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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

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 ½ 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

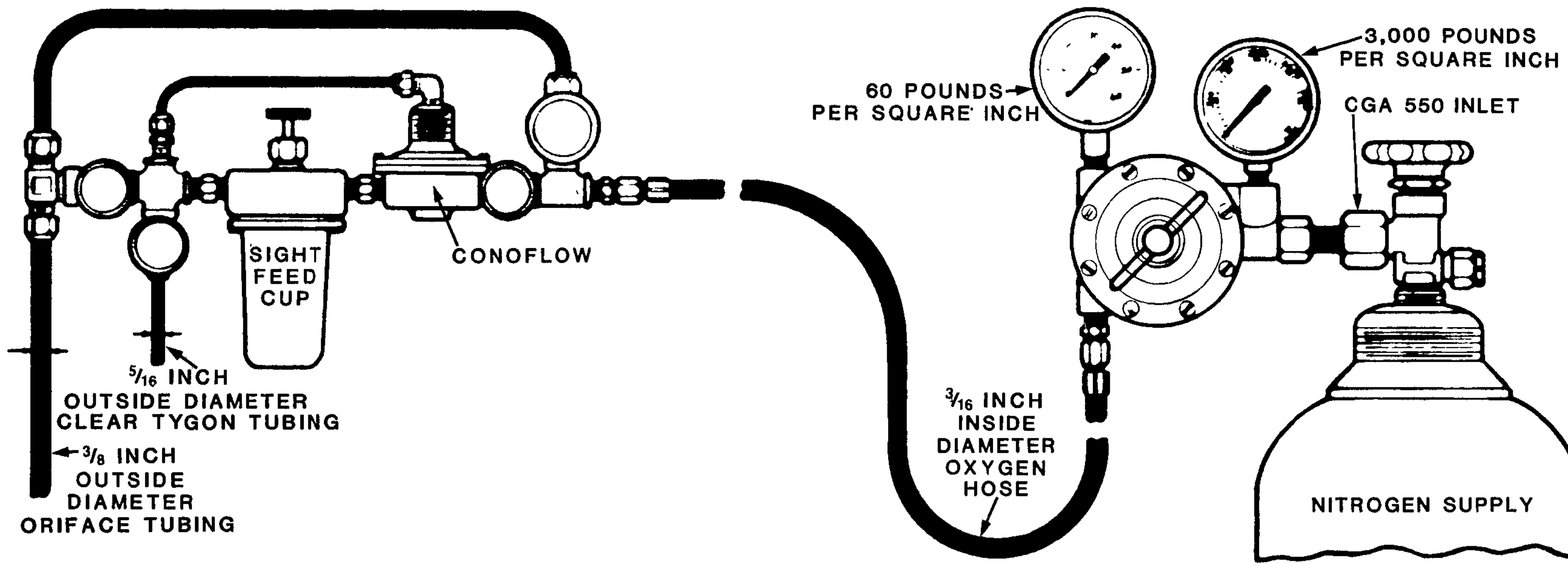


Figure 12.--Gas-purge system.

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

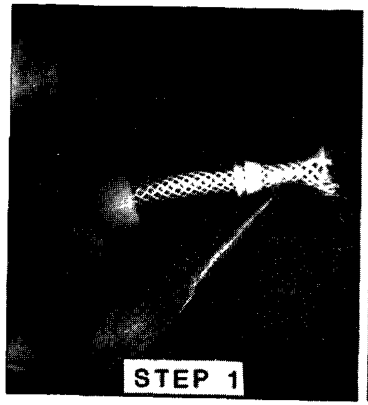
The streamward end of the bubble tubing is secured by a special fitting to a 2-inch pipe-cap for ease of mounting in the stream. The design of this fitting allows the cap to be screwed on a 2-inch pipe without twisting the bubble tubing. The orifice must be anchored securely in the stream, as changes 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

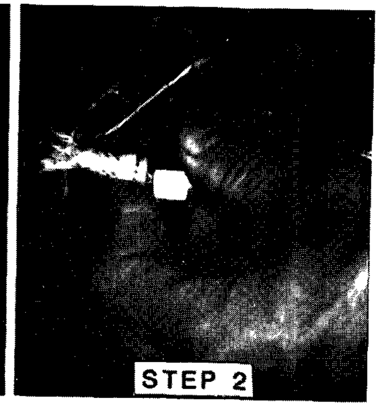
For the tables and drawings, see sheets 1 to 6 of Appendix for numbered parts for STACOM and sheets 1 to 4 for screw type.

Functional Operation

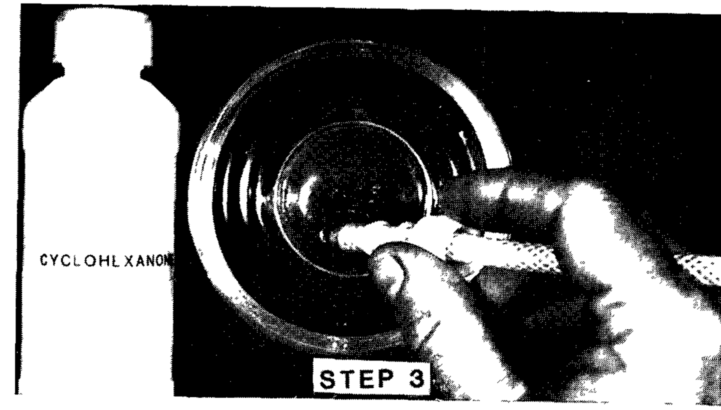
Pressure on the bubble orifice, corresponding to the head of water over the orifice, is transmitted to the manometer by the gas-purge system. This pressure is transmitted through the gas tubing to the mercury surface in the pressure reservoir (PC) via tubing (T-2) and displaces an equivalent head of 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



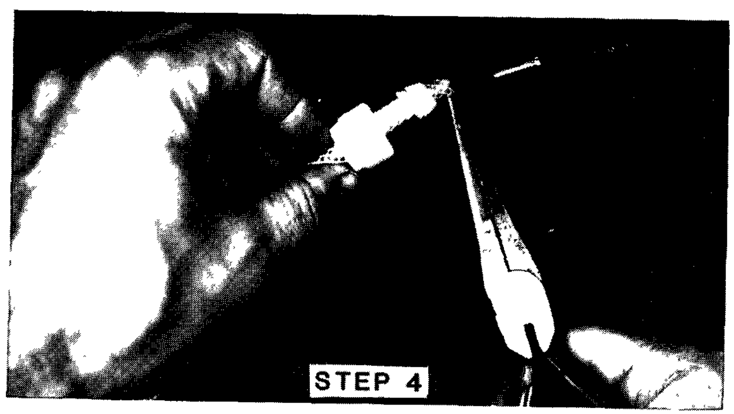
Pull back outside extrusion by grasping with long nosed pliers, simultaneous pushing against turned back edge also helps.



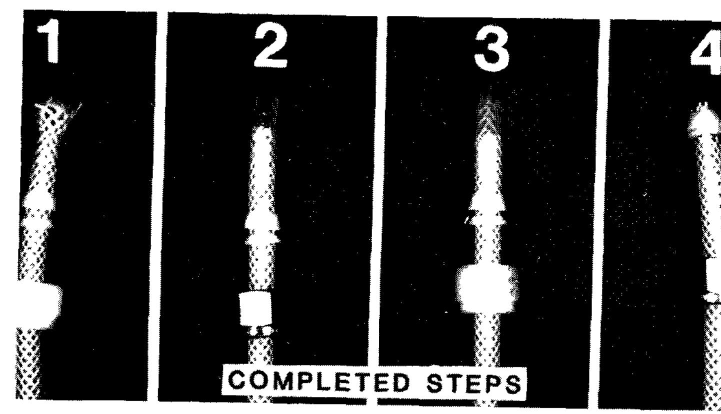
Clip fiber braid close. Take care not to nick extrusions.



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 $17^{\circ}40'$, 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. <u>Never manually operate the manometer while the ADR is cycling</u>. Although the cycle (motor) stops, lockup may have already occurred.

The nominal supply voltage for the servo-control unit is 7 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°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 1/2 inches x 4 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 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.

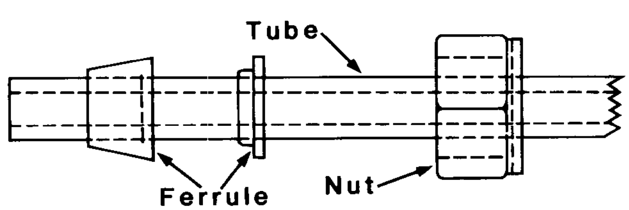
Gas-Purge System

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

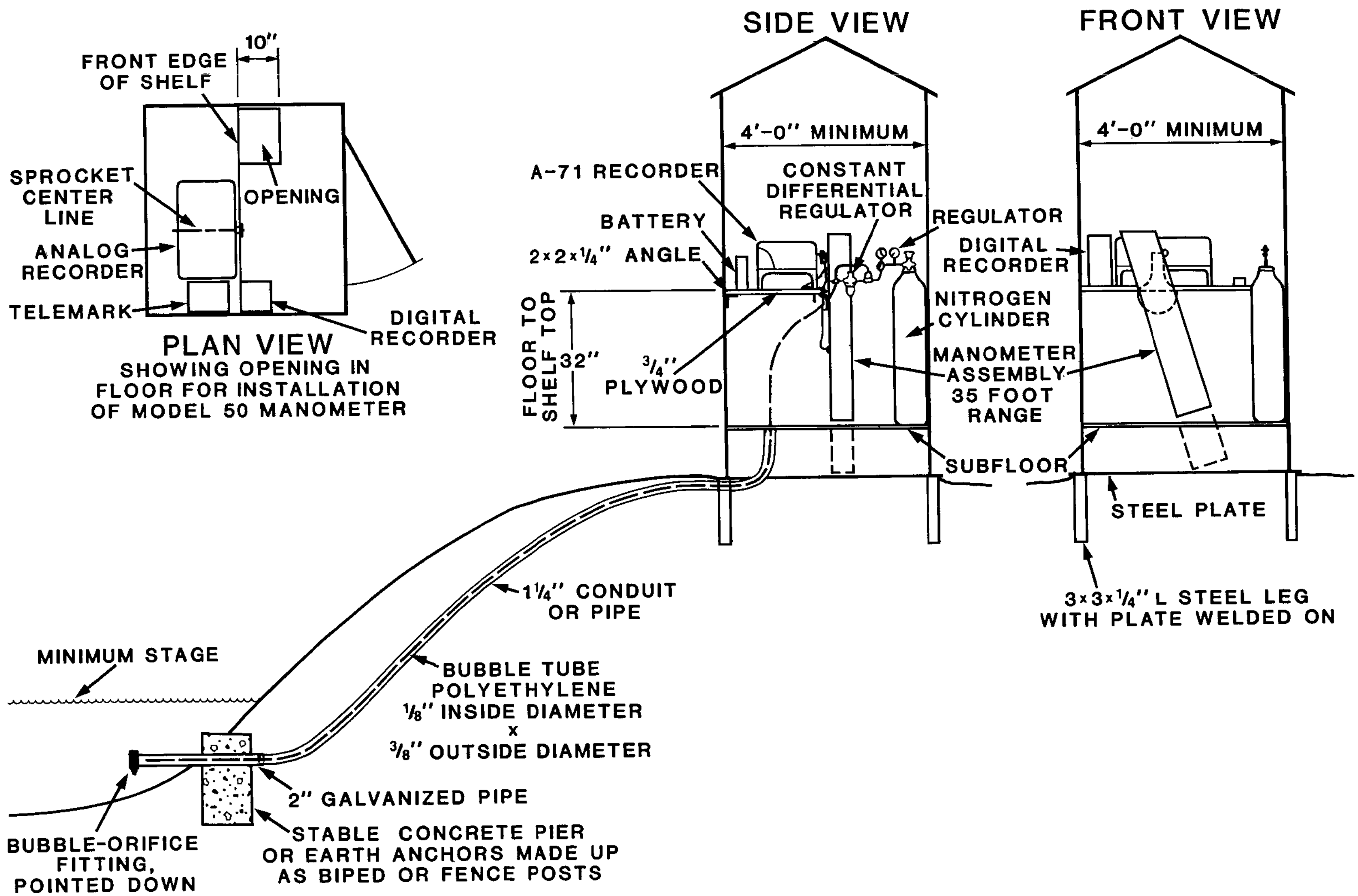
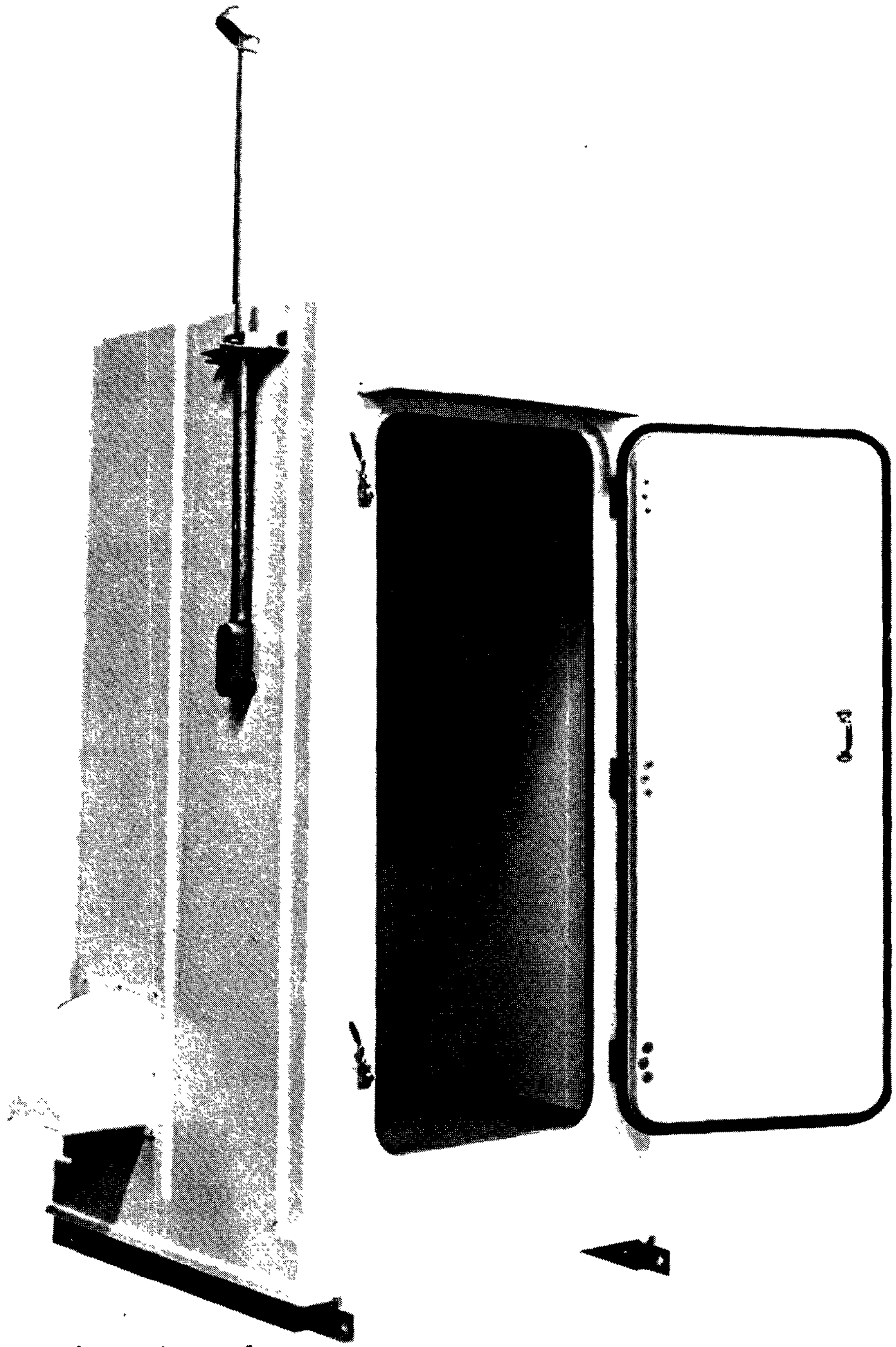


Figure 14.--Typical manometer-gage installation.



Photograph courtesy of
Vertex Plastics, Inc.

Figure 15.--Typical fiberglass shelter.

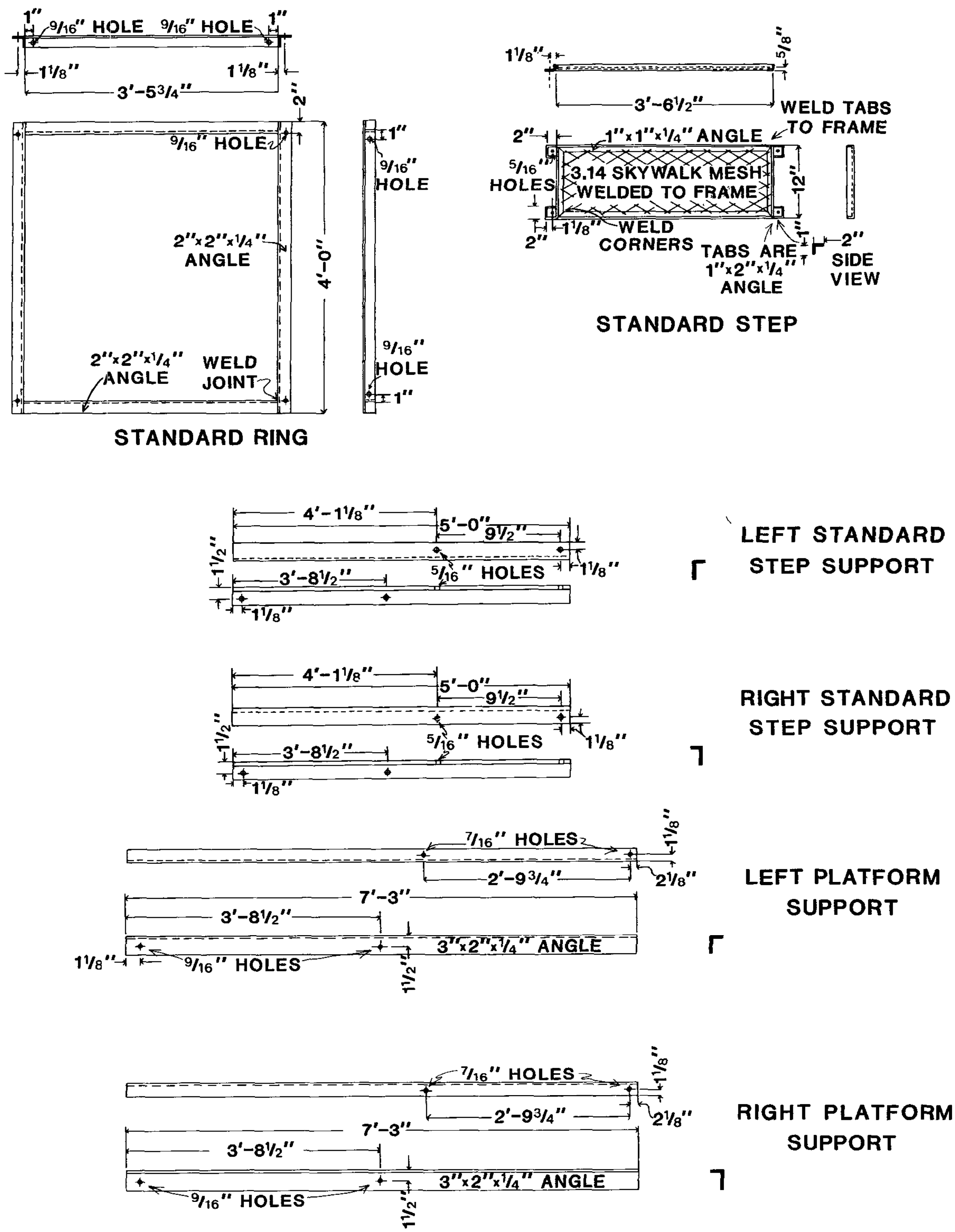
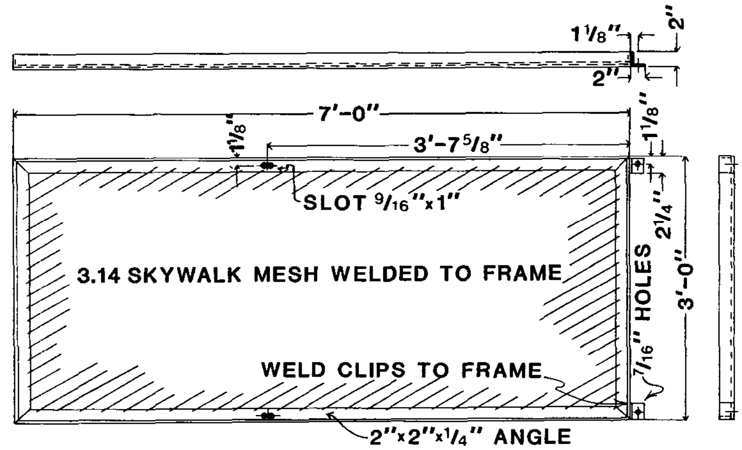
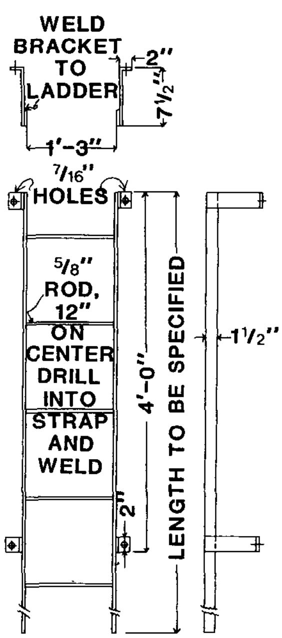


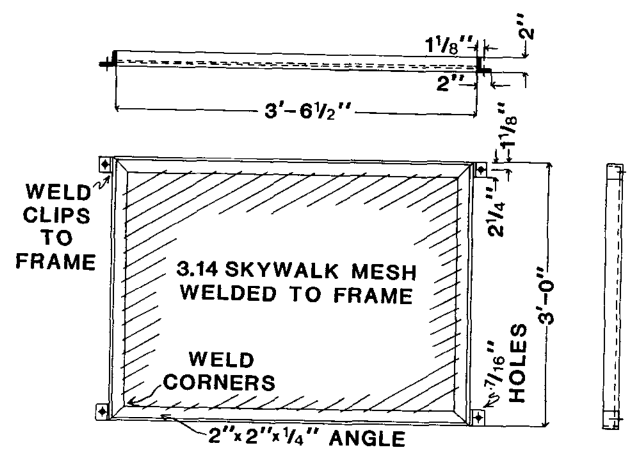
Figure 16.--Standard accessories

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'-7 1/2"	Rail
	4	4	1/2" bolt	1 1/2"	Platform support to house
	4	4	3/8" bolt	1 1/2"	Platform to platform support
STEP	2		1/4" bolt	1"	Step to support
	4		1/2" bolt	1 1/2"	Platform support to house
	4		1/4" bolt	1 1/2"	Step to step support
LADDER	4		3/8" bolt	3"	Ladder to house

for fiberglass shelter

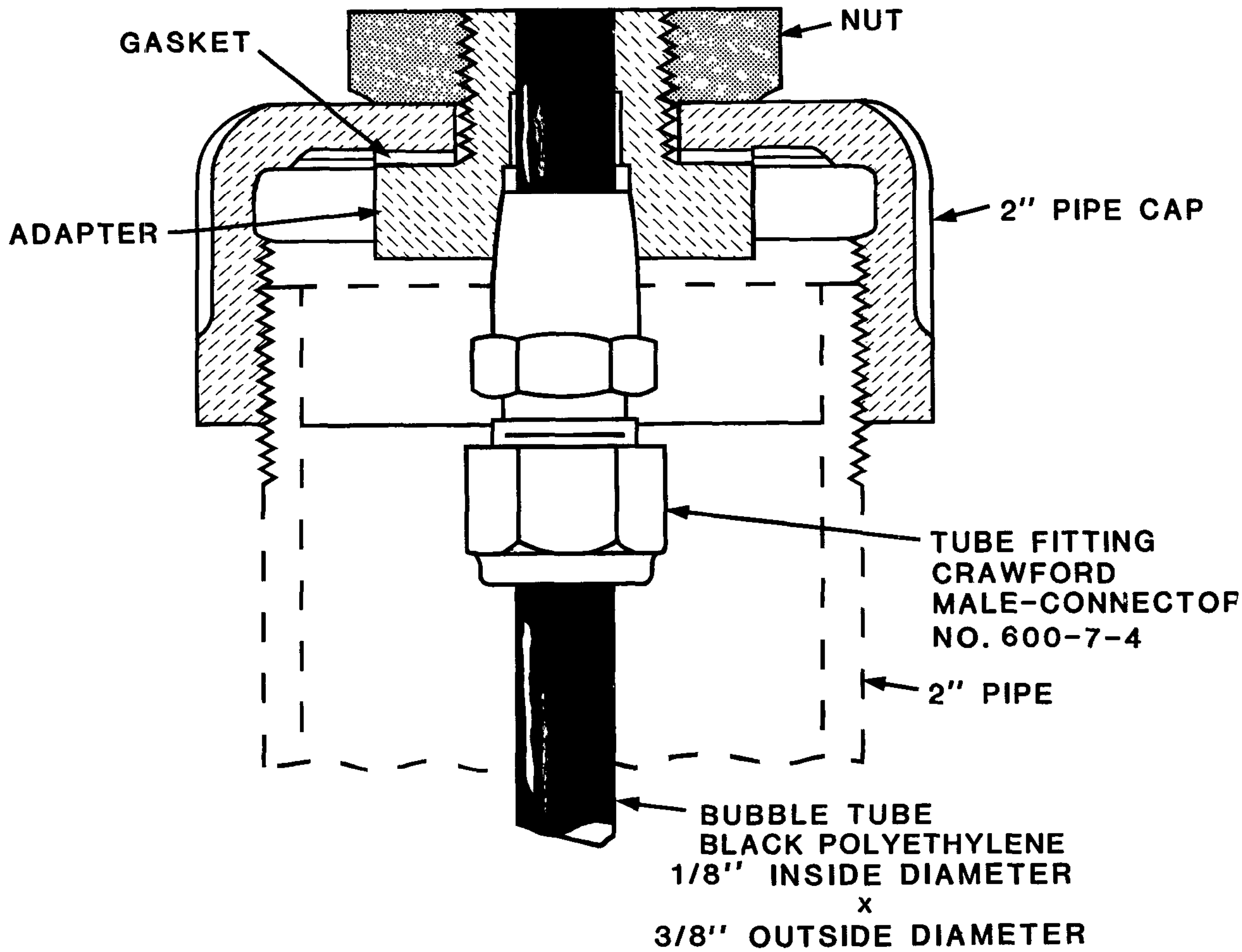
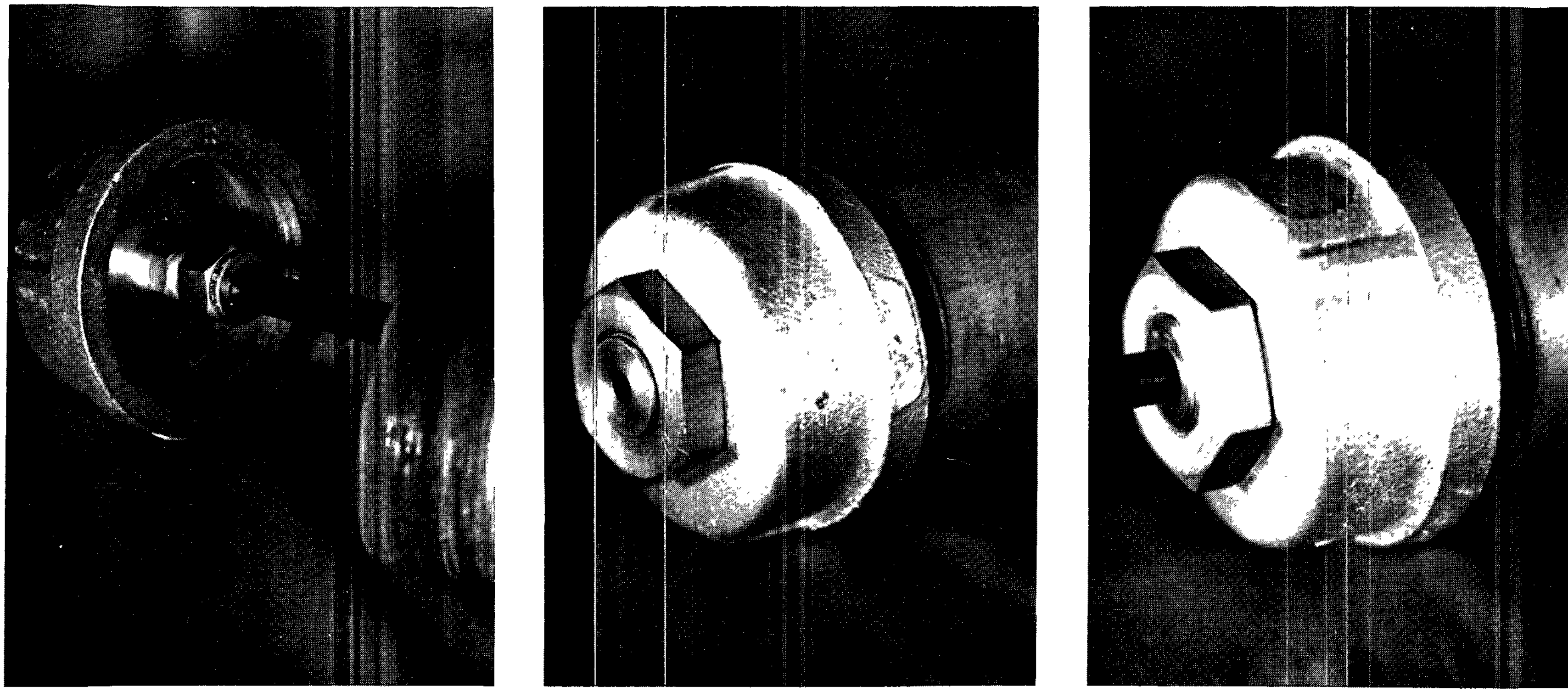


Figure 17.--Bubble-orifice assembly.



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.

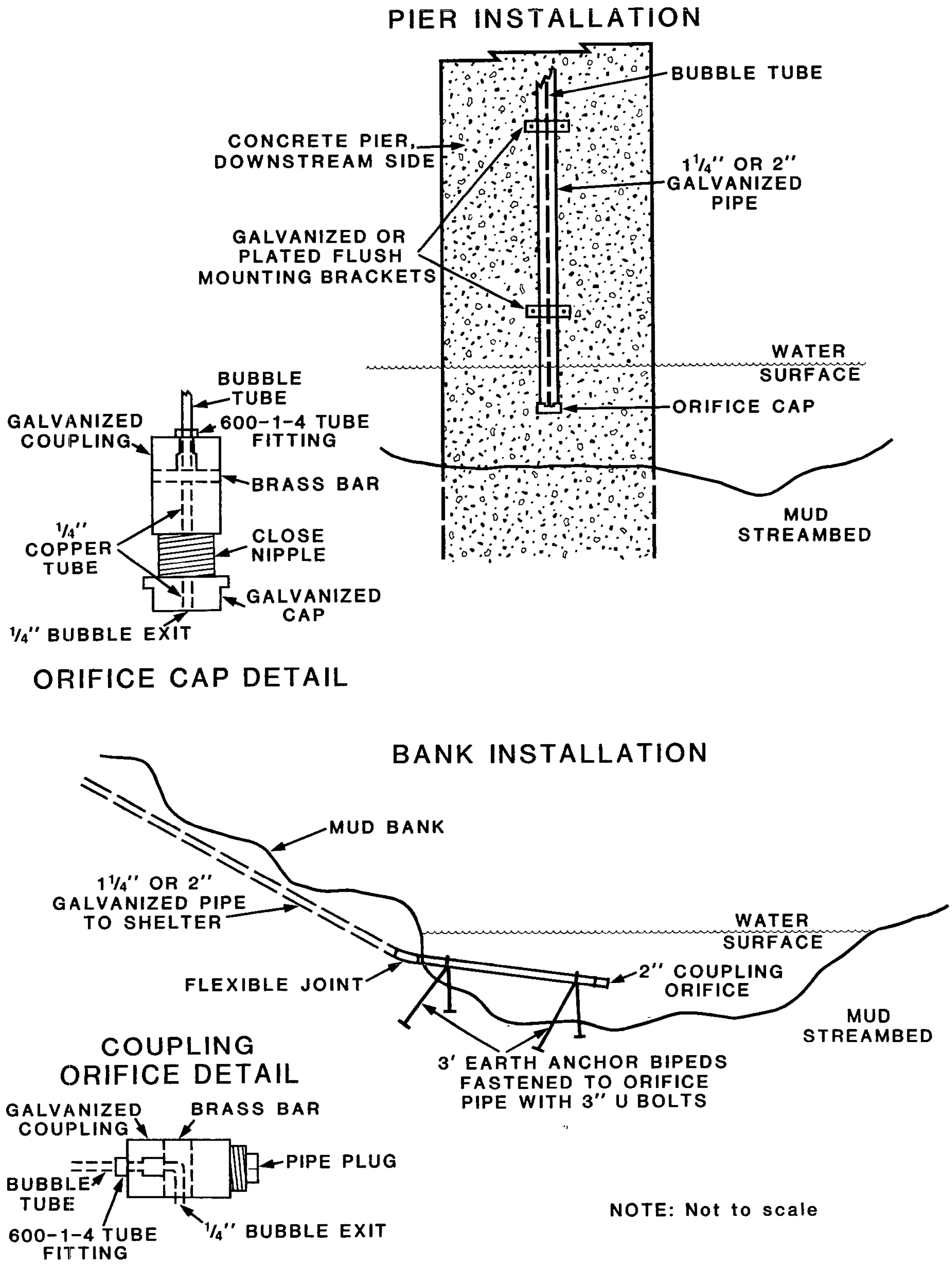


Figure 19.--Orifice installation for mud streambed.

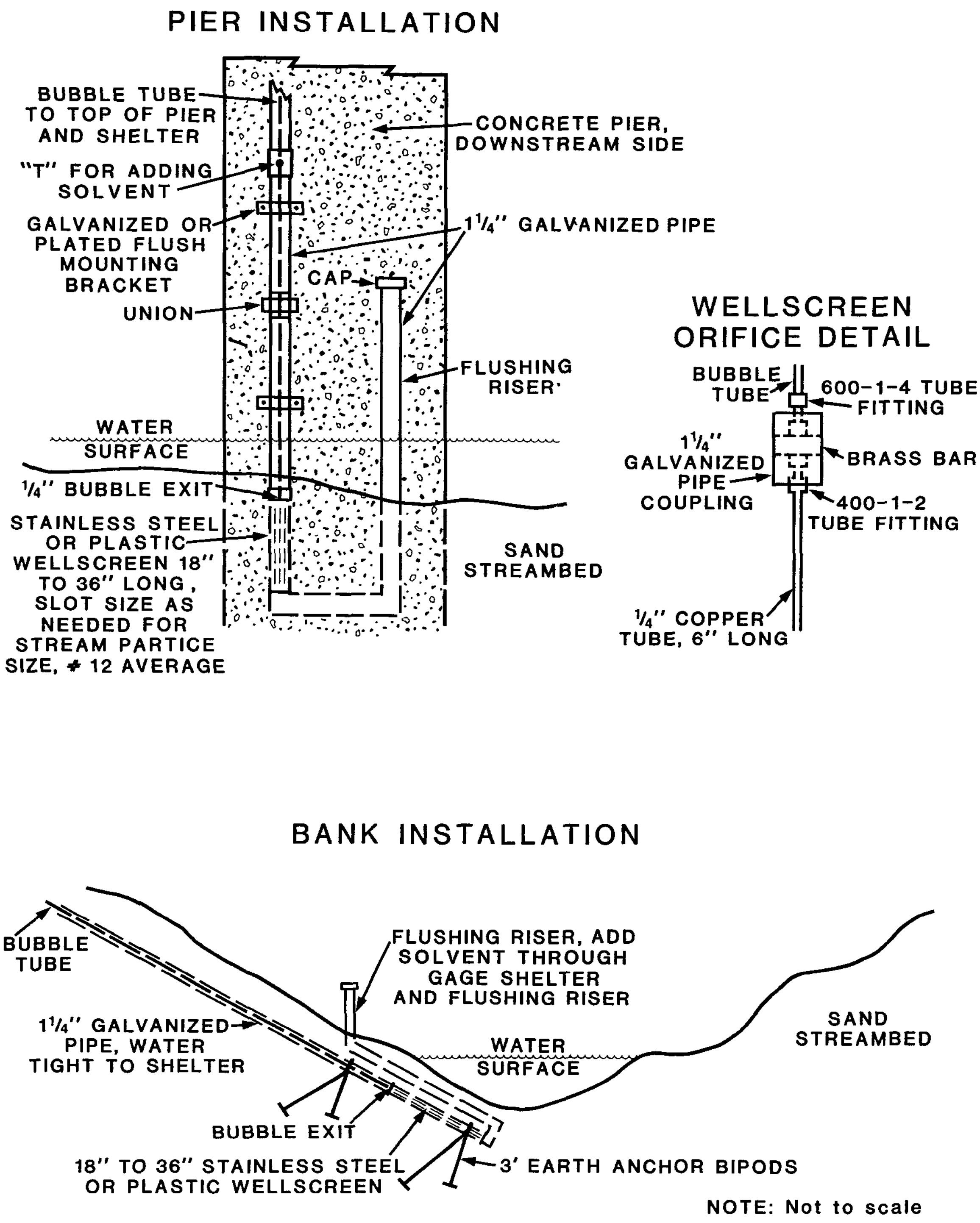


Figure 20.--Orifice installation for sand streambed.

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