corning "200 fluid" silicon oil, with 50 centistokes viscosity at 25°C, is furnished for use in the sight feet. The viscosity of this oil varies only slightly with temperature; therefore, the volume of gas per bubble will not vary with temperature.

Bubble tubing

The bubble tubing furnished is black polyethylene, 1/8-inch inside diameter and 3/8-inch outside diameter. Black polyethylene is not affected by ultraviolet light, as is the light-colored polyethylene, nor is it chemically affected by any constituent of ordinary soil. Black polyethylene tubing can, therefore, be buried directly in the ground. However, it is still recommended that the tubing be enclosed in a protective conduit or pipe to reduce problems with high stream velocities, rodents, and vandals.

Use of dual tubing

Friction created by the flow of gas through the tubing must be overcome by an increase in gas pressure, which appears at the manometer as an apparent increase in water stage. If the bubble-feed rate could be kept constant and temperature did not vary, the friction would remain constant and would not affect accuracy. However, with long bubble tubes or high gas-feed rates, variations in friction of the gas flowing through the tube can be significant.

Inaccuracies due to variations in gas friction can be eliminated by using two tubes--one to feed gas to the bubble orifice and the other as a static-pressure tube to transmit pressure from a point at or near the orifice back to the manometer. Dual installation of tubing is recommended only for distances greater than 500 feet.

When two tubes are used, they should be joined at a T-connector located at the top of the low-water bank and as near the bubble orifice as possible, with a single tube extending to the orifice. One tube serves as the supply line for gas to purge the system dynamically. The other tube simply transmits the static pressure at the "T" to the pressure-cup reservoir and does not serve as a flow line. Additional valves can be provided so that the static-pressure tube can be separately purged if necessary.

Orifice fitting

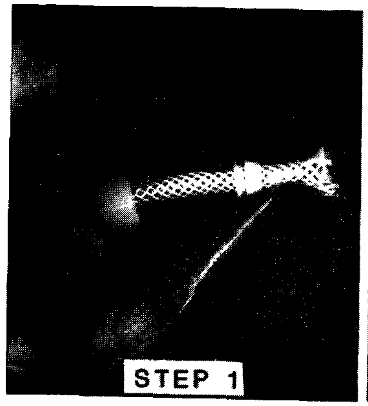
The streamward end of the bubble tubing is secured by a special fitting to a 2-inch pipe-cap for ease of mounting in the stream. The design of this fitting allows the cap to be screwed on a 2-inch pipe without twisting the bubble tubing. The orifice must be anchored securely in the stream, as changes in its elevation will result in corresponding errors in recorded gage height. Always point the orifice end downward as much as possible. To use the standard orifice fitting, add a standard steel elbow to assist in pointing the orifice down.

Manometer Assembly

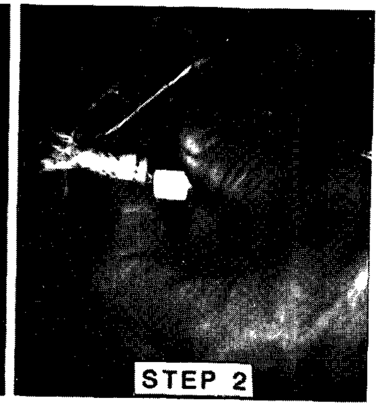
For the tables and drawings, see sheets 1 to 6 of Appendix for numbered parts for STACOM and sheets 1 to 4 for screw type.

Functional Operation

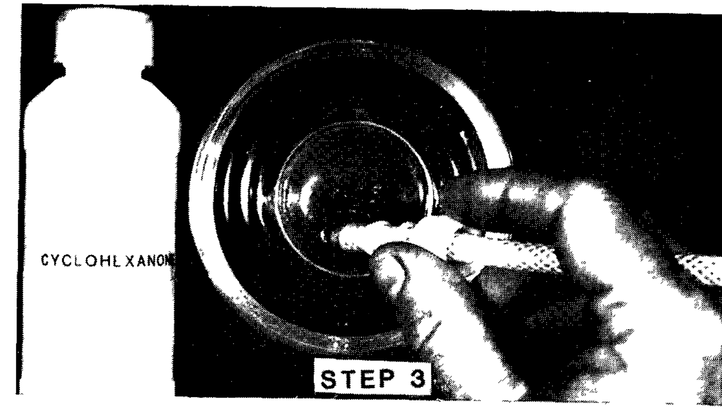
Pressure on the bubble orifice, corresponding to the head of water over the orifice, is transmitted to the manometer by the gas-purge system. This pressure is transmitted through the gas tubing to the mercury surface in the pressure reservoir (PC) via tubing (T-2) and displaces an equivalent head of mercury. (See fig. 22 for detail.) Therefore, mercury moves though the mercury-transfer tube (T-1) and changes the mercury level in the float-switch reservoir (FS). (See fig. 13 for method of welding T-1.) As the mercury level changes in the float-switch reservoir, the stainless-steel float



Pull back outside extrusion by grasping with long nosed pliers, simultaneous pushing against turned back edge also helps.

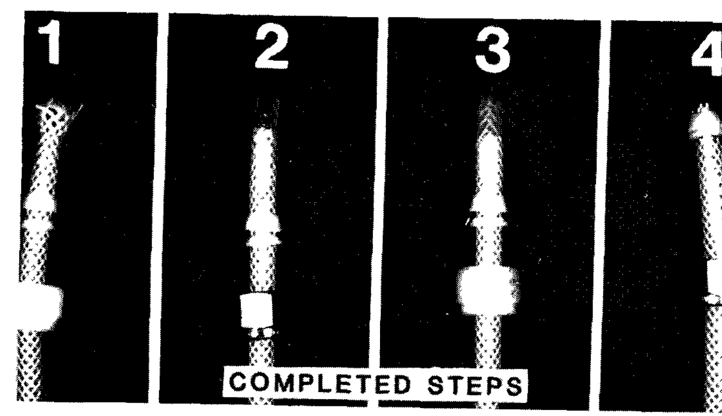


Clip fiber braid close. Take care not to nick extrusions.



Immerse inner extrusion in solvent for 1 minute. CAUTION: Do not let solvent touch outer extrusion; wet extrusion will shear off as it is pushed back.

Push outer extrusion into place immediately while inner extrusion is gummy. Place insert and ferrules immediately and let cure for 2 to 4 hours.



1. Outer extrusion turned back with braid exposed.
2. Outer extrusion turned back with braid clipped off.
3. Outer extrusion pushed back in place after dipping inner extrusion.
4. Insert and ferrules are placed immediately to hold extrusions during cure.

Figure 13.--Steps in welding inner and outer extrusions on tygon-braid tubing.

(FS-7) tips on jeweled pivots (FS-18). The center contact on top of the float armature moves laterally to touch either of the side contacts (FS-11, FS-12), which closes an electrical circuit and causes a motor to rotate a gear (US-3). The turning gear moves the cable belt on early models or roller chain on later models (part No. 20), which, in turn, moves the pressure reservoir up or down the carriage tracks until the head difference between mercury surfaces balances the new head of water in the stream.

Float switch

The float-switch contacts are made of a platinum-irridium alloy. Electrical continuity is maintained through the mercury from the float to the stainless-steel tube fitting (FS-25 and E-6). This fitting protrudes through the bottom of the float-switch reservoir so that a small quantity of mercury is trapped, thus maintaining contact with the pin (FS-27) in the float when a decrease in pressure drains mercury from the reservoir.

Drive motor

The standard drive motor (M-6) is a Barber-Column 6-volt dc, 0.8 revolutions per minute (rpm) reversible motor that draws about 0.2 ampere. The motor turns the upper sprocket through the motor-drive gear (M-7) and the shaft-drive gear (US-3). Other motor speeds are available for faster or slower following rates. Other following speeds are also possible by replacing the motor-drive gear (M-7). Contact the Instrument Development Laboratory for changes. The motor assembly is pivoted to disengage gears for ease of adjustment to stage height. The counter is normally engaged.

Cable belt or roller chain and gearing

Rotation of the upper sprocket assembly displaces the pressure-cup assembly along the support tracks and also drives the output-shaft assembly for ADR or digitizer connections. The sprocket-drive gear also engages the counter-drive gear (US-3 to CA-7) to rotate the counter shaft for the numerical display of stream stage. The gears rotate the counter shaft so that the last, or lower, wheel of the counter registers hundredths of a foot.

Limit switches

Limit switches (part No. 19) mounted on the carriage track are actuated by the pressure-reservoir carriage and stop the drive motor to prevent damage if the manometer is over or under pressured. The upper limit switch stops the motor drive when the carriage reaches the upper limit of its travel (minimum pressure), and the lower limit switch stops the motor when the carriage reaches the lower limit of its travel (maximum pressure). Each switch limits the movement of the carriage in only one direction so that the manometer unit again becomes operative when normal pressure is restored. The limit switches can be positioned on the carriage track to adjust the stop location as appropriate to the specific requirements of any installation.

Manometer-angle adjustment

Inclination of the manometer is adjustable to compensate for errors caused by temperature-dependent variations in specific gravity of mercury. A temperature-calibrated fold-out arm is used with a plumbline (fig. 4) to set the inclination for the average ambient temperature. The level bubble on the manometer plate is used to check alinement of the fold-out arm and plumbline pin. When the level bubble is centered, the manometer should be inclined at 17°40′, and the plumbline should cross the temperature scale on the fold-out arm at 67°F.

Servo-Control Unit

The purpose of this unit is to control the manometer motor by sensing an unbalanced condition through sensitive contacts on the float switch. This unit provides a time delay to decrease motor action and a ramp-start motor to allow a higher revolution per minute to be used for a higher following rate of the pressure reservoir while still maintaining stability at a narrow null setting. Time delay is achieved by charging a capacitor from a fixed voltage through a resistance to a given trigger voltage. A ramp-start motor is used so that voltage to the motor gradually increases rather than applying the full 6 volts instantaneously. The ramp-motor voltage is obtained by charging a capacitor with a constant current and forcing the applied motor voltage to follow the capacitor voltage, regardless of motor load, by using a feedback servo loop. This circuit gives a starting ramp slope of 0.3 volt per second. Therefore, it will take about 20 seconds to reach 6 volts. For a 5-rpm motor, this would give speed-time slope of 0.25 rpm per second; for a 15-rpm motor, 0.75 revolution per minute per second. This ramp-start technique initially provides the desirable dampening effect of a slow motor (for example, 1 rpm) but then maintains a higher revolution per minute to move the pressure reservoir.

Some additional features of the control unit are (1) protection from short circuits across the float-switch contacts, (2) ADR interlock, (3) high efficiency, (4) manual buttons, and (5) an off switch on the time delay. The short-circuit protection allows the float-switch contacts to be shorted together without damage to the control unit. A short simply causes the pressure reservoir on the manometer to rise (decreasing stage) until the limit switch is activated, which stops the drive motor. The ADR interlock feature allows the user to dispense with the conventional interlock relay. If some unorthodox recording scheme is used, the clock plug and terminals and the ADR plug may be left unused. They are not necessary for operation of the control unit. The plugs and terminals provide a simple means for interlocking the ADR and manometer. The manometer control unit operates efficiently by using high-gain, low-leakage silicon transistors. With open contacts, the current drain is typically less than 2 microamperes at 75°F and less than 5 microamps at 125°F. At contact closure, current drain increases to 5 milliamperes until the motor starts. At this point, current drain is determined by motor load and voltage, but is normally less than 250 milliamperes. The output-power transistors can carry 750 milliamperes at a supply voltage of 7 to 15 volts. The manual button allows the drive motor to be operated manually independent of the circuit card. The off switch on the time delay allows for direct on-off operation if desired.

Note that the control unit may be operated in any position, there is no fuse, and it will withstand shorting of the motor. Also note that the manual control switches disable the external ADR drive to prevent accidental damage during ADR lockup. Never manually operate the manometer while the ADR is cycling. Although the cycle (motor) stops, lockup may have already occurred.

The nominal supply voltage for the servo-control unit is $7\frac{1}{2}$ volts dc. Operational tests show that satisfactory performance can be obtained with supply voltages ranging from 7 to 15 volts throughout a temperature range of -35°F to $+130^{\circ}$F.

The full series voltage of both batteries is used in the sensing (float-switch) and time-delay circuits. Consequently, both batteries must be connected before operation in even one direction is possible. An accidental reversal of battery connections will cause no damage, but the equipment will not operate.

Mini servo-control unit

The mini servo-control unit is designed to do the same job as the present ramp-start servo-control unit now being used in the STACOM manometer. The new unit costs about half as much as the older unit. Cost reduction is made possible by omitting the ramp-start feature, simplifying the packaging, and using the latest in integrated circuitry. The unit still has the time-delay capability. One improved feature is that only a single battery is required. The features are listed below.

1. Operation from a single power source supplying from 7 to 15 volts.
2. Low standby current of less than 1 microampere.
3. Low servo-switch current of less than 120 microamperes.
4. Shorted float-switch contacts cause the servo to drive the pressure reservoir upward, preventing loss of mercury.
5. An inhibit input requiring from 4 to 12 volts is provided to stop the servo motor. This input can be hooked across the digital recorder motor to stop the servo when the recorder is operating.
6. A delay of about 15 seconds is provided. This can be changed to 30 seconds by cutting two jumpers on the circuit board. A switch is provided to turn the delay off if desired.
7. All inputs and outputs are short-circuit protected, and the power leads are protected from reverse polarity.
8. An up-scale, down-scale switch is provided for manual operation of the motor.
9. Approximate dimensions are 2 inches x $8\frac{1}{2}$ inches x $4\frac{1}{2}$ inches.

Power

Power for the manometer and servo-control unit will ordinarily be obtained from dry batteries. The pressure-sensing and time-delay circuits operate on a fixed polarity source of 7 to 15 volts; separate 6 (or $7\frac{1}{2}$) -volt sources of opposite polarity are provided to operate the drive motor in both directions.

At installations where commercial ac power is available, economy and reliability of operation can be improved by using transformer-rectifier power supplies. Power supplies of this type, specifically designed for bubble-gage operation, are available from the Hydrologic Instrumentation Facility. Solar-energy systems are also available as a power source.

Type of Recorder

In principle, the STACOM manometer can be used to chain drive any mechanical water-stage recorder fitted with sprockets of the proper size. Recorders in which a stage differential of 1 foot corresponds to one revolution of the drive shaft require a 3 to 2 sprocket ratio between the output shaft of the manometer and the drive shaft of the recorder. Most manometers are installed with the Leupold & Stevens Model A-71 graphic or digital recorder or the Fischer & Porter digital recorder. Detailed descriptions of these instruments are furnished by the manufacturers and are not included in this manual.

Operation with graphic recorder

No change in this recorder is required for use with the manometer except the substitution of a sprocket wheel for the usual float wheel and, possibly, a conversion of the type of clock drive. Sprocket sizes providing the usual gage-height scales are as follows:

Manometer sprocket	Recorder sprocket	Gage-height ratio
15-tooth	15-tooth	1:6
15-tooth	30-tooth	1:12

Operation with digital recorder

The proper drive ratio for this recorder is obtained by using the 30-tooth sprocket on the manometer output shaft with a 20-tooth sprocket on the recorder drive shaft.

With digital recorders, the correct direction of drive shaft rotation must be observed. When chain driven by the manometer, the proper direction is obtained by normal positioning of the recorder with the drive sprocket at the back.

The digital recorder locks its drive shaft during the punching cycle, and the equipment may be damaged unless the manometer is disabled at this time. The disabling function is provided through the ramp-start servo-control unit or the mini servo-control unit inhibit line.

Operation with Telemark

The manometer can be used to operate the Leupold & Stevens Telemark for long-distance transmission of stage information by wire or radio. The proper drive ratio from manometer to Telemark is obtained by using 15-tooth sprockets on both instruments.

The correct direction of rotation of the Telemark drive shaft must be observed. When chain driven by the manometer, the proper direction is obtained by normal positioning of the Telemark, with the drive sprocket toward the front of the instrument shelf.

Provision must be made for disabling the manometer during the keying cycle of the Telemark when this instrument "locks up." This can be done by connecting wires across the Telemark motor to the inhibit line on the side of the servo-control unit. The lock-up arm on the Telemark may be removed if two exact readings are not required.

Facility for installation where high stream velocities cause drawdown problems.

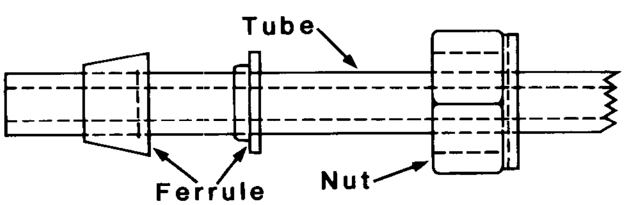
Gas-Purge System

The gas-purge system is shown in figure 12.

Tube fittings

Crawford "Swagelok" tube fittings are supplied with this equipment. These fittings are premium priced but will give satisfactory leak-proof service if installed correctly. Fittings are installed as follows:

Place nut and 2-part ferrule on tubing as shown in the sketch below:



Insert end of tubing, with ferrules and nut as shown, as far into the tube fitting as it will go with the nut drawn up finger tight. This should be almost tight enough for the nonmetallic nylon ferrules. Then tighten the nut a little more with a proper-sized wrench, but do not exceed one and one-quarter turns beyond finger tight. Use Teflon tape on all pipe threads, but not on tube ferrules and nuts.

Connecting cylinder regulator

Before connecting the regulator to the cylinder, open the cylinder valve very slightly to blow out any foreign matter that may be lodged in the cylinder valve and then reclose the valve. Connect the regulator to the cylinder, tightening the right-hand thread (CGA 580) connection nut firmly with a proper-sized wrench (not a pipe wrench). Now release the feed-pressure-adjust screw by turning it counterclockwise until the screw no longer exerts pressure on the internal parts of the regulator. Opening the cylinder valve slowly will prevent damage to the regulator valve and seat if the high cylinder pressure is suddenly applied to the regulator diaphragm.

A step-by-step procedure for changing cylinders is in the operation and maintenance section of this manual.

Constant-differential regulator and sight feed

Mount the Conoflow constant-differential regulator and sight feed in a level position on the wall of the shelter near the gas cylinder. Then proceed as follows:

a. Connect the cylinder regulator and inlet end of the constant-differential regulator with oxygen hose. This hose, with brass fittings, is used to reduce problems with leaks during cold weather.
b. Remove 1/4-inch brass plug and fill sight feed with the silicone oil to not more than one-third full. Wrap Teflon tape on the threads of the brass-pipe plug and retighten plug in sight feed.
c. Connect bubble tube from the orifice in the river to bubble-tube shut-off valve after cutting tubing square on end.

INSTALLATION

Equipment Shelter

A walk-in type shelter is recommended for the manometer equipment, and adequate space and protection from the elements are necessary for personnel while testing and servicing. The shelter should be at least 4 feet by 4 feet inside dimensions. It should have seals to aid in keeping equipment as clean and dry as possible. (See fig. 14 for a sketch of a typical installation and a plan view of a convenient arrangement of equipment in the shelter.)

A metal angle or 2-inch by 4-inch wood support is recommended for at least the front of the instrument shelf. The angle should come to within about an inch of the front of the shelf with the vertical leg toward the rear. This provides the rigid support required for the manometer but keeps the vertical leg of the angle far enough back to allow sufficient space between it and the back of the manometer.

A fiberglass shelter now being used by many Districts is available (figs. 15 and 16). This house is available in sizes 4 feet by 4 feet, 4 feet by 5 feet, 6 feet by 8 feet, 8 feet by 8 feet, and 8 feet by 12 feet. (See WRD Bulletin, April-June 1976 for more details.)

The shelf should be of 3/4-inch or 1-inch marine- or exterior grade plywood fastened securely to supports. The 35-foot-range manometer requires a shelf height of at least 34 inches. The 50-foot-range model requires the shelf to be at least 50 inches above the floor, or the floor must be cut away (fig. 14) to allow the manometer to project into the space below.

Bubble Tubing

The bubble tubing can be brought into the shelter from below ground level in a suitable elbow cast in the footing. It is recommended that the tubing be placed in a pipe or conduit to protect it from damage by vandals or floods. The tube can be buried directly in the ground, but it should have sand or other suitable material placed around it as protection from sharp-edged rocks during backfill.

Bubble Orifice

The bubble-orifice fitting (figs. 17 and 18) is installed in a pipe cap for mounting to a 2-inch pipe. The 2-inch pipe can be cast in a concrete pier or mounted so it can be adjusted for channel changes. The orifice must be anchored securely in the stream to avoid changes in elevation and positioned so it is slightly below the lowest stage to be recorded. The bubble tube, after square cutting the end, can be passed through the orifice-support pipe, inserted through the brass fitting, and seated against the internal shoulder of the machined brass part of the fitting. Tighten the fitting to hold the tube and, with the large nut slightly loosened, tighten the cap on the pipe without twisting the tube on the inside. The neoprene gasket on the inside of the cap will hold the machined part as the nut is finally tightened. The orifice should enter the stream underground, wherever possible, to prevent the pipe from being ripped out by floods, ice, or vandals. Common installations for the mud and sand streambeds are shown in figures 19 and 20. Static-tube systems are available from the Hydrologic Instrumentation

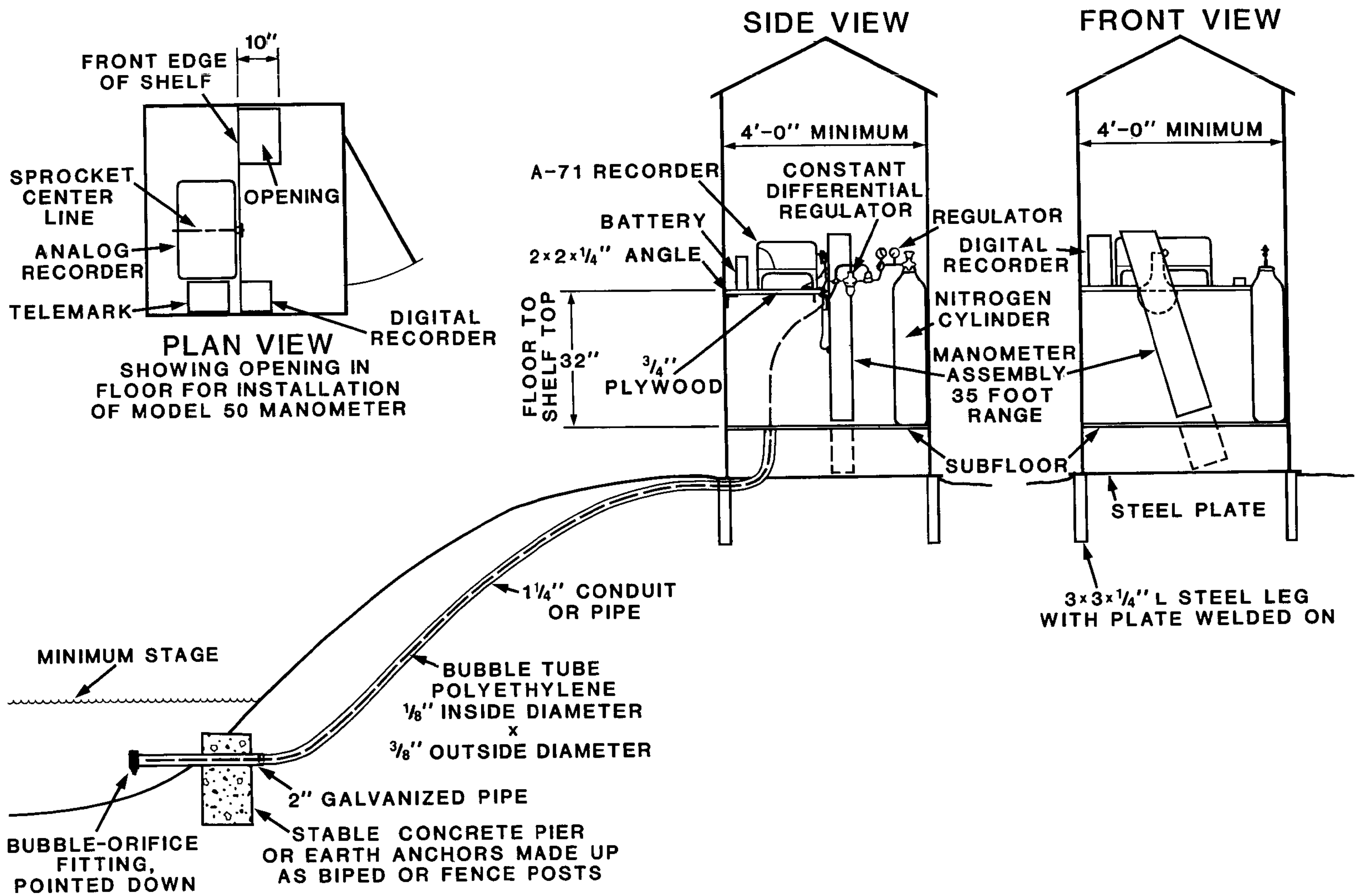
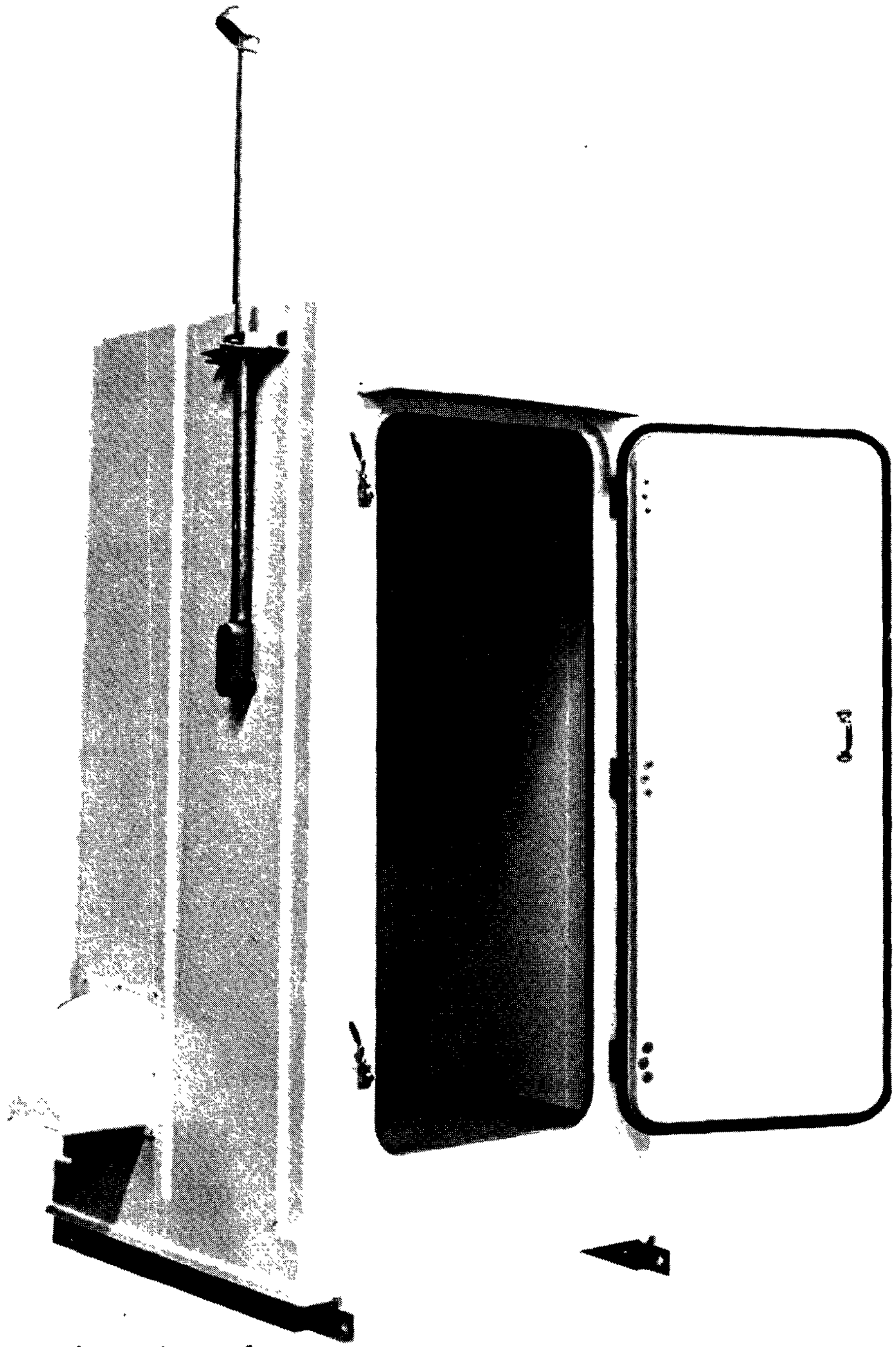


Figure 14.--Typical manometer-gage installation.



Photograph courtesy of
Vertex Plastics, Inc.

Figure 15.--Typical fiberglass shelter.

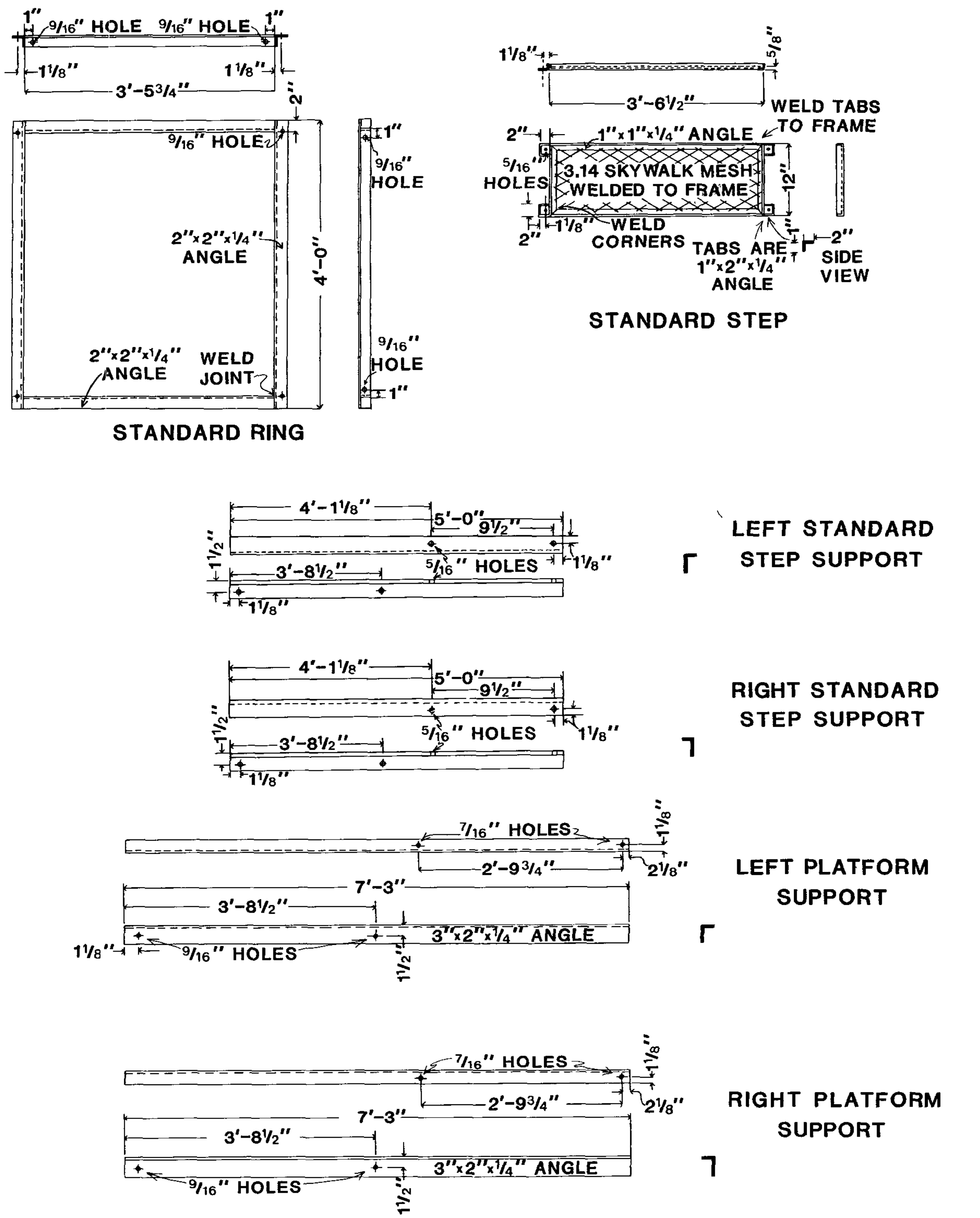
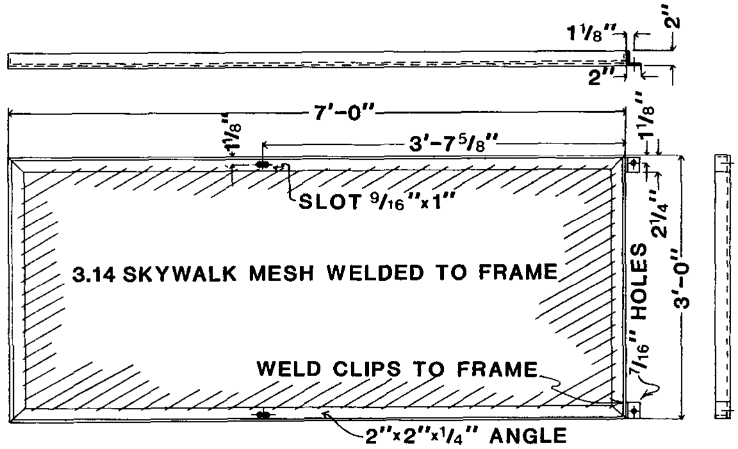
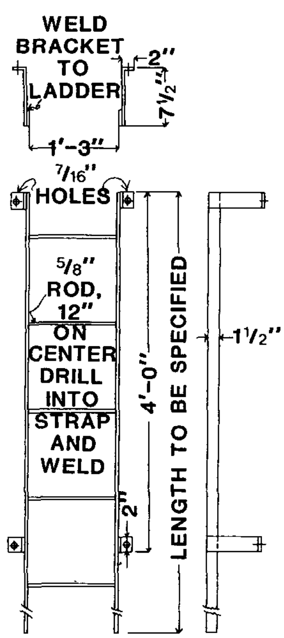


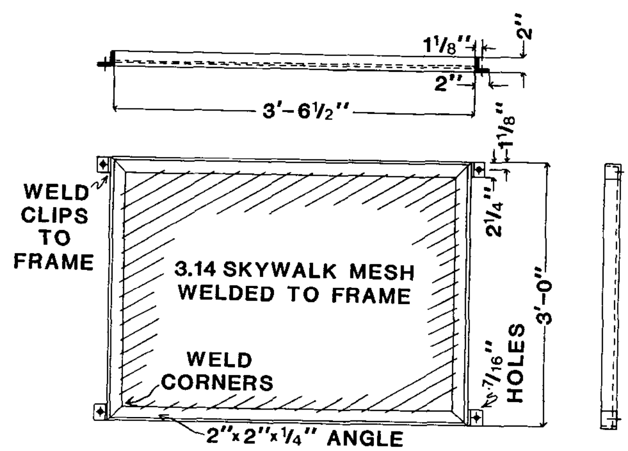
Figure 16.--Standard accessories



STANDARD LONG PLATFORM



STANDARD LADDER



STANDARD SHORT PLATFORM

LISTING OF ADDITIONAL PARTS					
PARTS FOR:	QUANTITY SHORT	QUANTITY LONG	STOCK	LENGTH	USED FOR:
PLATFORM	2	3	2"x2"x1/8" angle	3'-6"	Post
	—	1	2"x2"x1/8" angle	7'-1"	Rail
	1	2	2"x2"x1/8" angle	3'-2"	Rail
	1	—	2"x2"x1/8" angle	3'-7½"	Rail
	4	4	½" bolt	1½"	Platform support to house
	4	4	3/8" bolt	1½"	Platform to platform support
STEP	2		¼" bolt	1"	Step to support
	4		½" bolt	1½"	Platform support to house
	4		¼" bolt	1½"	Step to step support
LADDER	4		3/8" bolt	3"	Ladder to house

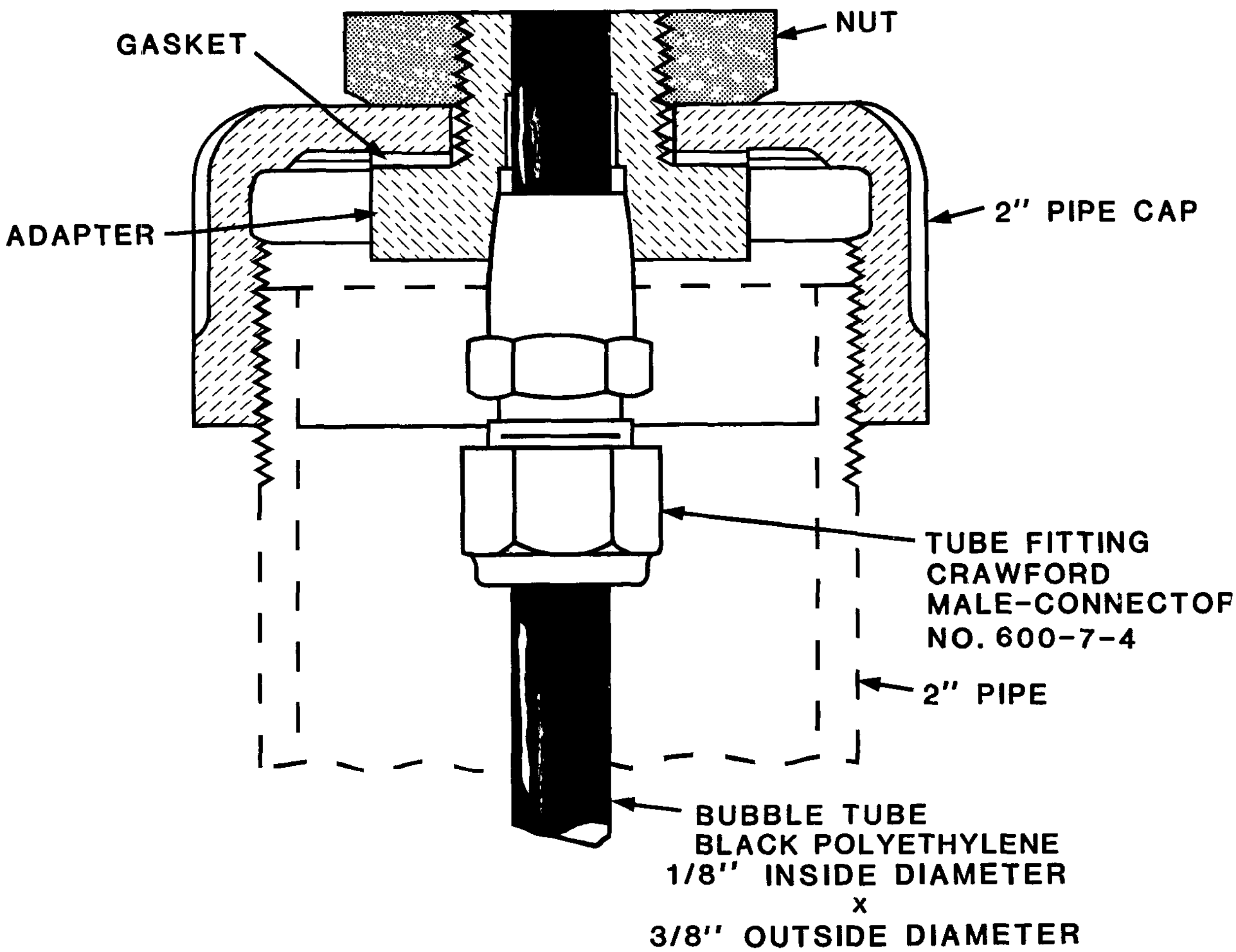
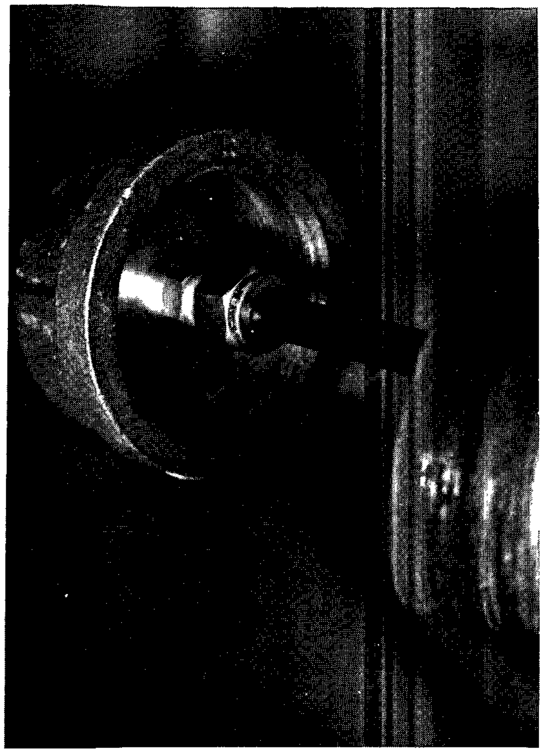
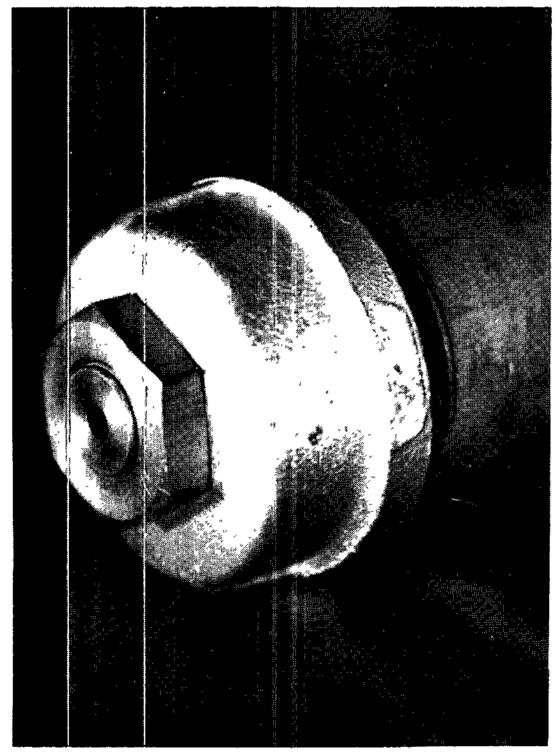


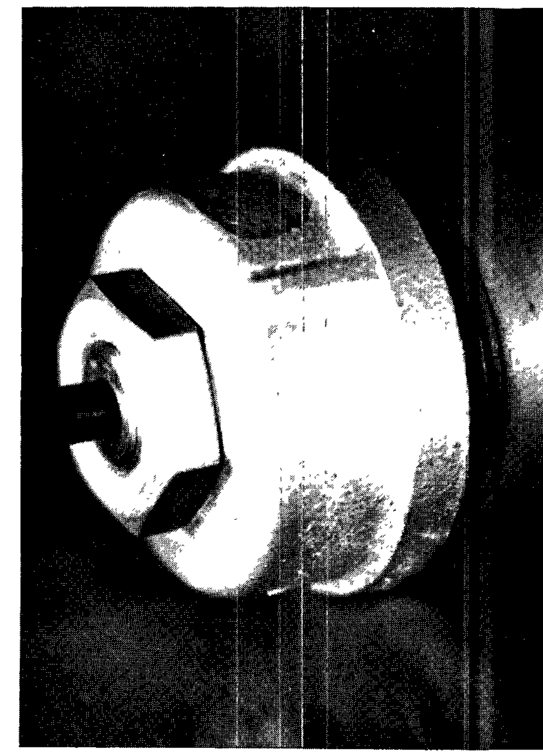
Figure 17.--Bubble-orifice assembly.



Inside view showing brass fitting



Outside view



Older type of orifice assembly with 3/8-inch drilled hole for bubble tubing

Figure 18.--Bubble-orifice assembly.

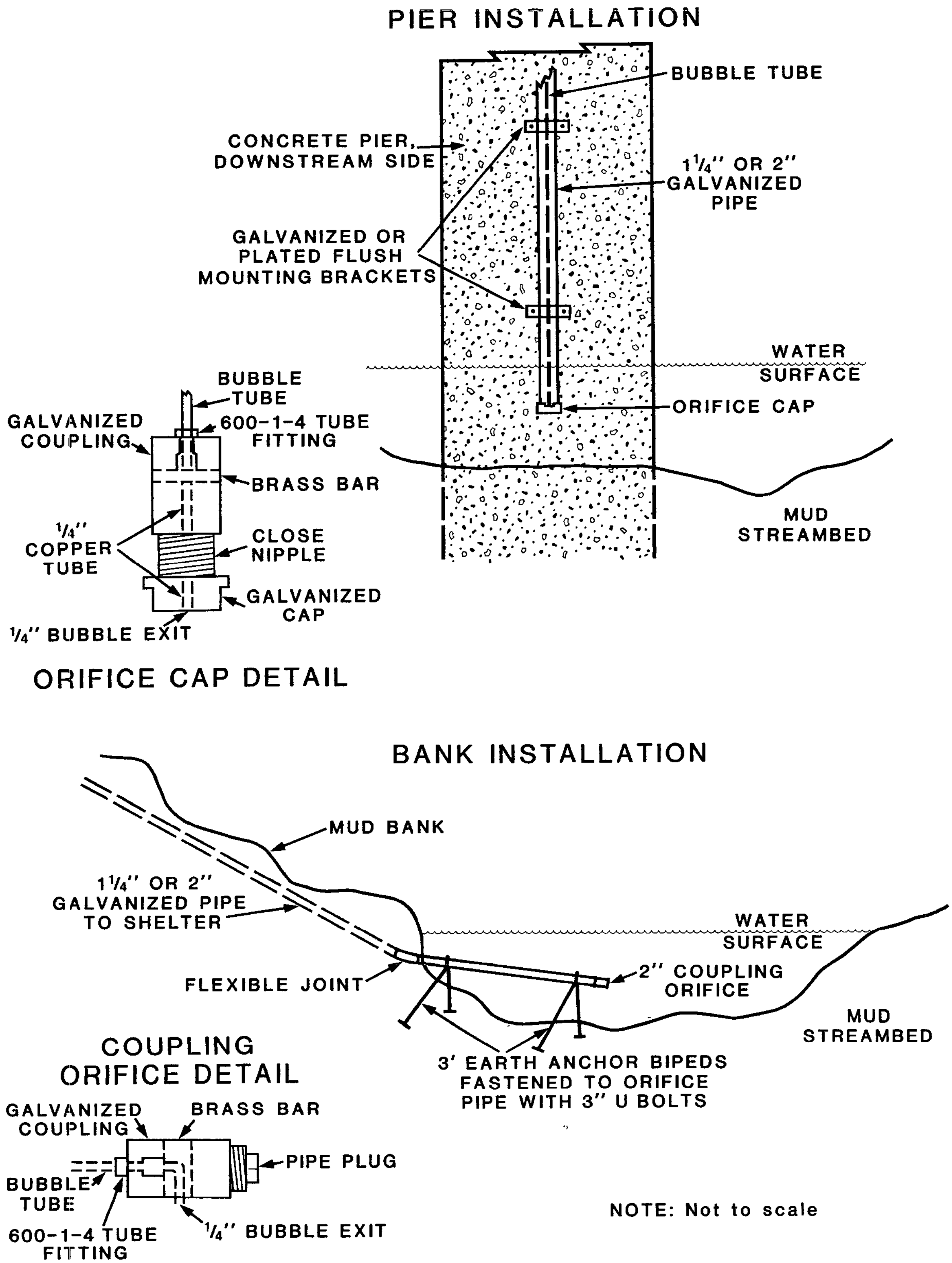


Figure 19.--Orifice installation for mud streambed.

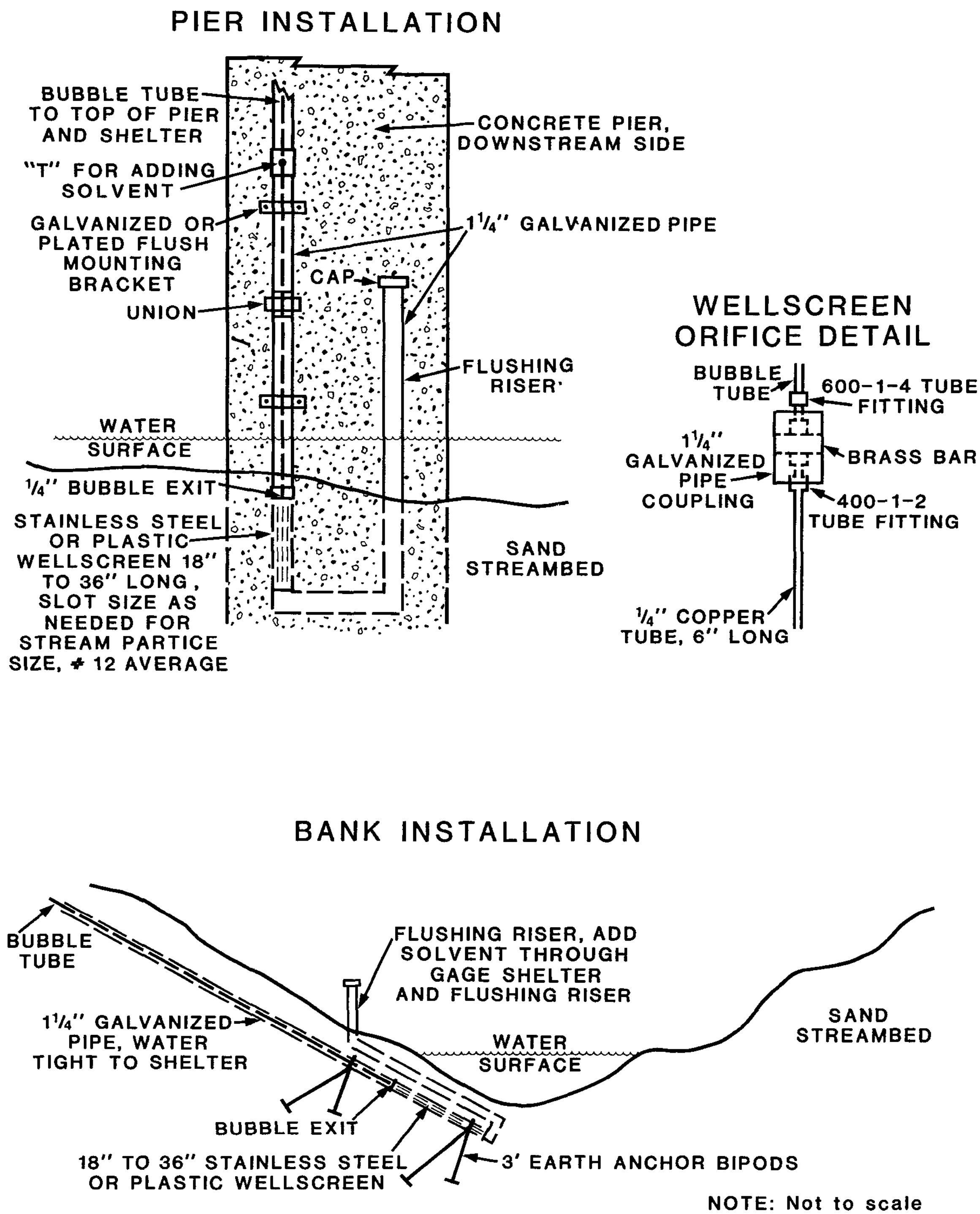


Figure 20.--Orifice installation for sand streambed.

d. Connect Tygon tube from the manometer to the manometer shut-off valve after cutting tubing to correct length. Make certain that there is a stainless-steel insert in each end of this tube before connecting. The inserts are necessary with this soft flexible tubing to insure that it does not collapse under the pressure of the tube fitting or blow completely out of the fitting.
e. To flush orifice, follow details in figure 21.

Manometer Assembly

Unpack manometer and other components. The manometer is complete, except for assembling the float switch. Power supply (batteries, solar system, and so forth) and control unit do not come with the manometer and must be supplied by the installer.

Assembly of float switch

The armature and float assembly will be found wrapped and taped between the carriage track. The armature assembly is too heavy to be shipped mounted in place on the jeweled bearings, which might severely damage the bearings.

The procedure for assembling of the float switch (fig. 22) is as follows:

a. Position the movable pressure cup manually to the approximate level of the float-switch reservoir.
b. Remove the terminal connectors.
c. Remove the float-switch stack by removing the three screws holding it in place on the reservoir and set aside with care.
d. Unwrap float and assemble into float stack. Use caution in assembly by positioning the armature center contact (FS-120) between the two contacts (FS-11) at the top of the stack.
e. Engage the pivot shaft (FS-17) of the armature between the jeweled bearings (FS-18) to finger tightness. Some looseness of the jewel screws is desirable to prevent damage to the pivot points (fig. 23). By trial and error adjustment, center the armature in the stack with no binding of the bearing points. The jewel screws should finally be adjusted so that slight lateral movement of the armature can be detected but not so much as to allow the armature to fall from the jeweled bearings.
f. Test freedom by tilting the stack and observing that the center contact is free to oscillate between the two contacts. No holdup in the oscillation should occur; if it does, the jeweled bearings are too tight.
g. Reassemble the stack on the reservoir. The stack (with float and armature) should now be replaced temporarily on the reservoir, and the mercury-contact roll pin should be adjusted, if necessary, so that it does not touch the bottom of the reservoir but will contact the small pool of mercury that will be trapped in the bottom by the reentrant stainless-steel tube fitting. The float switch can now be loosely reassembled

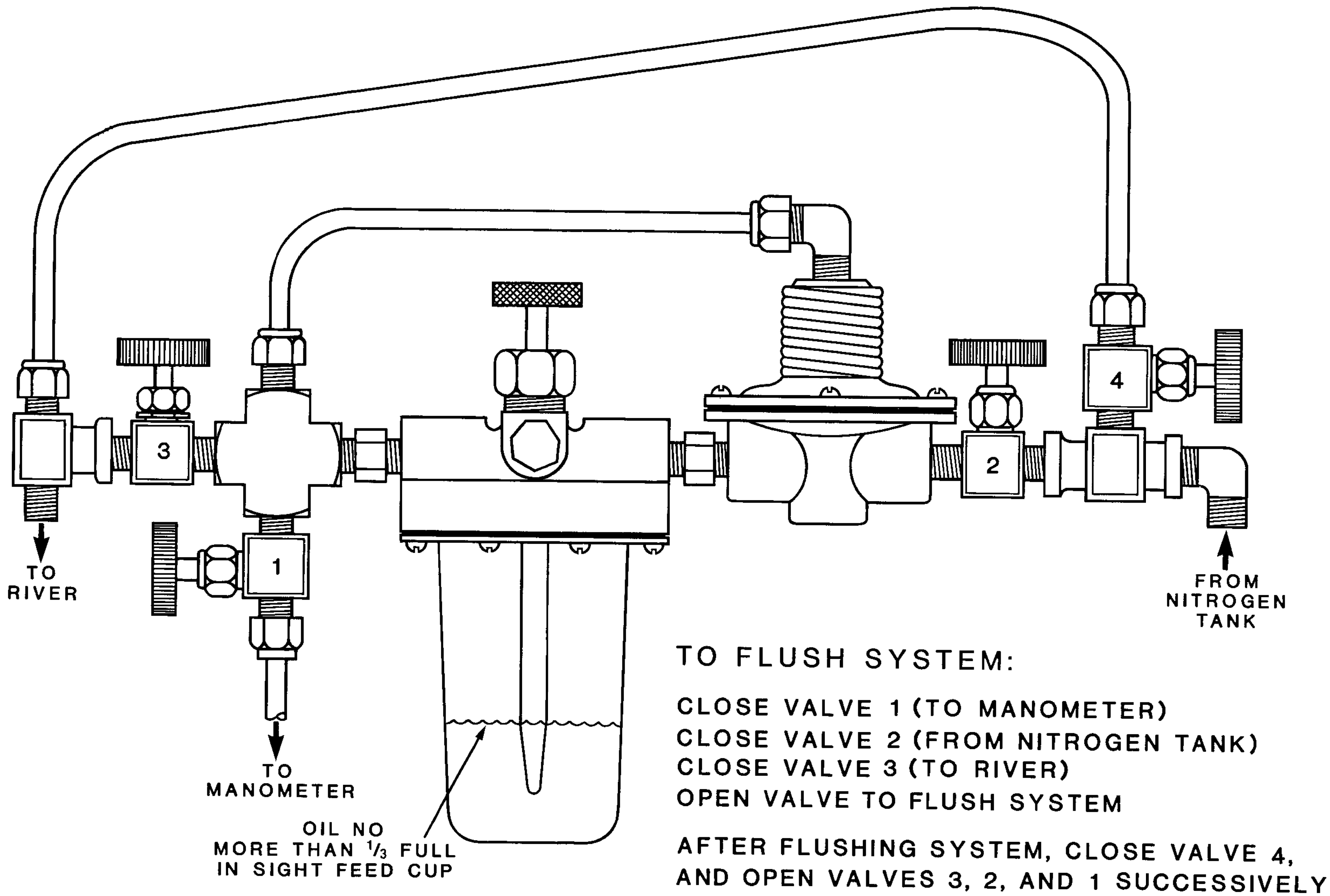


Figure 21.--Procedure for purging the orifice line.

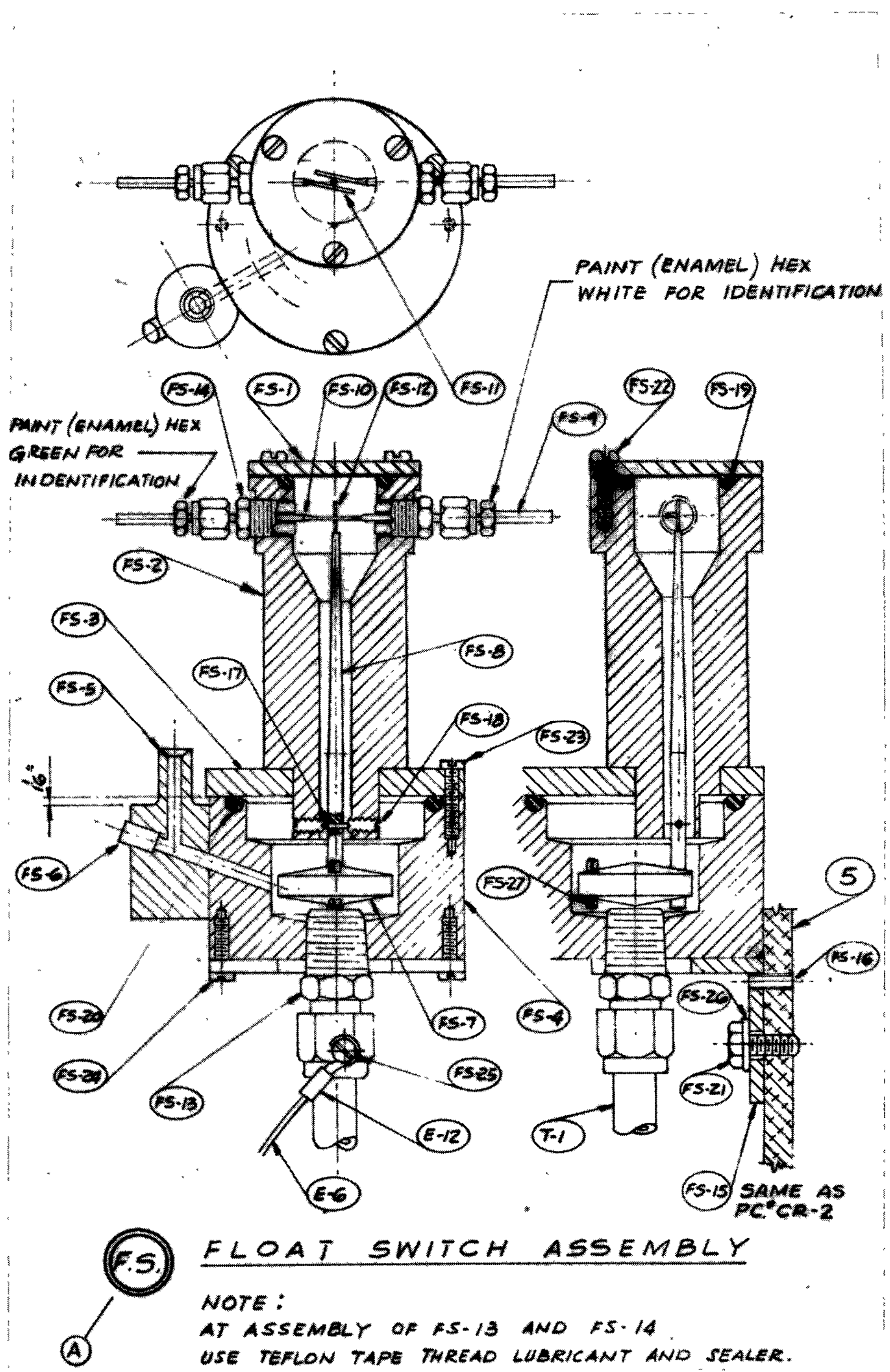
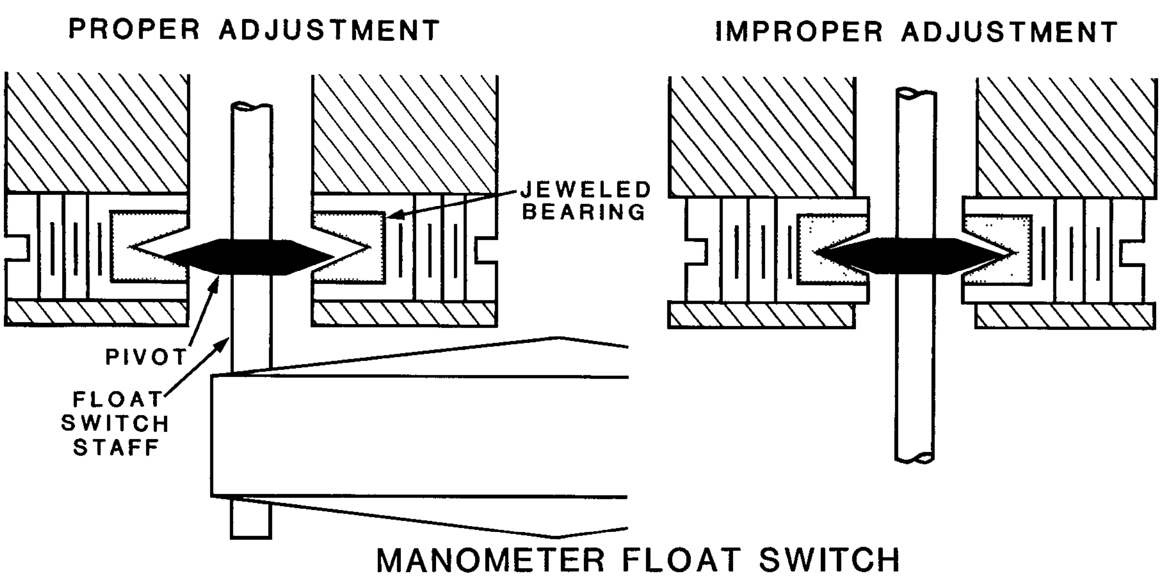


Figure 22.--Float-switch assembly.



PIVOT ADJUSTMENT:

THE FLOAT SWITCH STAFF COULD TIP BACK AND FORTH ON SIMPLE KNIFE EDGES BUT FOR PRACTICAL REASONS OF CONTAINMENT, DURABILITY AND EASE OF PROCUREMENT THE JEWELED BEARINGS AND PIVOTS ARE USED

THE JEWELED BEARINGS MUST BE ADJUSTED WITH CARE SO AS NOT TO JAM AND DEFORM THE VERY DELICATE PIVOT POINTS. A VERY LOOSE ADJUSTMENT OF THE JEWELED BEARINGS IS PREFERRABLE AS ANY DRAG ON THE PIVOT WILL CAUSE SYSTEM INSENSITIVITY

Figure 23.--Pivot adjustment.

until the mercury is installed in the manometer. The two contacts should now be bent slightly, as required to center them and to make them parallel, with a spacing that will allow a movement of the armature of about 1/32-inch.

h. Connect electrical terminals, following the color coding.
i. Hook up pressure lines to pressure cup--two ferrules front and back.

Connecting pressure tube

This soft-type tube should be passed through the tube fitting in the manometer backplate. Pull the tube through the fitting until only enough remains on the inside of the manometer to nicely reach the pressure reservoir at both limits of its travel.

Mounting manometer on shelf

Temporarily place the recorder that will be used on the shelf. Place the manometer-mounting casting on the front of the shelf and as far back on the shelf as the downward-projecting part of the casting will allow. Fasten the casting securely to the shelf with the four stainless-steel screws provided.

Connect the pressure tube projecting from the back of the manometer to the manometer shut-off valve after cutting the tube to a convenient length. If the tube is shortened, be sure that the stainless-steel insert is replaced in the end before the tube is connected to the shut-off valve.

Placing mercury in manometer

The amount of triple-distilled mercury supplied with this equipment is a little more than is actually required. It is more convenient to place only about 3/4 pound in the manometer at this time, adding more (about 1/4 pound to 35 feet and 3/4 pound to 50 feet) when the equipment is placed in operation. To place mercury, proceed as follows:

a. Remove stack from float-switch reservoir.
b. Grasp mercury-transfer tube about a foot below the float-switch reservoir and lift tube a little higher than the reservoir.
c. Pour about 3/4 pound of mercury into the reservoir.
d. Lower mercury-transfer tube slowly, allowing mercury to flow through it to the pressure reservoir without trapping air in the tube or fittings. If any small bubbles remain in the mercury-transfer tube, they can be dislodged by gently tapping the mercury-filled tube with the fingers. Continue to add the proper amount of mercury as indicated above.
e. Replace stack and tighten screws snugly to seal the O ring.

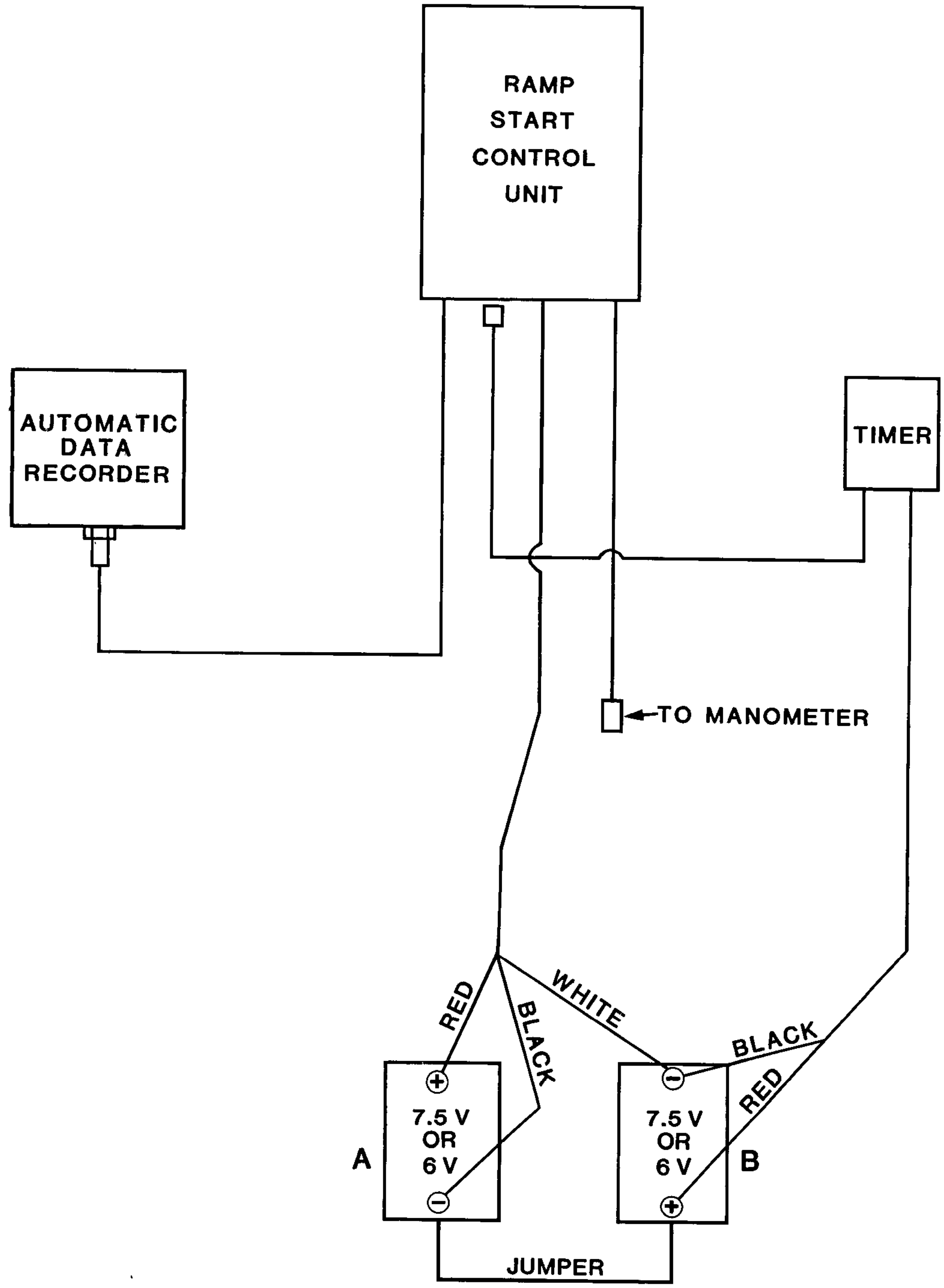
Check of connections

At this point, all tube and electrical connections on the manometer unit should be checked to make sure that they have not worked loose in transit.

Servo-Control Unit

Battery connections

Connect battery leads from the servo-control unit to 6-volt (or 7 1/2-volt) batteries, as indicated in figures 24 and 25,



NOTES: (1) REPLACE BOTH BATTERIES IN OCTOBER AND TIMER SIDE BATTERY (B) AGAIN IN MARCH
(2) TIMER MUST BE CONNECTED TO THE NEGATIVE SIDE OF BATTERY

Figure 24.--Wiring diagram for use with ramp-start control.

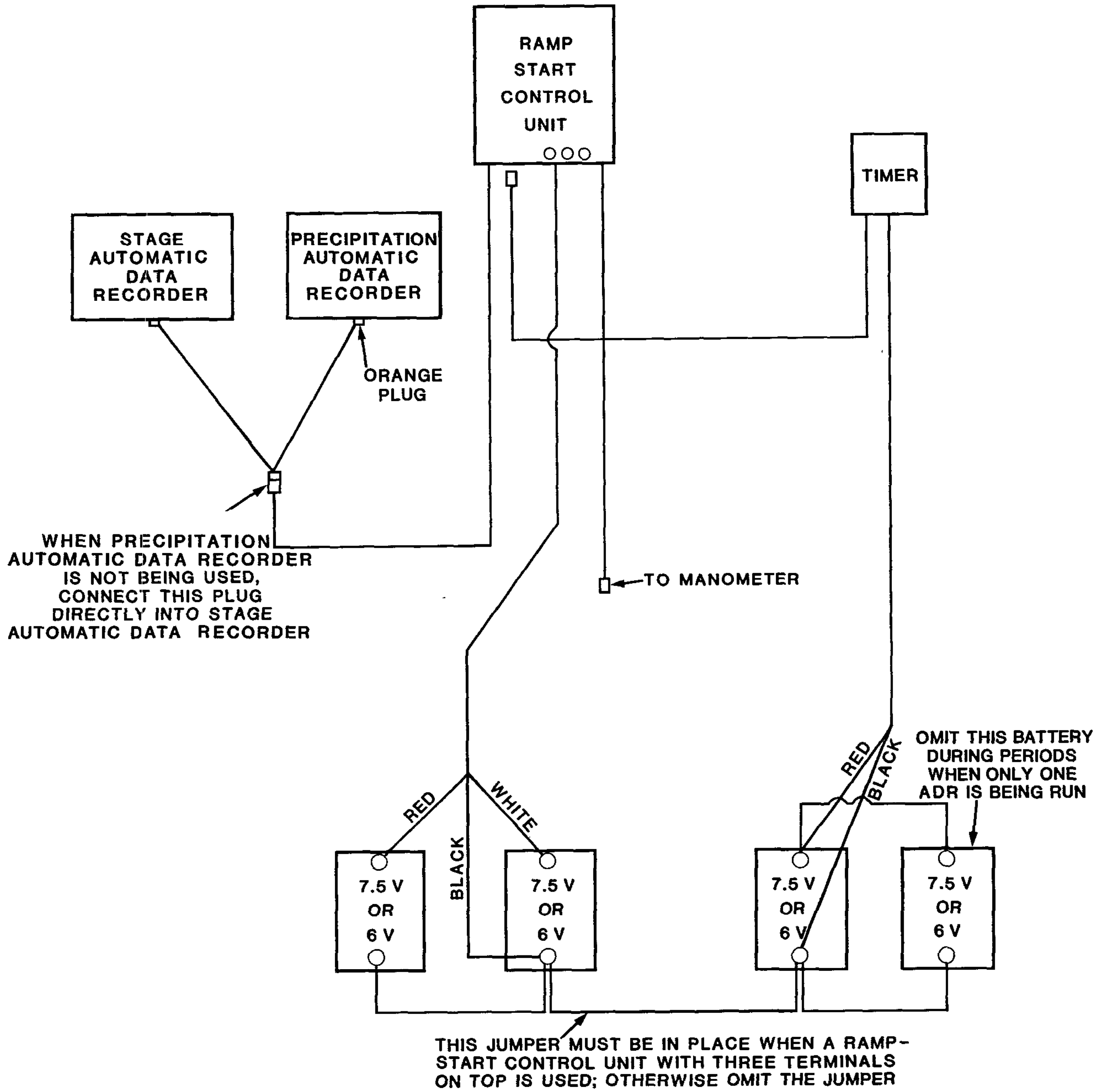


Figure 25.--Wiring diagram for use with ramp-start control and precipitation automatic data recorder.

carefully observing the color coding of the wires. The manometer will not operate if the polarity of the batteries is reversed. The servo-control unit should not be connected to the manometer at this time.

Recorder

Drive sprocket.--Place the desired sprocket (see section on operation with graphic recorder) on the float-wheel shaft of the graphic or digital recorder in place of the float wheel. (Note that, by loosening the right-hand and left-hand screws in the retaining disc, the float-wheel shaft of the recorder can be rotated in the usual manner to check reversal points and to set pen.) Connect the ends of the $1/2$-inch ladder drive chain and place the chain over the sprockets. With the graphic recorder and 1 to 12 gage-height ratio, a 22-inch length of chain is used; with the 1 to 16 ratio, the chain can be shortened if desired. For the ADR, the chain lengths are 31 inches and 23 inches with the jack shaft and 37 $1/2$ inches without.

Placement and leveling.--Level the recorder on the shelf. Move the recorder into place to properly line up and tighten the drive chain, leaving a little slack in the chain. When the chain is properly tightened, check the recorder leveling and secure the recorder in place with foot screws as usual.

A step-by-step procedure for smooth and fast installation of the gagehouse equipment follows:

1. Install battery box (if used) and batteries.
2. Drill holes in floor for bubble- orifice tubes.
3. Install Conoflow regulator assembly. Note arrow on regulator showing direction of gas flow.
4. Install holders and strap to hold nitrogen tank.
5. Install nitrogen tank and tank regulator.
6. Complete tube hookup from tank regulator to Conoflow regulator and attach orifice tube to Conoflow regulator.
7. Start nitrogen flow, and let gas continue to bubble through bubble tube and orifice to clean and dry system. Check for gas leaks.
8. Install manometer mounting bracket and manometer, and adjust level.
9. Hook up pressure tube from Conoflow regulator manifold to pressure cup on manometer.
10. Install mercury and float switch; adjust jewels and points. Mercury level should be about $1/8$ -inch above bottom of pressure cup, which takes a total of about 1 $1/2$ pounds of mercury. The amount varies depending on the model of manometer used.
11. Install control unit, and connect to batteries and manometer.
12. Install graphic recorder (if used).
13. Install digital recorder and timer.
14. Install Telemark (if used).
15. Make final gas test, including high pressure, and check all electrical connections.

OPERATION AND MAINTENANCE

Manometers are more complex than most other water-stage-recording devices. Successful operation requires alertness and the ability to recognize and diagnose malfunctions, some of which may be subtle. Familiarity with these instruments leads to instinctive recognition of common trouble symptoms. The general procedure described below is intended as an aid in developing this instinct.

Observation

The first and most important step in manometer operation is observation. Items that should always be given attention during routine manometer inspection are listed below:

1. Relation between outside and inside gage readings.
2. Relation of mercury surfaces in pressure reservoir and in float-switch reservoir.
3. Quantity of mercury in pressure reservoir and stability of surface.
4. Appearance of recorder chart.
   a. Magnitude of steps.
   b. Painting of pen trace (surge).
   c. Flattened crests and troughs.
   d. Intermittent failure of manometer to follow stage.
   e. Sudden breaks in continuity of record.
   f. Frequent "inspection marks."
   g. Sags in pen trace for short periods.
   h. Rapid rise to limit during cold weather.
   i. One-way operation (up or down only).
5. Bubble rate.
6. Gas pressure.

Electrical Malfunction

If no abnormalities are evident, good operation may be assumed, and no further attention is needed. If electrical malfunctions are indicated by chart appearance, the following items should be considered:

1. Condition of float-switch points, jewels, and float.
2. Motor performance.
3. Servo-control unit response.
4. Battery voltage.

Common Problems and Suggestions

If performance of the manometer is not satisfactory, as judged from the above observations, steps should be taken to improve it. Factors causing poor operation and suggestions for correcting them are listed below.

1. A stage reading on the counter that is higher than the outside-gage reading and is not due to orifice movement is common and serious. Obstructions in the bubble tube, usually oil or water, cause the difference between the inside and outside gage readings to increase slowly over a period of months. If the obstruction is not removed, operation of the gage will become increasingly unreliable, eventually causing severe painting or hunting. The oil or water can be removed by forcing a solvent, which itself can be easily removed, through the tubing. One quart of n-hexane (available from bulk-petroleum distributors) can be forced through the tubing by use of a pressure-tank garden sprayer. The spray nozzle is replaced by a fitting that connects the bubble tube to the sprayer hose. The pressure pump

will force the solvent through the line easily if the orifice is only a few feet under water. After the line is purged, it should be flushed with nitrogen to remove the heavy solvent fumes which otherwise would affect gage operation for a few days. The flushing nitrogen should be taken from the bypass system or the regulator, not from the sight-feed outlet. The source of contaminating oil is usually the sight-feed valve when the bubble rate is too fast.

A low inside-gagereading is unusual and is generally caused by orifice movement or a gas leak. The orifice anchorage and all fittings in the gas line should be checked. If the counter reads low only during high stages, drawdown or incorrect setting of the manometer angle is likely. The angle should be changed only after a careful analysis of variation versus stage to insure that the relation is linear.

Orifices in highly minera lized water often become obstructed or completely closed by mineral deposits that build up at the river end of the orifice. This can be corrected by using a short length of larger ID tube at the river end. A 1/4-inch ID copper tube orifice fitting can be reamed periodically to remove any buildup. Gas other than nitrogen may also correct this condition.

2. The vertical displacement of mercury in the manometer should indicate the distance of the orifice below water surface. Lack of displacement shows that the orifice may be above water. Negative displacement shows a vacuum, which, though uncommon, may be highly significant. This condition is relieved by venting the float-switch reservoir to the atmosphere.
3. Mercury in the pressure reservoir should just cover the reservoir surface at lowest operating temperature. Less mercury causes erratic operation. Excess mercury is much less harmful.

   Pulsation of themercury surface indicates orifice trouble unless the orifice is in rough water. This pulsation causes either stepped or painted pen tracings, depending on the delay circuit. Amplitude of the surge can sometimes be minimized by slowing the bubble rate to the lowest value that other conditions will permit. Better operation may be obtained by cleaning the orifice, moving it to quiet water, or pointing the tube vertically downward.
4. Appearance of the graphic-recorder chart is the prime indicator of manometer performance. The symptoms of malperformance are much more difficult to find on a digital tape than on a graphic chart. The careful scanning of a digital record can be better done after it has been translated, but the best field analysis possible is well worth the effort.

a. The size of step is not related to contact-point spacing at all. It is a function of motor speed, electrical resistance through the float-switch contacts (affected by cleanliness), water-surface surge, bubble rate, and delay-circuit characteristics. Stepping can often be minimized by use of a 1-rpm motor instead of the standard 5-rpm motor on the screw-type manometer. In the STACOM, a gear change (M-7) may be used to control speed of the manometer. This will permit the unit to follow only stage changes slower than 3 feet per hour. The delay circuit changes surge into steps. The step size is usually equal to the amplitude of the surge. Sometimes careful location of the orifice in quiet water will minimize steps. The slowest permissible bubble rate will minimize some stepping. Large steps may also be due to servo-control malfunction. The servo-control unit should be replaced, and the one thought to be malfunctioning should be brought in for tests and repairs.

b. Painting at low stages is almost always due to an obstruction in the gas line or at the orifice. (See figure 21 for procedure to flush gas line.) If the orifice is horizontal, the painting may be stopped by pointing the orifice down. Float-switch jewels that are faulty or too tight or float-switch contacts that are set too closely may cause painting. Welding of the contact points will cause the recorder to paint, but welding also indicates other electrical difficulties.

c. Float-switch contacts that are too far apart cause long flat spots at the tops of rises or at troughs.

d. Intermittent malfunctions might be corrected by replacing the entire servo-control unit and motor. Field repairs are impractical.

e. Debris catching on or being washed off the orifice will cause sudden breaks in the record. Swimmers or animals stepping on or lifting a lightly anchored orifice will have the same effect. Clean and reanchor the orifice if necessary.

f. Inspection marks not made intentionally are usually made by sticking points (tight jewels) or sticking relays. Adjust jewels, or replace control unit. Some combinations of control units and certain motors cause unintentional inspection marks by frequent overrun.

g. Gas leaks are most frequent when the temperature is changing rapidly. Scratching in the tubing under the

Swagelock fittings is a prolific source of leaks. A light coating of black Permatex on the tubing and under the ferrule will prevent leaks due to scratches. Some sight-feed components were furnished with brass ferrules, which should be replaced with nylon ferrules. Intermittent leaks are very difficult to find unless the joint is leaking when the hydrographer is present.

h. A frozen orifice or ice in the bubble tube causes the pressure reservoir to rise as high as the gas pressure or limit switch will allow. This causes the mercury to blow out at times. If this has occurred and the orifice has thawed, install fresh mercury or recover mercury from the overflow reservoir. (Do not sweep up and reuse the spilled mercury, as it will have a lower specific gravity than new mercury.) Set the bubble rate and line pressure as low as practicable during cold weather. Check all soldered joints carefully, as the blown mercury may have rotted them.

i. The set screw on the float may have vibrated out of adjustment so that the armature does not touch one of the contacts. A fitting under the mercury may have vibrated up to interfere with the float and armature. Repairs are obvious in these cases. A tripped circuit breaker or blown fuse may cause one-way operation only. The control unit may be faulty.

5. Bubble rates higher than 60 per minute may contaminate the orifice tube with silicon oil from the sight feed and cause poor operation. Rates too low can cause the record to lag during rapid rises in stage, which will show as a straight line instead of a curve on the rising limb of a flood hydrograph. A sight-feed valve in good operation will hold its rate within close limits. Rapid changes in rate or inability to hold settings are usually due to lint in the needle valve. Lint is easily removed, but extensive repairs are impractical in the field.

6. Tank pressure should fall about 100 psi per month (112 cubic-foot cylinder, 60 bubbles per minute). A more rapid pressure loss indicates leaks. Changes in temperature between successive readings will affect pressure loss. Line pressure of 22 psi will operate a 50-foot bubble gage throughout its range, and 15 psi will suffice for a 35-foot model. Low line pressure limits operating range.

7. Float-switch jewels that are too tight or too loose cause erratic operation (fig. 22.) They should be on the loose side when set during most normal opera-

ting conditions. However, they should be set as tightly as operation permits during cold weather. The screw (roll pin) on the float should just touch the mercury surface when all the mercury that will drain has been drained. Any deeper submergence may impede the armature. The contact points should be scraped from time to time with a burnishing tool or a sharp-edged tool.

8. A motor in excellent adjustment will run from one fresh flashlight D cell. A motor that will not start with two cells should be replaced. Field cleaning of motors is not generally practical but can be done as a last resort.
9. The response should be quick and clean when the servo-control unit delay switch is off. The up and down delay times should be about the same. If the responses are not satisfactory, try a jumper wire from mercury ground to each contact point head (in turn) to rule out float-switch troubles. The float-switch armature must be in null position while the jumper is connected. Also check voltage at motor leads before replacing the control unit.
10. Batteries go dead quickly in cold weather if the motor becomes too stiff to start. Painting is especially hard on batteries. If voltage is found to be low for no obvious reason, the mechanical parts of the manometer should be checked for binding bearings or gears.

Complex testing devicesare available that can pinpoint a faulty relay or diode and can measure float-switch resistance. However, these are rarely needed. The best testing apparatus is the graphic recorder. With this, a simple voltmeter, and the procedure suggested above, almost all malfunctions can be corrected or prevented by the hydrographer on a routine trip. Once the hydrographer is familiar with the general procedure, it need take no more time than servicing the water-stage recorder. Without alert observation and trouble-shooting, high-quality records of stage from manometers (or any other gage) are impossible to obtain. With skillful maintenance, an excellent stage record can be collected at less expense and with less effort with the STACOM maonometer than with any other type of gage at most locations.

PROCEDURE FOR CHANGING GAS CYLINDER

1. Refer to figure 21. Turn off valve to manometer. (1)
2. Turn off valve at cylinder.
3. Close Conoflow sight-feed valve. (2)
4. Close river line. (3)
5. Remove regulator screw.
6. Remove old cylinder and secure new cylinder in place. Open valve of new cylinder for a second or so to blow

out any dirt or dust before connecting regulator.

7. Open cylinder valve slowly until tank pressure gage shows full tank pressure. Open valve completely.
8. Close cylinder valve and watch tank pressure gage. If it returns slowly to zero, either the inlet connection nut or the cylinder valve-stem packing is leaking. If the connection nut is leaking, the condition must be corrected.
9. Open cylinder valve slowly and completely.
10. Open bypass valve. (4)
11. Replace backout screw in regulator and adjust to desired pressure.
12. Close bypass valve. (4)
13. Open Conoflow sight feed. (2)
14. Open river line. (3)
15. Open valve to manometer. Gage should now be back in operation.

APPENDIX

STACOM Manometer Parts List, p. 48-53

Screw-Type Manometer Parts List, p. 54-57

PC NO	NAME	MAT	QUAN	NOTES	DETAIL DWG. NO
	BASE PLATE - COMPONENTS & FITTINGS				
1-35	BASE PLATE (MODEL 35)	CAST AL. TOOLING PL	1	3/8 x 9 x 49 3/8 ETCH & CLEAR ANODIZE	8
1-50	BASE PLATE (MODEL 50)	CAST AL. TOOLING PL	1	3/8 x 9 x 65 3/8 ETCH & CLEAR ANODIZE	8
2-35	SUPPORT, TRACK (MODEL 35)	2024 T4 AL	2	1/2 x 1 x 38 1/8 ETCH & CLEAR ANODIZE	9
2-50	SUPPORT, TRACK (MODEL 50)	2024 T4 AL.	2	1/2 x 1 x 54 1/4 ETCH & CLEAR ANODIZE	9
3-35	TRACK, RIGHT (MODEL 35)	BRASS	1	1/8 x 3/4 x 38 1/8 CHROME PLATE	9
3-50	TRACK, RIGHT (MODEL 50)	BRASS	1	1/8 x 3/4 x 54 1/4 CHROME PLATE	9
4-35	TRACK, LEFT (MODEL 35)	BRASS	1	1/8 x 3/4 x 40 CHROME PLATE	9
4-50	TRACK, LEFT (MODEL 50)	BRASS	1	1/8 x 3/4 x 56 1/8 CHROME PLATE	9
5	FLOAT SWITCH PLATFORM	2024 T4 AL.	1	ETCH & CLEAR ANODIZE	10
6	STAND - OFF	2024 T4 AL	3	ETCH & CLEAR ANODIZE	10
7	ADAPTER PLATE, CHASSIS PLUG	2024 T4 AL	1	ETCH & CLEAR ANODIZE	10
8	STOP, ADJUSTMENT SCREW	2024 T4 AL	1	ETCH & CLEAR ANODIZE	10
9	BRACKET, UPPER LIMIT SWITCH	2024 T4 AL	1	ETCH & CLEAR ANODIZE	10
10	BRACKET, LOWER LIMIT SWITCH	2024 T4 AL.	1	ETCH & CLEAR ANODIZE	10
11	SPACER, LOCK KEEPER	2024 T4 AL	8	ETCH & CLEAR ANODIZE	10
12	KEEPER, LOCK	STL CAD PLATED	4	SIMMONS FASTNER CORP, FOR #3 LINK-LOCK	5
13	HOLE PLUG, SNAP-ACTION	STEEL	1	1/2 HOLE SIZE, NICKEL PLATED	5
14	HOLE PLUG, SNAP-ACTION	STEEL	3	1/4 HOLE SIZE, NICKEL PLATED	5
15	CABLE CLAMP	PLASTIC	1	1/8 SIZE	7
16	CABLE CLAMP	PLASTIC	3	3/16 SIZE	5
17	CABLE CLAMP	PLASTIC	1	3/8 SIZE	7
18	TUBE FITTING, MALE CONNECTOR	BRASS ZYTEL FERRULES	1	CRAWFORD #500-1-4 1/4 O.D TUBE - 1/4 NPT REDRILL BODY LET "P" (.323 DIA) DRILL	5
19	LIMIT SWITCH	–	2	MICRO # V3-1	5
(A) 20-35	ROLLER CHAIN 304	STAIN STL.	348 PITCHES	DAIDO #RC2555 1/4" PITCH (7'-3")	5
(A) 20-50	ROLLER CHAIN 304	STAIN STL.	476 PITCHES	DAIDO #RC2555 1/4" PITCH (9'-11")	5
(A) ~~21~~	~~CONNECTOR, CABLE BELT~~		~~1~~	~~BERG #8CCR-7~~	5
22	MACH SCR, FL HD	STAIN STL	6	1/4-20 NC - 2 x 1	7
23	MACH SCR. PAN. HD	STAIN STL	16 MOD.35 22 MOD.50	8-32 NC - 2 x 1 1/2	5
24	MACH SCR FL. HD	STAIN STL.	2	6-32 NC - 2 x 3/4	5
25	MACH SCR, PAN HD	STAIN STL	9	6-32 NC - 2 x 1/2	5
26	MACH SCR, PAN HD	STAIN STL	4	4-40 NC - 2 x 9/16	5
27	MACH SCR. PAN HD	STAIN STL	2	4-40 NC - 2 x 1/2	5
28	MACH SCR, PAN HD	STAIN STL	8	4-40 NC - 2 x 3/8	5
29	MACH SCR, PAN HD	STAIN STL	4	4-40 NC - 2 x 1/4	5
30	SET SCR, SOFT TIP	STAIN STL	2	BERG #SCB-12, 8-32 NC - 2 x 3/8	6
31	WASHER, PLAIN	STAIN STL	5	# 6 SIZE	5
32	WASHER, LOCK	STAIN STL	4	# 6 SIZE	5
33	WASHER, LOCK	STAIN STL	8	# 4 SIZE	5
(B) 34	~~LEVEL BUBBLE ASSEMBLY~~		1	~~0046031~~	
35	BRACKET, BUBBLE VIAL		1	0046032	
36	SCREW, PAN HD.	STAIN. STL.	2	#8-32 UNC-2, X .625 LG	

PC NO.	NAME	MAT	QUAN	NOTES	DETAIL DWG NO	
	MOUNTING BRACKET ASSEMBLY				5	
MB-1	BRACKET	TENZALOY	1	CASTING	11	
MB-2	CAP SCR. HEX HD	STAIN STL	1	3/8-24 NF-2 x 1 1/4	5	
MB-3	WASHER PLAIN	STAIN STL	1	3/8 SIZE	5	
MB-4	MACH SCR. RD HD.	STAIN STL	1	10-32 NF-2 x 1 1/2	5	
	UPPER SPROCKET SHAFT ASSEMBLY				12	
US-1	BEARING HOUSING	2024 T4 AL	1	ETCH & CLEAR ANODISE	12	
US-2	SPROCKET	STAIN STL	1	BERG #25SP175-20	12	(A)
US-3	GEAR	AL / STAIN HUB	1	DYNACO # 151-270	12	
US-4	KNURLED KNOB	STAIN STL	1	BERG # CN1-13 ALTERED	12	
US-5	SHAFT	303 STAIN STL	1	BERG # S6-41 ALTERED	12	
US-6	SPACER	303 STAIN STL	1	3/8 I.D. x 9/16 O.D. x .359 +.000/-.005 LG.	12	(A)
US-7	SPACER	303 STAIN STL	1	BERG # SS2-43	12	
US-8	BEARING	–	2	N.D # 77 R6	12	
US-9	SPRING PIN (ROLL PIN)	STAIN STL.	2	3/32 ϕ x 3/4	12	
US-10	MACH SCR, PAN HD	STAIN STL	2	8-32 NC-2 x 1/2	12	
US-11	SET SCR, SOC. HD.	STAIN STL	2	1/4-20 NC-2 x 1/4, CUP PT	12	(A)
US-12	LOCK WASHER	STAIN STL	2	# 8 SIZE	12	
US-13	HUB	STAIN STL.	1		12	(A)
	PRESSURE CUP ASSEMBLY				19	
PC-1	CUP	ACRYLIC	1	WELD TO PC-2	21	
PC-2	CUP BOTTOM	ACRYLIC	1		21	
PC-3	TUBE FITTING, MALE CONN	ZYTEL	1	CRAWFORD #ZY500-1-4, 5/16 O.D. TUBE - 1/4 NP	19	
PC-4	TUBE FITTING, MALE ELBOW	ZYTEL	1	SWAGELOK #ZY500-2-2	19	
PC-5	MACH SCR PAN HD.	STAIN STL	2	4-40 NC - 2 x 3/8	19	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.010 ANGLE ±0°-30'

DO NOT SCALE THIS DRAWING

REVISIONS			
LTR	REMARKS	DATE	APPROVED
A	SEE REV. SH.	3-4-72	GPS
B	[illegible]	[illegible]	[illegible]

NO.	NAME	MAT.	QUAN.	REQ.

UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY

STACOM MANOMETER - PARTS LIST

Drawn by G. MILES Date 10-21-71

Approved by

SCALE SHEET 1 of 29

0046001-0047001

Rev	PC. NO.	NAME	MAT	QUAN	NOTES	DETAIL DWG. NO.
		OUTPUT & PIVOT SHAFT ASSEMBLY				12
	PS-1	PIVOT	2024 T4 AL.	1	ETCH & CLEAR ANODIZE	13
	PS-2	RETAINER	2024 T4 AL	1	ETCH & CLEAR ANODIZE	13
	PS-3	SHAFT	303 STAIN STL	1	BERG # S6-45 ALTERED	13
	PS-4	SPROCKET HUB	BRASS	1	CHROME PLATE AFTER ASSEMBLY	13
	PS-5	SPROCKET, 30T	BRASS	1	CHROME PLATE AFTER ASSEMBLY	16
	PS-6	SPROCKET, 15T	BRASS	1	CHROME PLATE AFTER ASSEMBLY	13
	PS-7	BEARING	——	2	N D # 77 R6	12
	PS-8	BEARING, PLAIN CYLINDRICAL	POROUS BRONZE	1	BOSTON # B-2024-10	12
	PS-9	BEARING, THRUST	POROUS BRONZE	2	BOSTON # TB-2028	12
	PS-10	GEAR	STAIN STL	1	PIC # G3-75	12
	PS-11	SPACER	STAIN STL.	1	BERG # 552-43	12
	PS-12	SPRING PIN	STAIN. STL	1	1/16 φ x 1/2 LG	12
	PS-13	MACH SCR, PAN HD	STAIN STL	3	8-32 NF-2 x 1/2	12
	PS-14	SET SCR, SOC HD	STAIN. STL	2	10-24 NC-2 x 1/4 CUP PT	12
	PS-15	SET SCR, SOC HD	STAIN STL	1	8-32 NC-2 x 1/4 CUP PT	12
	PS-16	LOCKWASHER	STAIN STL.	3	#8 SIZE.	12
		LOWER SPROCKET ASSEMBLY				12
	LS-1	BEARING HOUSING	2024 T4 AL	1	ETCH & CLEAR ANODIZE	13
	LS-2	SHAFT	303 STAIN STL	1	BERG # S6-33 ALTERED.	13
(A)	LS-3	SPROCKET, 20 TEETH	STAIN STL.	1	BERG # 25SP175-20	12
	LS-4	COLLAR	STAIN STL	1	BERG # CS-9.	12
	LS-5	SPACER	2024 T4 AL.	1	ETCH & CLEAR ANODIZE	13
	LS-6	BEARING	–	2	ND. # 77 R6	12
	LS-7	SPRING PIN	STAIN STL	1	3/32 φ x 3/4	12
	LS-8	CAP SCR, HEX HD.	STAIN STL.	2	8-32 NC-2 x 3/4	12
	LS-9	SET SCR, SOC	STAIN. STL	1	10-24 NC-2 x 1/4 CUP PT	12
	LS-10	WASHER, PLAIN	STAIN. STL	2	#8 SIZE	12
(A)	LS-11	PIVOT ARM	2024-T4 AL	1	ETCH & CLEAR ANODIZE	28
(A)	LS-12	SHOULDER SCREW	STAIN. STL	1	#10-32	28
(A)	LS-13	SHOULDER SCREW	STAIN. STL	1	#10-32	28
(A)	LS-14	SPRING ANCHOR	STAIN. STL	1	#10-32	28
(A)	LS-15	SPACER	STAIN. STL.	1		28
(A)	LS-16	IDLER	2024-T4 AL	1	ETCH & CLEAR ANODIZE	28
(A)	LS-17	SPRING	STAIN. STL.	1		28
(A)	LS-18	BEARING	BRONZE	1	OIL IMPREGNATED	28
(A)	LS-19	HUB	STAIN STL.	1		12

PC. NO.	NAME	MAT	QUAN.	NOTES	DETAIL DWG. NO.
	COUNTER ASSEMBLY				14
CA-1	BASE PLATE	2024-T4 AL.	1	ETCH & CLEAR ANODIZE	16
CA-2	OUTBOARD PLATE	2024-T4 AL	1	ETCH & CLEAR ANODIZE	16
CA-3	COUNTER SUPPORT	6063-T52 AL	1	MAKE FROM ALCOA SEC #78Y, ETCH & CL. ANOD.	16
CA-4	SHAFT	303 STAIN	1	PIC # A3-30 ALTERED	16
CA-5	GEAR, COUNTER DRIVE	AL	1	PIC # G4-105	14
CA-6	GEAR, COUNTER	AL.	1	PIC # G6Z-21 ALTERED	14
CA-7	GEAR, JACK SHAFT DRIVE	STAIN	1	PIC # G3-25	14
CA-8	BEARING, FLANGED	POR. BRONZE	1	BOSTON # FB-46-3	14
CA-9	BEARING, FLANGED	POR. BRONZE	1	BOSTON # FB-46-2	14
CA-10	COUNTER	—	1	DURANT # 4-Y-40592-402-R-CL	14
CA-11	COLLAR	STAIN	1	PIC # C1-3	14
CA-12	SPACER POST	STAIN	4	PIC # AT-4	14
CA-13	SHOULDER SCR	STAIN	1	PIC # 4315	14
CA-14	MACH SCR PAN HD	STAIN	4	4-40 NC-2 x 1/4	14
CA-15	MACH SCR F. H.	STAIN	4	4-40 NC-2 x 1/2	14
CA-16	MACH SCR PAN HD	STAIN	4	4-40 NC-2 x 1/2	14
CA-17	MACH SCR PAN HD	STAIN	1	6-32 NC-2 x 3/8	14
CA-18	MACH SCR PAN HD	STAIN	2	8-32 NC-2 x 5/8	14
CA-19	SET SCR	STAIN	1	4-40 NC-2 x 1/8 SOC CUP. PT.	14
CA-20	SET SCR	STAIN	1	6-32 NC-2 x 1/8 SOC. CUP. PT.	14
CA-21	WASHER PLAIN	STAIN	1	#6	14
CA-22	WASHER, LOCK	STAIN	4	#4	14
CA-23	WASHER, LOCK	STAIN	2	#8	14
CA-24	ROLL PIN	STAIN	2	1/16 DIA x 1/2 LG	14
	OVERFLOW CHAMBER ASSEMBLY				19
OC-1	CAP	ACRYLIC	1		22
OC-2	BOTTOM	ACRYLIC	1		22
OC-3	BODY	ACRYLIC	1		22
OC-4	VENT	ACRYLIC	1		22
OC-5	PLATE	ACRYLIC	1		22
OC-6	CLAMP, 3/8 I.D.	BRASS	2	NICKLE PLATED CINCH-JONES #CC-161-6	5 & 7
OC-7	TUBING	TYGON	21"	CLEAR 5/16" O.D. x 3/16" I.D.	5 & 7

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.010 ANGLE ±0°30'

DO NOT SCALE THIS DRAWING

REVISIONS

LTR	REMARKS	DATE	APPROVED
A	SEE REV SH.	2-4-77	GFS

NO.	NAME	MAT.	QUAN.	REM.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STACOM MANOMETER - PARTS LIST

Drawn by G. MILES Date 10-22-71
Approved by Date
SCALE SHEET 2 of 29

0046002-0047002

PC NO.	NAME	MAT	QUAN	NOTES	DETAIL DWG NO
	MOTOR ASSEMBLY				15
M-1	MOTOR PLATE	2024-T4-AL	1	ETCH & CLEAR ANODIZE	16
M-2	BASE PLATE	2024-T4-AL	1	ETCH & CLEAR ANODIZE	17
M-3	SPACER MOTOR PLATE	2024-T4-AL	2	ETCH & CLEAR ANODIZE	17
M-4	FINGER TAB	6063-T52-AL	1	ALCOA SEC #1944 ETCH & CLEAR ANODIZE	17
M-5	JACK BRACKET	EPOXY BOARD	1		17
M-6	MOTOR 6V DC	—	1	BARBER-COLMAN #CYQM-23110-7	17
M-7	GEAR, MOTOR	STAIN	1	DYNACO #154-20 (ALTERED ADDITIONAL SET SCR 90° FROM EXISTING ONE.)	15
M-8	SHOULDER SCREW	STAIN	1	PIC. #4328	15
M-9	MACH SCR. PAN HD	STAIN	1	8-32NC-2 x 5/8	15
M-10	MACH SCR PAN HD	STAIN	2	8-32NC-2 x 1/2	15
M-11	MACH SCR F.H	STAIN	4	4-40NC-2 x 1/2	15
M-12	MACH SCR PAN HD	STAIN	2	4-40NC-2 x 9/16	15
M-13	MACH SCR PAN HD	STAIN	2	4-40NC-2 x 1/2	15
M-14	MACH SCR PAN HD	STAIN	2	4-40NC-2 x 1/4	15
M-15	SET SCR	STAIN	2	6-32NC-2 x 1/8 SOC CUP PT	15
M-16	WASHER, LOCK	STAIN	2	#8	15
M-17	WASHER, LOCK	STAIN	6	#4	15
M-18	WASHER, PLAIN	STAIN	1	#8	15
M-19	JACK	—	1	SWITCHCRAFT #41 JAX	15
M-20	PLUG	—	1	SWITCHCRAFT #755	15
	WIRING & ELECTRICAL COMPONENTS.				
E-1	CABLE, LIMIT SWITCH	—	41" MOD.35 57" MOD.50	BELDON #8443 (3 COND)	23
E-2	HOOK-UP WIRE	#22 STRANDED COPPER	1	RED & WHITE 3" LG	23
E-3	HOOK-UP WIRE	#22 STRANDED COPPER	1	YELLOW 3" LG	23
E-4	HOOK-UP WIRE	#22 STRANDED COPPER	1	WHITE 15" LG	23
E-5	HOOK-UP WIRE	#22 STRANDED COPPER	1	GREEN 9" LG	23
E-6	HOOK-UP WIRE	#22 STRANDED COPPER	1	BLACK 12" LG	23
E-7	DIODE	—	1	GE IN91	23
E-8	JACK & SLEEVE ASSEMBLY	—	1	E F JOHNSON #105-701 (WHITE)	23
E-9	JACK & SLEEVE ASSEMBLY	—	1	E.F JOHNSON #105-704 (GREEN)	23
E-10	CHASSIS PLUG, 5 TERM	—	1	AMPHENOL OR CANNON MS 3102A14S-5P	23
E-11	TERMINAL, SOLDERLESS	—	8	AMP #31880 RING TYPE	23
E-12	TERMINAL, SOLDERLESS	—	1	AMP #34313 HOOK TYPE	23
E-13	INSULATION SLEEVE	PLASTIC	5	#604 (106 I D) WALSCO FLEXITUBE 1/4" LG	5
E-14	BATTERY, 6 VOLT	—	2	EVEREADY HOTSHOT #1461 OR EQUAL	23
E-15	55 SERVO CONTROL (U S G S. SPEC)	—	1	NOT FURNISHED BY CONTRACTOR	23

PC NO	NAME	MAT	QUAN	NOTES	DETAIL DWG NO.
	FLOAT SWITCH ASSEMBLY				19
FS-1	CAP	ACRYLIC	1		20
FS-2	STACK	ACRYLIC	1	WELD TO FS-3	20
FS-3	COVER, FLOAT CUP	ACRYLIC	1		20
FS-4	FLOAT CUP	ACRYLIC	1		20
FS-5	OVER FLOW PORT	ACRYLIC	1	WELD TO FS-4	20
FS-6	PLUG	ACRYLIC	1	WELD TO FS-5	20
FS-7	FLOAT	303 STAIN STL	1		20
FS-8	MAST	303 STAIN STL	1	MAKE FROM PIC #AB-6 PREC. SHAFTING	21
FS-9	CONTACT HOLDER	303 STAIN STL	2	1/4" HEX STOCK	21
FS-10	CONTACT HOLDER EXTENSION	303 STAIN STL	2	MAKE FROM PIC #AB-24 PREC SHAFTING	21
FS-11	CONTACT	90% PLATINUM 10% IRIDIUM	2	.025 DIA WIRE	21
FS-12	CONTACT	90% PLATINUM 10% IRIDIUM	1	.025 DIA WIRE	21
FS-13	TUBE FITTING, MALE CONNECTOR	STAIN STL BODY ZYTEL FERRULES	1	CRAWFORD #500-1-4-316 ALTERED	21
FS-14	TUBE FITTING, MALE CONNECTOR	ZYTEL	2	SWAGELOK #ZY-100-1-1, BODY REAMED TO 1/16 DIA	19
FS-15	BRACKET	BRASS CHROME PLATE	1	SAME AS CR-2 SEE SH #18	19
FS-16	PIVOT, BRACKET	STAIN STL	1	PIC #DS-375 DOWEL PIN.	19
FS-17	PIVOT, MAST	STAIN STL	1	.030 DIA x 1/4 LG DUTONE CO	19
FS-18	BEARING, JEWEL	—	2	BRASS-SAPPHIRE, V TYPE, 6-40NF-2 x 5/16 LG	19
FS-19	SEAL "O" RING	NEOPRENE	1	NOM 3/4 I.D x 1/8 DIA SEC	19
FS-20	SEAL "O" RING	NEOPRENE	1	NOM 1 5/8 I.D x 1/8 DIA SEC	19
FS-21	MACH SCR HEX HD	STAIN STL.	1	10-32NF-2 x 7/16 HEX HD	19
FS-22	MACH SCR PAN HD	STAIN STL.	3	4-40NC-2 x 1"	19
FS-23	MACH. SCR PAN HD	STAIN STL	3	4-40NC-2 x 1/2	19
FS-24	MACH. SCR PAN HD	STAIN STL	2	4-40NC-2 x 3/8	19
FS-25	MACH. SCR PAN HD	STAIN STL	1	4-40NC-2 x 1/8	19
FS-26	WASHER, PLAIN	STAIN STL.	1	#10 SIZE.	19
FS-27	SPRING PIN (ROLL)	STAIN STL.	1	3/32 DIA. x 7/16 LONG	19

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ±1/64
DECIMALS ±.010 ANGLE ±0°-30'
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REVISIONS			
LTR	REMARKS	DATE	APPROVED

NO.	NAME	MAT.	QUAN.	REM.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STACOM MANOMETER - PARTS LIST

Drawn by G MILES Date 10-22-71
Approved by Date
SCALE SHEET 3 of 29

0046003-0047003

PC. NO.	NAME	MAT	QUAN.	NOTES	DETAIL DWG. NO.
	PRESSURE CUP CARRIAGE ASSEMBLY.				15
CR-1	CARRIAGE PLATE	2024 T4 AL	1	ETCH & CLEAR ANODIZE	18
CR-2	CUP BRACKET	BRASS CHROME FINISH	1	ONE ALSO REQD. IN FLOAT SWITCH ASSEM-BLY. IDENTIFIED FS-15 ON SHT. #19	18
CR-3	CARRIAGE PIVOT ARM	2024 T4 AL	1	ETCH & CLEAR ANODIZE	18
CR-4	ROLLER, PIVOTED	DELRIN	1		18
CR-5	ROLLER, FIXED	DELRIN	2		18
CR-6	BELT ANCHOR, UPPER	2024 T4 AL	1	ETCH & CLEAR ANODIZE	18
CR-7	BELT ANCHOR, LOWER	2024 T4 AL.	1	ETCH & CLEAR ANODIZE	18
CR-8	SPRING ANCHOR, SHORT	303 STAIN	1	MAKE FROM PIC. SH SCR #4310	18
CR-9	SPRING ANCHOR, LONG	303 STAIN	1	MAKE FROM PIC. SH SCR #4313	18
CR-10	SPRING	STAIN	1	MAKE FROM PIC. #AZ-3	18
CR-11	SHOULDER SCR	STAIN	1	PIC #4329 ALTERED (PIVOTED ROLLER)	15
CR-12	SHOULDER SCR	STAIN	2	PIC #4331 (FIXED ROLLER)	15
CR-13	SHOULDER SCR	STAIN	1	PIC #4316	15
CR-14	PIN	STAIN	1	PIC #D5-375	15
CR-15	MACH SCR HEX HD	STAIN	1	10-32 NF-2 x $\frac{7}{16}$	15
CR-16	MACH SCR PAN HD	STAIN	4	8-32 NC-2 x $\frac{1}{2}$	15
CR-17	~~SET SCR~~	~~STAIN~~	~~2~~	~~6-32 NC-2 x $\frac{1}{4}$ SOC, CUP PT~~	15
CR-18	WASHER, PLAIN	STAIN	1	#10	15
	ACCESSORIES				
A-1	WOOD SCR, RD. HD SLOTTED	STAIN STL	4	#10 x $1\frac{1}{2}$ (FOR SHELF MTG OF BRACKET MB-1)	
A-2	LAG BOLTS	STEEL	2	$\frac{1}{4}$ x 1 LG (FOR MTG REGULATOR ASSEMBLY)	
A-3	HEX KEY WRENCH	STEEL	1	#4 SIZE	
A-4	HEX KEY WRENCH	STEEL	1	#6 SIZE	
A-5	HEX KEY WRENCH	STEEL	1	#8 SIZE	
A-6	HEX KEY WRENCH	STEEL	1	#10 SIZE	
A-7	MERCURY, TRIPLE DISTILLED	—	$1\frac{1}{2}$ LB.	SHIP IN PLASTIC BOTTLE CONTAINER	
A-8	SILICON FLUID, DOW CORNING #200		1 LB	VISCOSITY @ 25°C, 50 CS	

NOTE : ITEMS A-1 THRU A-6 TO BE SHIPPED IN 3x6 MANILA ENVELOPE PROPERLY INDENTIFIED.

PC. NO.	NAME	MAT.	QUAN.	NOTES	DETAIL DWG. NO.
	PROTRACTOR ASSEMBLY				5 & 6
P-1	LEVEL INDICATOR ARM	2024 T4 AL.	1	ETCH & CLEAR ANODIZE	17
P-2	PIN, PLUMB BOB	2024 T4 AL	1	ETCH & CLEAR ANODIZE	17
P-3	KEEPER	2024 T4 AL	1	ETCH & CLEAR ANODIZE	17
P-4	SPACER	NYLON	1		17
P-5	INDEX PLATE, °F	ALUMINUM	1	ETCHED.	17
P-6	LEVEL VIAL, .310 DIA. x 1" LG	—	1	WA MOYER & SONS, INC. #M310-1-50ARCH METALLIC SEAL, 50 MINUTES PER 1/10"	6
P-7	SHOULDER SCREW	STAIN STL	1	PIC #4331	6
P-8	KNURLED THUMB SCREW	BRASS	1	10-32NF-2 x $\frac{1}{2}$ BRIGHT NICKEL PLATED	6
P-9	MACH SCR, F.H	STAIN STL	1	10-24 NC-2 x $1\frac{1}{4}$"	6
P-10	MACH SCR, BIND HD.	STAIN STL.	2	4-40 NC-2 x $\frac{1}{4}$"	6

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.010 ANGLE ±0°-30' DO NOT SCALE THIS DRAWING

REVISIONS			
LTR	REMARKS	DATE	APPROVED
A1	DELETE CR-17	2-4-77	GJS

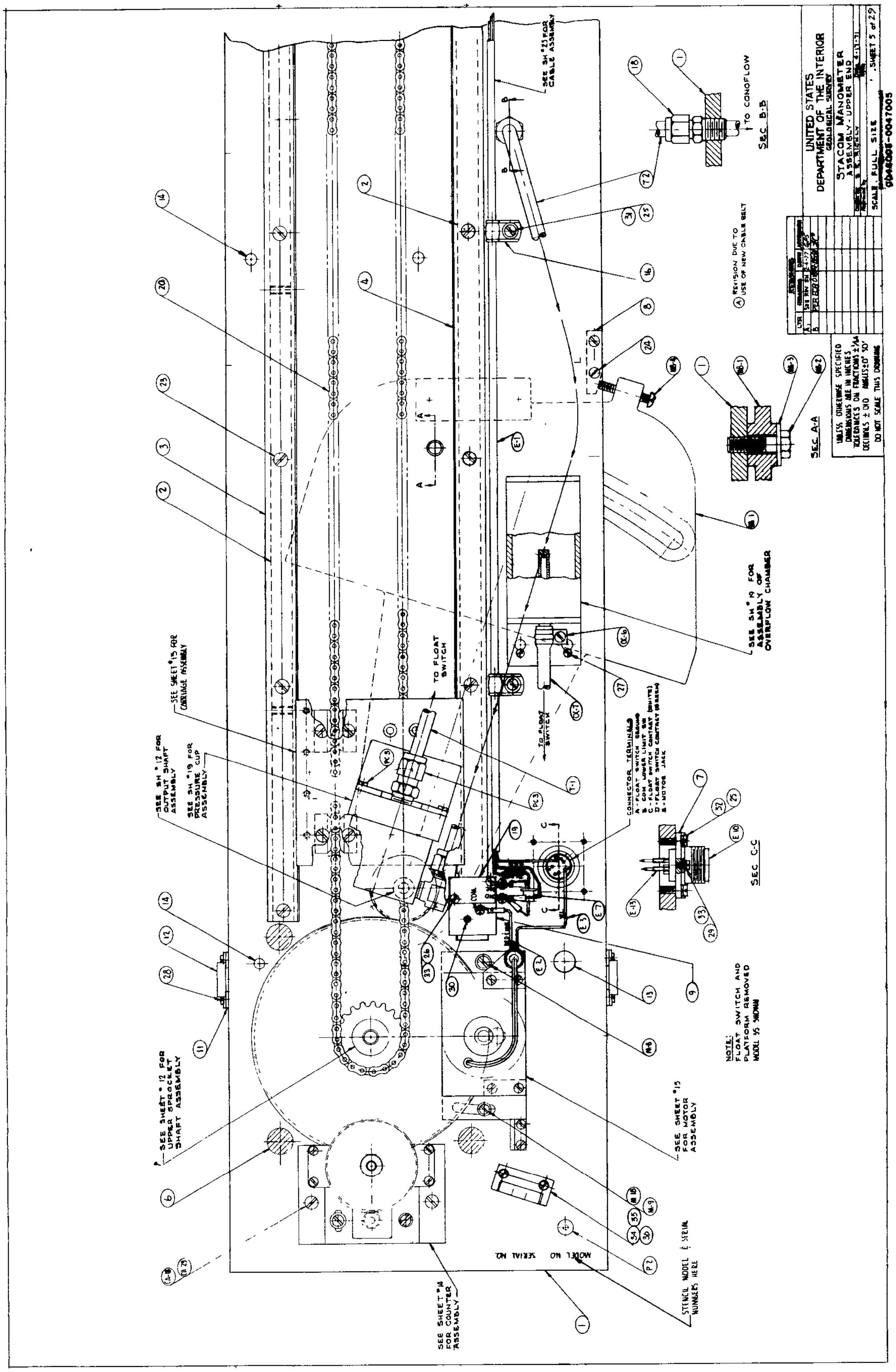
NO.	NAME	MAT.	QUAN.	REM.

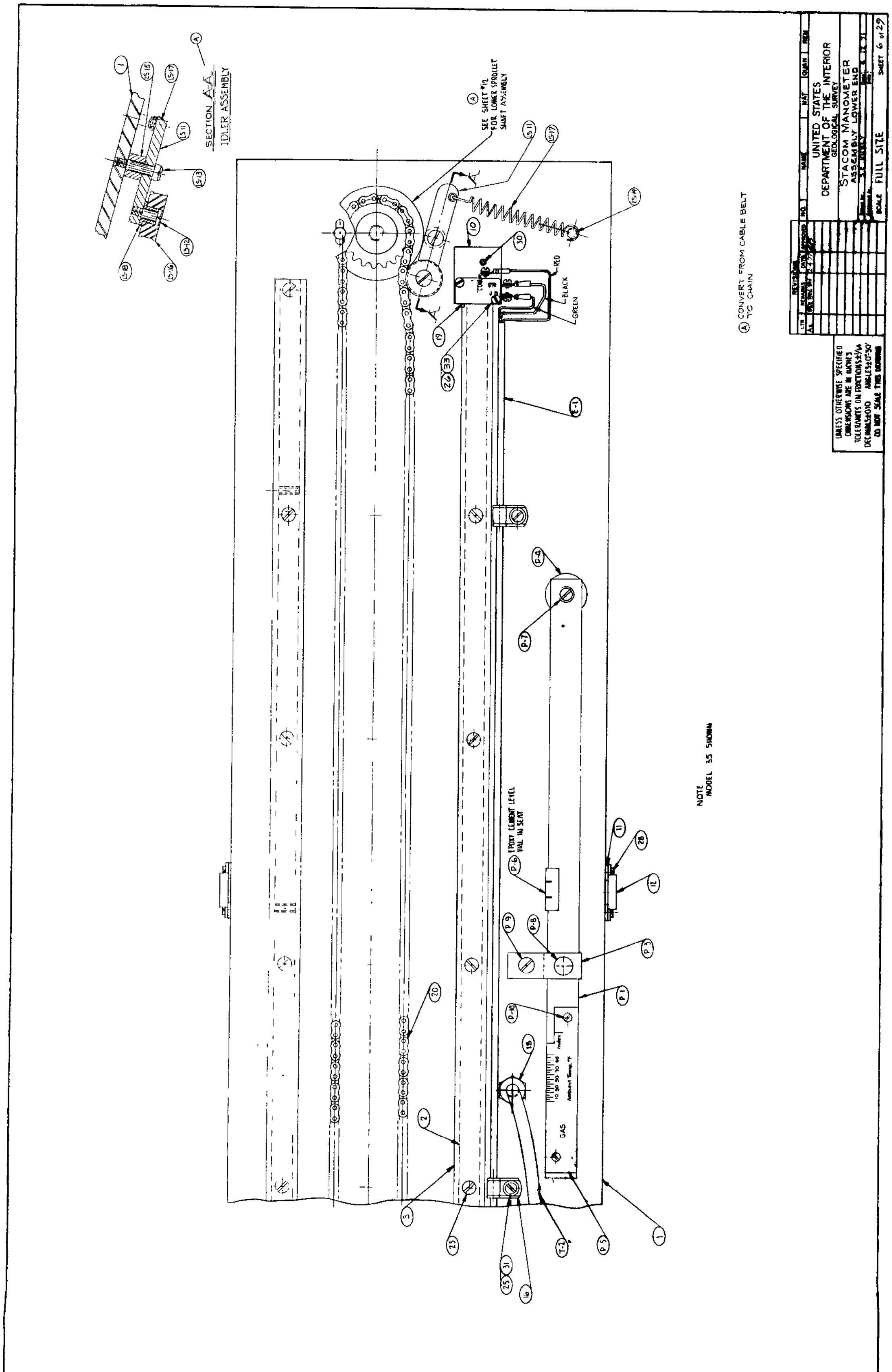
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STACOM MANOMETER - PARTS LIST

Drawn by G. MILES Date 10-22-71
Approved by Date
SCALE SHEET 4 of 29

0046004-0047004


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STACOM MANOMETER
ASSEMBLY - UPPER END
SCALE FULL SIZE
SHEET 5 of 29
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/64 DECIMALS ± .010 ANGLES ± 0° 30'
DO NOT SCALE THIS DRAWING
SEC A-A
SEC B-B
SEC C-C
TO CONOFLOW
A REVISION DUE TO USE OF NEW CABLE BELT
SEE SH. #21 FOR CABLE ASSEMBLY
SEE SH. #10 FOR ASSEMBLY OF OVERFLOW CHAMBER
CONNECTOR TERMINALS
TO FLOAT SWITCH
SEE SHEET #15 FOR CARRIAGE ASSEMBLY
SEE SH. #12 FOR OUTPUT SHAFT ASSEMBLY
SEE SH. #19 FOR PRESSURE CUP ASSEMBLY
SEE SHEET #12 FOR UPPER SPROCKET SHAFT ASSEMBLY
SEE SHEET #15 FOR MOTOR ASSEMBLY
SEE SHEET #14 FOR COUNTER ASSEMBLY
NOTE: FLOAT SWITCH AND PLATFORM REMOVED MODEL 55 SHOWN
STENCIL MODEL & SERIAL NUMBERS HERE
MODEL NO. SERIAL NO.


SECTION A-A
IDLER ASSEMBLY
SEE SHEET #12 FOR LOWER SPROCKET SHAFT ASSEMBLY
RED
BLACK
GREEN
CONVERT FROM CABLE BELT TO CHAIN
EPOXY CEMENT LEVEL VIAL IN SEAT
NOTE
MODEL 35 SHOWN
GAS
REVISIONS
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STACOM MANOMETER
ASSEMBLY LOWER END
FULL SIZE
SHEET 6 of 29
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ±1/64
DECIMALS ±.010 ANGLES ±0°-30'
DO NOT SCALE THIS DRAWING

PC. NO.	NAME	MAT	QUAN. MOD 45	QUAN. MOD 60	NOTES	DETAIL DWG. NO
1-1	BASE (MODEL 45)	2024 T4 AL	1	—	FINISH - GRAY ANODIZE	5
1-2	BASE (MODEL 60)	2024 T4 AL	—	1	FINISH - GRAY ANODIZE	6
2	HOUSING, BEARING	BRASS	1	1	CHROME PLATE	7
3	NUT, JAM	BRASS	1	1	CHROME PLATE	7
4	WASHER, FLAT	BRASS	1	1	CHROME PLATE	7
5	SPROCKET HUB	BRASS	1	1	CHROME PLATE	7
6	STANDARD, SCREW BEARING	BRASS	1	1	CHROME PLATE	7
7	INSULATING SLEEVE (E)	CLEAR APVC 105	2	2	3/8 I.D. × .025 WALL × 7/8 L.G.	3 & 4
8	NUT, CARRIAGE	POROUS BRONZE	1	1	OIL IMPREGNATED	7
9	BEARING, SCREW LWR	BRONZE	1	1	CHROME PLATE	7
10	PIN	303 STAIN. STL	1	1		7
11	WRENCH	303 STAIN. STL.	1	1		7
12	SHAFT	303 STAIN. STL	1	1		7
13	MOTOR MOUNT	BRASS	1	1	CHROME PLATE	8
14	GEAR, MOTOR	303 STAIN. STL	1	1	PIC-DESIGN CORP #63-32	8
15	GEAR, COUNTER	BRASS	1	1	CHROME PLATE	8
16	GEAR, SCREW	BRASS	1	1	CHROME PLATE	8
17	COLLAR	BRASS	1	1	CHROME PLATE	8
18	WORM	STEEL	1	1	BOSTON #HDUH - CHROME PL.	8
19	WORM GEAR	BRONZE	1	1	BOSTON #D1137 - CHROME PL.	8
20	SPROCKET	BRASS CHROME FIN.	1	1	SILVER SOLDERED TO PC #5 BEFORE PLATING	8
21	SPROCKET	BRASS CHROME FIN.	1	1	SILVER SOLDER TO PC. #5 BEFORE PLATING	8
22	CLAMP SCREW	303 STAIN. STL.	1	1		8
23	SPRING	STAIN. STL.	1	1	.020 SPRING WIRE	8
24	SCREW, POINTER PIVOT	303 STAIN STL.	1	1		8
25	CARRIAGE BASE	BRASS	1	1	CHROME FINISH	9
26	CARRIAGE PIVOT ARM	BRASS	1	1	CHROME FINISH	9
27	ROLLER SHAFT	303 STAIN STL.	2	2		9
28	ROLLER SHAFT	DO.	1	1		9
29	BRACKET	BRASS	1	1	CHROME FINISH	9
30	ROLLER	BRASS	3	3		9
31	BUSHING	BRASS	1	1		9
32	EXTENSION SPRING	STAIN. STL	1	1	.030 DIA SPRING WIRE	9
33	SPRING ANCHOR	303 STAIN STL.	2	2	1 EACH OF 2 SIZES	9
34-1	LEFT TRACK (MODEL 45)	BRASS	1	-	CHROME FINISH	10
34-2	LEFT TRACK (MODEL 60)	BRASS	-	1	CHROME FINISH	11
35-1	RIGHT TRACK (MODEL 45)	BRASS	1	-	CHROME FINISH	10
35-2	RIGHT TRACK (MODEL 60)	BRASS	—	1	CHROME FINISH	11
36-1	TRACK BASE (MODEL 45)	2024 T4 AL.	2	-	FINISH - GRAY ANODIZE	10
36-2	TRACK BASE (MODEL 60)	DO.	-	2	DO.	11
37	SCREW	303 STAIN STL.	1	1	5 3/8 LG. (MOD. 45) 5 5/8 LG. (MOD 60)	10
38	MICRO SWITCH PLATE	BRASS	2	2	1 AS SHOWN, 1 OPP HAND - CHROME FINISH	11

PC NO.	NAME	MAT.	QUAN MOD 45	QUAN MOD 60	NOTES	DETAIL DWG NO
39	SCALE	ALUMINUM	1	1	RAISED NUMERALS & GRADUATIONS BLACK BACKGROUND	12
40	NAME PLATE	ALUMINUM	1	1	RAISED LETTERS - BLK BACKGROUND	12
41	POINTER	356-T6 AL	1	1	FINISH - GRAY ANODIZE	12
42	MOUNTING BRACKET	356-T6 AL.	1	1	DO.	13
43	MERCURY CUP	PLEXIGLASS	1	1		14
44	MERCURY CUP BOTTOM	DO.	1	1		14
45	FLOAT SWITCH CUP	DO	1	1		14
46	FLOAT CUP COVER	DO.	1	1		14
47	FLOAT STACK	DO.	1	1		14
48	CONTACT CAP	DO.	1	1		14
49	CONTACT HOLDER	BRASS	2	2		14
50	FLOAT	303 STAIN. STL	1	1		14
51	FLOAT MAST	DO	1	1	PIC #AB-6 PRECISION (E) SHAFTING.	14
52	CONTACT	90% PLATINUM 10% IRIDIUM	1	1	.025 DIA. × 1/2 LG	14
53	CONTACT	DO	1	1	.025 DIA. × 3/8 LG	4
54	CONTACT	DO	1	1	.025 DIA. × 1/4 LG.	4
55-1	COVER BODY (MODEL 45)	3003-H14 AL	1	-		15
55-2	DO (MODEL 60)	DO.	-	1		15
56	COVER TOP PLATE	DO	1	1		16
57	COVER BOTTOM PLATE	DO.	1	1		16
58	COVER WINDOW	PLEXIGLASS	1	1	1/8 THICK	13
59-1	COVER ANGLE - LEFT (MODEL 45)	6063 T5 AL.	1	-	ALCOA SECTION #1944 OR EQUAL	16
59-2	DO (MODEL 60)	DO	-	1	DO	16
60-1	COVER ANGLE - RIGHT (MODEL 45)	DO	1	-	DO	16
60-2	DO (MODEL 60)	DO	-	1	DO	16
61	COVER ANGLE - TOP	DO	1	1	DO	17
61A	DO - BOTTOM	DO	1	1	DO.	17
62	BEARING	—	2	2	NEW DEPARTURE # 77R6	3
63	BEARING	—	2	2	DO # 77R4	3
64	WASHER, PLAIN	BRASS	3	3	FOR #5 SCREW	9
65	MICRO SWITCH	—	2	2	# V-3-1	3 & 4
66	LEVEL VIAL, 3/8 D × 1 1/8 LG.	—	1	1	150-300 SECONDS 1/10 GRADUATION W.A. MOYER & SONS	3
67	COUNTER	—	1	1	PRODUCTIMETER #4Y7-3R-AC DURANT MFG. CO.	3
68	MOTOR, 5 RPM 6 VOLT DC	—	1	1	BARBER COLMAN CO. PART No. FLYM 73010-1 .250 AMP	3
69	CHASSIS PLUG, 5 TERMINAL	—	1	1	AMPHENOL OR CANNON MS 3102A14S-5P	3
70	BANANA JACK	—	2	2	1-RED #108-745-1 1-BLK #108-745-2 E. F. JOHNSON	3
71	BANANA PLUG (MOTOR LEADS)	—	2	2	1-RED #108-302 1-BLK #108-303 E. F. JOHNSON	3
72	PIN JACK (FLOAT SWITCH) H.H. SMITH #202, BODY ALTERED	—	4	4	2 REQ'D WITH HEX LOCK NUT 2 REQ'D WITH PLASTIC NUT (1 RED, 1 BLK)	11
73	PIN PLUG (FLOAT SWITCH)	—	2	2	#200 H.H. SMITH ALTERED & WITHOUT NUT & PLASTIC HANDLE	13

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TOLERANCES ON FRACTIONS ± 1/64
DECIMALS ± .010 ANGLES ± 0°-30'
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REVISIONS

LTR	REMARKS	DATE	Drawn	Approved
C	Title change	11-7-69	CWA	
D	Sheet 2	11-7-69	CWA	
E	Per ECR-059	9-25-81		

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
RESEARCH SECTION (SW) COLUMBUS, OHIO

MANOMETER-SERVO

DRAWN BY S.E.R. | 9-1-59 | SH. 1 OF 20

REV. 4-63, 1-69

0280001

SHEET 1 of 20 W51000

PC. NO.	NAME	MAT.	QUAN MOD. 45	QUAN MOD. 60	NOTES	DETAIL DWG. NO.
74	WIRE CLAMPS	NYLON	4	5	BIRNBACH #726 OR EQUAL	3 & 4
75	TERMINAL LUG (SOLDERLESS)	———	8	8	RING TYPE AMP #31880	11 & 19
76	DIODE	———	1	1	G.E. IN91	11
77	TUBING	PLASTIC	33"	48"	#4 TEMFLEX-105	3 & 4
78	COVER LOCK	STEEL CAD PLATED	4	6	#3 LINK-LOCK, SIMMONS FASTNER CORP	17
79	KEEPER PLATE, COVER LOCK	STEEL CAD PLATED	4	6	SIMMONS FASTNER CORP - FOR #3 LINK-LOCK, ALTERED	3,4 & 11
80	COVER SEAL	SPONGE RUBBER	104"	134"	$\frac{3}{16}$ x $\frac{3}{8}$ SECTION	17
81	PIVOT	STAIN. STL.	1	1	.030 D. x $\frac{1}{4}$ LG - DUOTONE CO.	4 & 14
82	JEWEL BEARING	———	2	2	BRASS-SAPPHIRE V-TYPE	4
83	PIN PLUG (FLOAT SWITCH)	———	2	2	H.H SMITH #203 1-RED 1-BLACK	3,4 & 19
84	SLEEVE, FLEXIBLE	PLASTIC	2	2	I.D. TO FIT #22 HOOK-UP WIRE, $\frac{3}{16}$ O.D., $\frac{3}{4}$ LG	4 & 19
85	HOOK-UP WIRE, #22 STRANDED VINYL INSULATION	COPPER	1	1	COLOR CODED GREEN 14" LG.	19
86	DO.	DO.	1	1	DO WHITE 14" LG.	19
87	HEX NUT (SPECIAL)	BRASS	2	2	CHROME FINISH	13
88	TERMINAL LUG (SOLDERLESS)	———	1	1	HOOK TYPE AMP #34313	4 & 19
89	HOOK-UP WIRE, #22 STRANDED VINYL INSULATION	COPPER	1	1	COLOR CODED BLACK 5" LG	19
90	DO	DO.	1	1	DO. RED $9\frac{1}{2}$" LG	19
91	DO.	DO.	1	1	DO. BLK & WH $11\frac{1}{2}$" LG	19
92	DO.	DO.	1	1	DO GREY 38" MOD. 45 55" MOD. 60	19
93	DO.	DO.	1	1	DO. GREEN 38" MOD. 45 55" MOD. 60	19
94	DO.	DO.	1	1	DO. RED 36" MOD. 45 51" MOD. 60	19
95	SERVO CONTROL UNIT (USGS SPEC.)	———	1	1	NOT FURNISHED BY CONTRACTOR	19
96	BATTERY, 6 VOLT	———	2	2	EVEREADY HOTSHOT #1461 OR EQUAL	19
97	MANOMETER TUBING	*TYGON WITH DACRON INNERBRAID	1	1	MOD. 45 - $\frac{1}{16}$ I.D. x .312 O.D. x 37" LG. MOD. 60 - $\frac{3}{16}$ I.D. x .312 O.D. x 52" LG.	3
98	MANOMETER TUBING	*TYGON	1	1	.125 I.D. x .312 O.D. x 84" LG.	3 & 20
99	TUBE FITTING (ALTERED, RE-DRILL BODY LET. "P", .323 DIA)	● BRASS	1	1	#500-1-4 CRAWFORD MALE CONNECTOR - $\frac{5}{16}$ O.D TUBE - $\frac{1}{4}$ NPT	3
100	TUBE FITTING (ALTERED)	●STAIN STL.	1	1	#500-1-4-316 CRAWFORD MALE CONNECTOR - $\frac{5}{16}$ O.D TUBE - $\frac{1}{4}$ NPT	13
101	TUBE FITTING	ZYTEL	1	1	#ZY500-1-4 CRAWFORD MALE CONNECTOR - $\frac{5}{16}$ O.D. TUBE - $\frac{1}{4}$ NPT	3
102	TUBE FITTING	DO.	1	1	#ZY500-1-2 CRAWFORD MALE CONNECTOR - $\frac{5}{16}$ O.D TUBE - $\frac{1}{8}$ NPT	3
103	TUBE INSERT (FOR PC. #98)	STAIN. STL.	2	2	CRAWFORD FITTING CO. #405-2-316	—
103-1	TUBE INSERT (FOR PC. #97)	STAIN. STL.	2	2	CRAWFORD FITTING CO. #405-3-316	—
104	CAP SCR., HEX HD.	STAIN. STL.	1	1	$\frac{1}{4}$-24NF-2 x 1" LG.	3
105	MACH SCR., HEX HD	DO.	1	1	10-32NF-2 x $\frac{1}{2}$ LG	3
106	DO.	DO.	1	1	10-32NF-2 x $\frac{3}{8}$ LG.	9
107	MACH SCR., SOC HD.	DO.	6	6	10-32NF-2 x $\frac{1}{2}$ LG	3 & 4
108	DO.	DO.	1	1	8-32NC-2 x $\frac{5}{8}$ LG.	3
109	MACH. SCR., FIL HD	DO.	2	2	5-40NC-2 x $\frac{5}{16}$ LG	9
110	DO.	DO.	1	1	5-40NC-2 x $\frac{3}{16}$ LG.	9
111	DO.	DO.	1	1	5-40NC-2 x $\frac{3}{8}$ LG.	9
112	MACH. SCR., FL. HD.	DO	4	4	4-40NC-2 x $\frac{1}{4}$ LG.	4
113	MACH. SCR., RD. HD	DO.	2	2	10-32NF-2 x $\frac{3}{8}$ LG	9
114	DO	DO.	16	22	8-32NC-2 x $1\frac{1}{4}$ LG.	3,4 & 9

REV. 4-63, 1-69

PC. NO.	NAME	MAT.	QUAN MOD. 45	QUAN MOD. 60	NOTES	DETAIL DWG. NO.
115	MACH SCR, RD HD.	STAIN STL.	7	7	6-32NC-2 x $\frac{1}{2}$ LG	3 & 4
116	DO.	DO.	4	5	6-32NC-2 x $\frac{3}{8}$ LG	3 & 4
117	DO.	DO.	1	1	5-40NC-2 x $\frac{5}{8}$ LG	3
118	DO.	DO.	11	11	4-40NC-2 x $\frac{1}{2}$ LG	3 & 4
119	DO	DO.	12	16	4-40NC-2 x $\frac{1}{4}$ LG	3,4 & 17
120	WASHER, PLAIN	DO	1	1	$\frac{3}{8}$	3
121	WASHER, PLAIN	STAIN. STL.	2	2	#10	3 & 9
121-1	WASHER, PLAIN	NEOPRENE	2	2	$\frac{1}{4}$ I.D. x $\frac{7}{16}$ O.D. x $\frac{1}{32}$ TH.	4
122	SHIPPING BOX	WOOD	1	1	1"-NO. 2 WHITE PINE - NAILED CONSTRUCTION	18
123	ROLL PIN	STAIN. STL.	1	1	$\frac{1}{8}$ D. x $\frac{3}{4}$ LG	3
124	DO.	DO	1	1	$\frac{3}{32}$ D. x $\frac{1}{2}$ LG.	3
125	DO.	DO.	1	1	$\frac{3}{32}$ D. x $\frac{3}{8}$ LG	3
126	SET SCR, SOC	DO	1	1	8-32NC-2 x $\frac{1}{4}$ CUP PT.	3
127	DO.	DO.	1	1	4-40NC-2 x $\frac{3}{16}$ CUP PT.	3
128	WOOD SCR., RD. HD.	DO.	4	4	#10 x $1\frac{1}{2}$ LG. SLOTTED	3
129	DO., FL. HD.	BRASS	18	20	#8 x 2" LG. SLOTTED	18
130	MACH. SCR., PHILLIPS PAN HD.	STAIN STL.	19	19	#6-32NC-2 x $\frac{1}{4}$ LG.	17
131	NUT, HEX.	DO.	19	19	#6-32NC-2	17
132	RIVET, TRUSS HD	ALUMINUM	68	80	$\frac{1}{8}$ DIA x $\frac{5}{16}$ LG	17
133	SET SCR., SOC	STAIN STL.	2	2	6-32NC-2 x $\frac{1}{16}$ CUP PT	3
134	WRENCHS, ALLEN	STEEL	3	3	1-EA. FOR #4, #6 & #8 SETSCREW	—
135	MACH. SCR., RD. HD.	STAIN. STL.	1	1	4-40NC-2 x $\frac{1}{8}$ LG.	4
136	SLEEVE, FLEXIBLE $\frac{1}{2}$" LG.	PLASTIC	5	5	WITH I.D. FOR SINGLE #22 WIRE LEAD	3
137	MERCURY, TRIPLE DISTILLED	——— Ⓓ	$1\frac{1}{2}$ LB.	$1\frac{1}{2}$ LB.	IN SHIPPING CONTAINER (PLASTIC BOTTLE)	—
138	THREAD LUBRICANT & SEALER CRAWFORD FITTING CO.	TEFLON TAPE	—	—	USE ON PC. NOS. 100, 101 AND 102 AT ASSEMBLY	—
139						
140	MACH. SCR., FIL HD.	STAIN. STL.	2	2	6-32NC-2 x $\frac{7}{16}$ LG.	3

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ±1/64
DECIMALS ±.010 ANGLES ±0°-30'
DO NOT SCALE THIS DRAWING

REVISIONS

LTR	REMARKS	DATE	Drawn / Chk / Approved
D2	PC. 137-1½ lb. was 1 lb.	11-7-69	
E	Per ECR-059	9-25-69	

Ⓔ

● FITTINGS TO HAVE NYLON FERRULES
* FORMULATION R-3603 LABORATORY TUBING MANUFACTURED BY PLASTICS & SYNTHETIC DIV., THE UNITED STATES STONEWARE CO., AKRON, OHIO
* FORMULATION R-3603 LAB TUBING, MFG BY U.S. STONEWARE CO., AKRON, OHIO. TUBE ENDS IMMERSION WELDED WITH CYCLOHEXANONE SOLVENT (CUT BACK DACRON $\frac{1}{8}$ INCH BEFORE WELDING)

REVISION	DATE	CHANGE OR ADDITION
	1-2-69	GAS-PURGE ACCESSORIES REMOVED, NOW SHOWN ON SH. #20
PC. #138	1-2-69	MATERIAL SPEC. CHANGED
PC. #103-1	1-2-69	NEW PART ADDED
PC. #105	1-2-69	QUANTITY REDUCED, WAS 4
PC. #97	1-2-69	MATERIAL SPEC. CHANGED

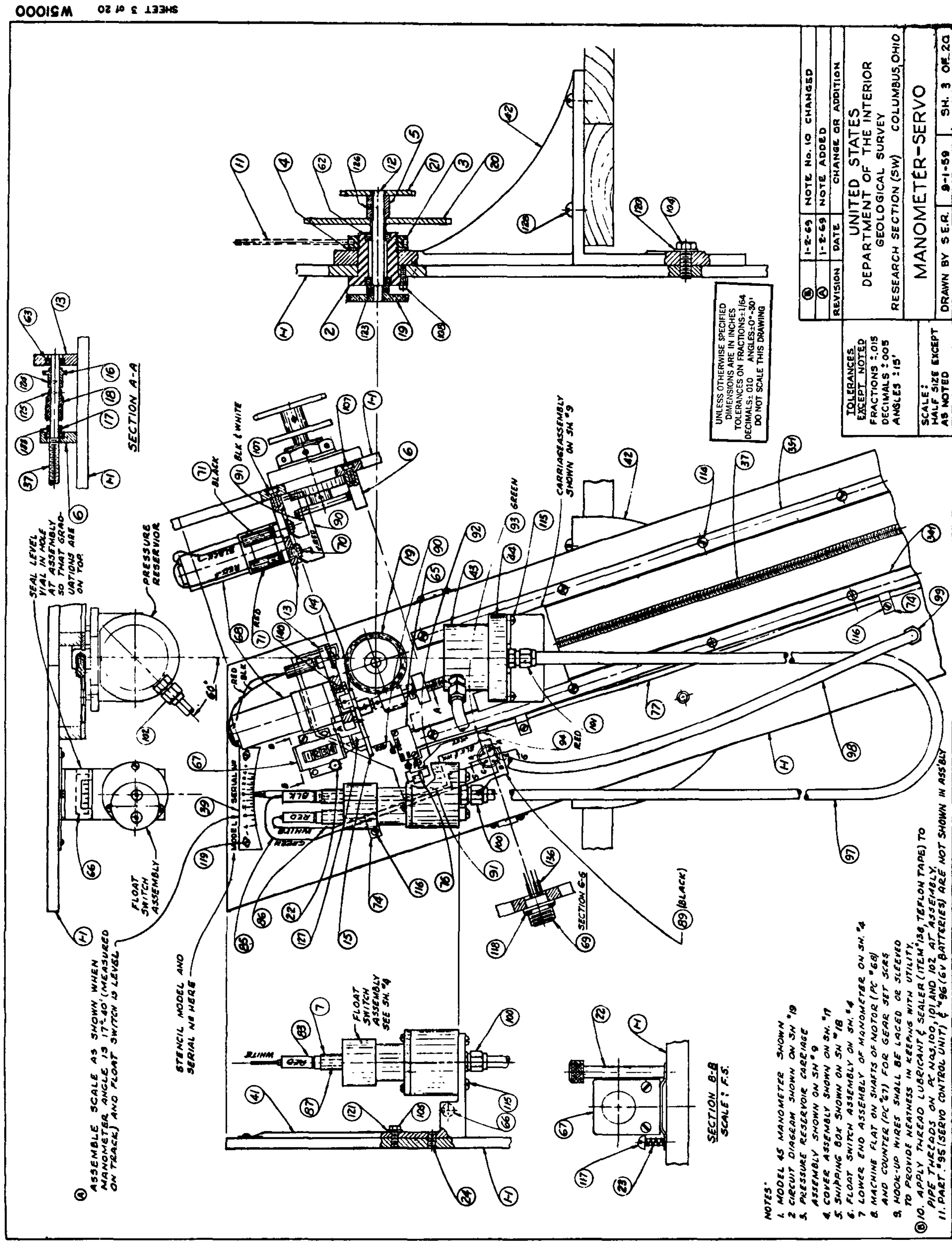
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
RESEARCH SECTION (SW) COLUMBUS, OHIO

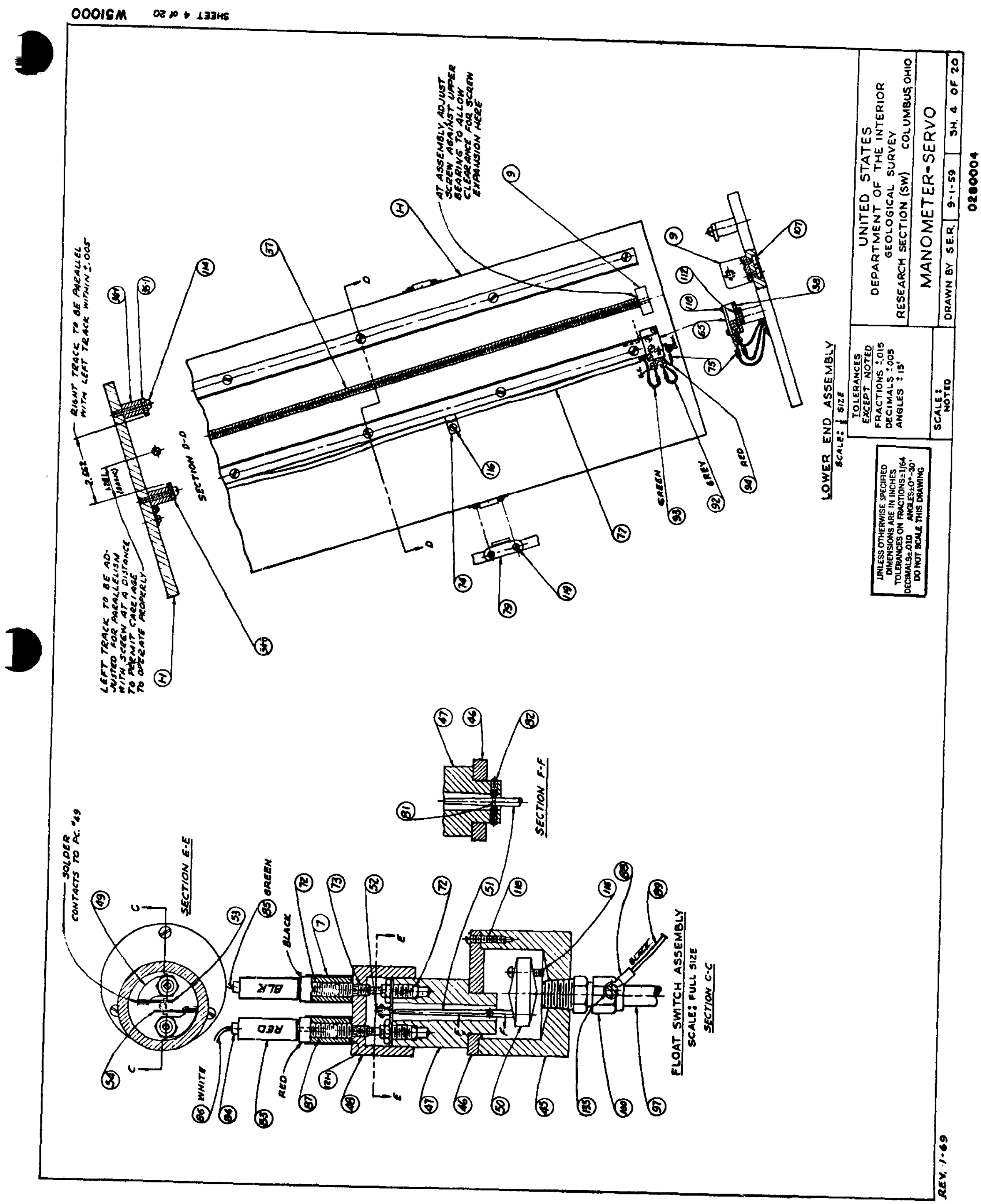
MANOMETER-SERVO

DRAWN BY S.E.R | 9-1-59 | SH. 2 OF 20

0280002

W51000 SHEET 2 of 20


SHEET 3 of 20 W51000
MANOMETER-SERVO
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
RESEARCH SECTION (SW) COLUMBUS, OHIO
DRAWN BY S.E.R. 9-1-59 SH. 3 OF 20
0280003
REVISION DATE CHANGE OR ADDITION
Ⓐ 1-2-69 NOTE ADDED
Ⓑ 1-2-69 NOTE No. 10 CHANGED
TOLERANCES EXCEPT NOTED
FRACTIONS ±.015
DECIMALS ±.005
ANGLES ±15'
SCALE: HALF SIZE EXCEPT AS NOTED
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ±1/64
DECIMALS ±.010 ANGLES ±0°-30'
DO NOT SCALE THIS DRAWING
SECTION A-A
SECTION B-B
SCALE: F.S.
SECTION G-G
CARRIAGE ASSEMBLY SHOWN ON SH #9
PRESSURE RESERVOIR
FLOAT SWITCH ASSEMBLY
FLOAT SWITCH ASSEMBLY SEE SH. #4
SEAL LEVEL VIAL IN HOLE AT ASSEMBLY SO THAT GRADUATIONS ARE ON TOP.
STENCIL MODEL AND SERIAL No HERE
MODEL SERIAL No
Ⓐ ASSEMBLE SCALE AS SHOWN WHEN MANOMETER ANGLE IS 17°-40' (MEASURED ON TRACK) AND FLOAT SWITCH IS LEVEL
NOTES:
1. MODEL 45 MANOMETER SHOWN
2. CIRCUIT DIAGRAM SHOWN ON SH #19
3. PRESSURE RESERVOIR CARRIAGE ASSEMBLY SHOWN ON SH #9
4. COVER ASSEMBLY SHOWN ON SH. #11
5. SHIPPING BOX SHOWN ON SH #18
6. FLOAT SWITCH ASSEMBLY ON SH. #4
7. LOWER END ASSEMBLY OF MANOMETER ON SH. #4
8. MACHINE FLAT ON SHAFTS OF MOTOR (PC #68) AND COUNTER (PC #27) FOR GEAR SET SCRS
9. HOOK-UP WIRES SHALL BE LACED OR SLEEVED TO PROVIDE NEATNESS IN KEEPING WITH UTILITY.
Ⓑ 10. APPLY THREAD LUBRICANT & SEALER (ITEM #138, TEFLON TAPE) TO PIPE THREADS ON PC NOS. 100, 101 AND 102 AT ASSEMBLY.
11. PART #95 (SERVO CONTROL UNIT) & #96 (6V BATTERIES) ARE NOT SHOWN IN ASS'BLY
REV. 1-69



SHEET 4 of 20
WS1000
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
RESEARCH SECTION (SW) COLUMBUS, OHIO
MANOMETER-SERVO
DRAWN BY S.E.R.
9-1-59
SH. 4 OF 20
0280004
TOLERANCES EXCEPT NOTED
FRACTIONS ±.015
DECIMALS ±.005
ANGLES ±15'
SCALE: NOTED
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS±1/64 DECIMALS±.010 ANGLES±0°-30' DO NOT SCALE THIS DRAWING
LOWER END ASSEMBLY
SCALE: 1/2 SIZE
AT ASSEMBLY ADJUST SCREW AGAINST UPPER BEARINGS TO ALLOW CLEARANCE FOR SCREW EXPANSION HERE
RIGHT TRACK TO BE PARALLEL WITH LEFT TRACK WITHIN ±.005
LEFT TRACK TO BE ADJUSTED FOR PARALLELISM WITH SCREW AT A DISTANCE TO PERMIT CARRIAGE TO OPERATE PROPERLY
SECTION D-D
GREEN
GREY
RED
SECTION F-F
SOLDER CONTACTS TO PC. #49
SECTION E-E
GREEN
BLACK
BLK
RED
WHITE
FLOAT SWITCH ASSEMBLY
SCALE: FULL SIZE
SECTION C-C
REV. 1-69