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HYDRAULIC LABORATORY REPORT NO. 149

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DESIGN OF HIGH-HEAD MERCURY MANOMETER FOR OUTLET WORKS

AT

GREEN MOUNTAIN DAM
COLORADO-BIG THOMPSON PROJECT, COLORADO

By

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Denver, Colorado
September 18, 1944

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Engineering and Geological Control
and Research Division
Denver, Colorado
September 18, 1944

Laboratory Report No. 149
Hydraulic Laboratory

Compiled by: F. C. Lowe
Reviewed by: J. E. Warnock

Subject: Design of high-head mercury manometer for Green Mountain Dam - Colorado-Big Thompson project, Colorado.

1. Introduction. When the hydraulic laboratory was requested to furnish rating curves for the discharge through the tube valves at Green Mountain Dam, it was found that a gage would be necessary to measure pressure head at the valve. A dial gage was first suggested for this purpose, but objections as to the accuracy of a dial gage led to the adoption of a high-head mercury manometer. Dial gages are unquestionably the most practical type for field installations. They are small, easy to read, and sufficiently accurate for most purposes. They do have a disadvantage, however, in not being precise, and may become inaccurate after a long period of service due to wear in the linkage mechanism. Dial gages overhauled and calibrated by the hydraulic laboratory have been found to vary from two to seven percent. Some were accurate at one range of pressure but in error at other pressures. Several large gages were found to be from 20 to 30 percent off due to slippage of the linkage to the dial hand. For these reasons, a dial gage is not entirely reliable. In tests on the 20-inch Shasta Dam tube-valve model at Boulder Dam, they were abandoned in favor of the more cumbersome mercury manometers.

2. Need for accurate pressure gage. The accuracy of a mercury manometer is basic. The height of a column of mercury is a measure of pressure. With corrections for temperature and surface tension, the pressure can be measured as accurately as the reading can be made. There are, however, several disadvantages to a mercury manometer which restrict its use outside of the hydraulic laboratory. The height of the gage often makes it impractical. A gage 19 feet high is required to measure a static head of 250 feet. Nevertheless, such a gage may be installed satisfactorily in a stair well or on a wall next to a permanent stairway, as was done with the gage at Green Mountain Dam (figure 1). The chief troubles experienced by the hydraulic laboratory have not been in the bulk of the gages but in their maintenance. Leakage of mercury at the connections is always a problem. The glass columns break easily, causing the loss of expensive mercury, and dirt and mercuric oxide foul the manometer tubes to such an extent that the top of the mercury column cannot be seen. When it was decided to use a high-head mercury manometer at Green Mountain

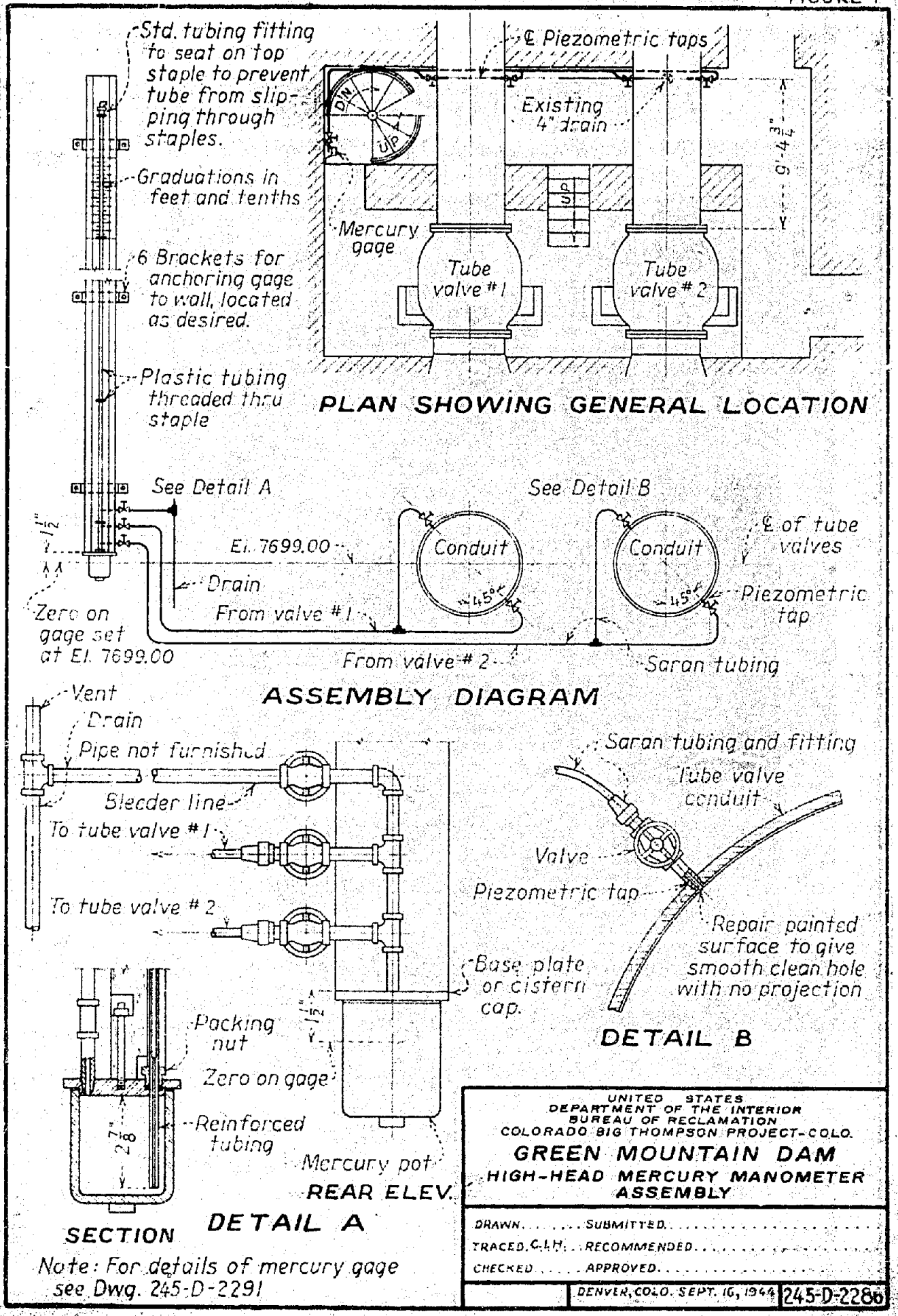
Dam, the more conventional types of mercury manometers were abandoned for a design, perhaps not new, but also not common, which, insofar as possible, will eliminate adverse features of maintenance and also simplify installation. It is the purpose of this memorandum to describe the features of this design in anticipation that occasion may arise where such a gage is needed elsewhere.

3. The Green Mountain mercury manometer. In the new design (figure 2), the manometer tube is a single plastic tube which passes through the cap of the mercury cistern directly into the mercury. Mercury rising in this tube passes no connections; so troublesome mercury leaks are avoided. As the plastic tube is flexible, it will not be broken by a jar or a blow as would glass. Moreover, it has a better appearance on a tall manometer, since glass comes in 3- or 4-foot lengths which must be connected by cumbersome connections. To keep the tube clean and free of mercuric oxide, an inch or two of water should be kept in the manometer tube over the mercury. Corrections may be made for this water, but they will be small. Inserting the water into the tube will be simplified by using a weak solution of Aerosol, or other wetting agent. The mercury cistern consists of a cap and a pot. The pressure and the manometer connections are made to the cap which is connected to the gage board by a steel bolt and held in place by two pins. The pot is screwed to the cap. There cannot be any leaks in this cistern because the pot has no openings. The connections to the cap are above the mercury; so only water leaks can occur at that point. To remove the mercury it is only necessary to unscrew the pot. This eliminates opening a valve and catching a stream of mercury in a container; moreover, the inside of the gage and the end of the plastic tube are accessible for cleaning. The exact amount of mercury may be shipped in the pot by capping it. By shipping the correct amount of mercury, zeroing of the gage is eliminated, a tedious process. However, in so shipping, the operator is warned to be careful not to spill the contents. The zero of the gage may be marked on the cistern pot and corrections for changes in level calculated. If it is necessary to observe the mercury level in the cistern, a transparent pot of plastic or glass may be used by making minor changes in the design.

4. Installation of gage. The installation of the gage is as follows; (1) mount the gage board; (2) connect the cistern cap to board; (3) connect the pressure and the bleeder line to cap; include valves for closing lines; (4) insert small, steel reinforcing tube in lower end of plastic manometer tube; push reinforced end of manometer tube through the hole in the packing nut on the cistern cap, and tighten nut; (5) fasten manometer tube to gage board with staples; do not drive staples in so tight as to bruise tube; (6) screw cistern pot in place with the correct amount of mercury in pot; (7) pour a small amount of water into top of gage to have an inch or two of water over mercury column; (8) bleed air from pressure line. The gage is then ready for use.

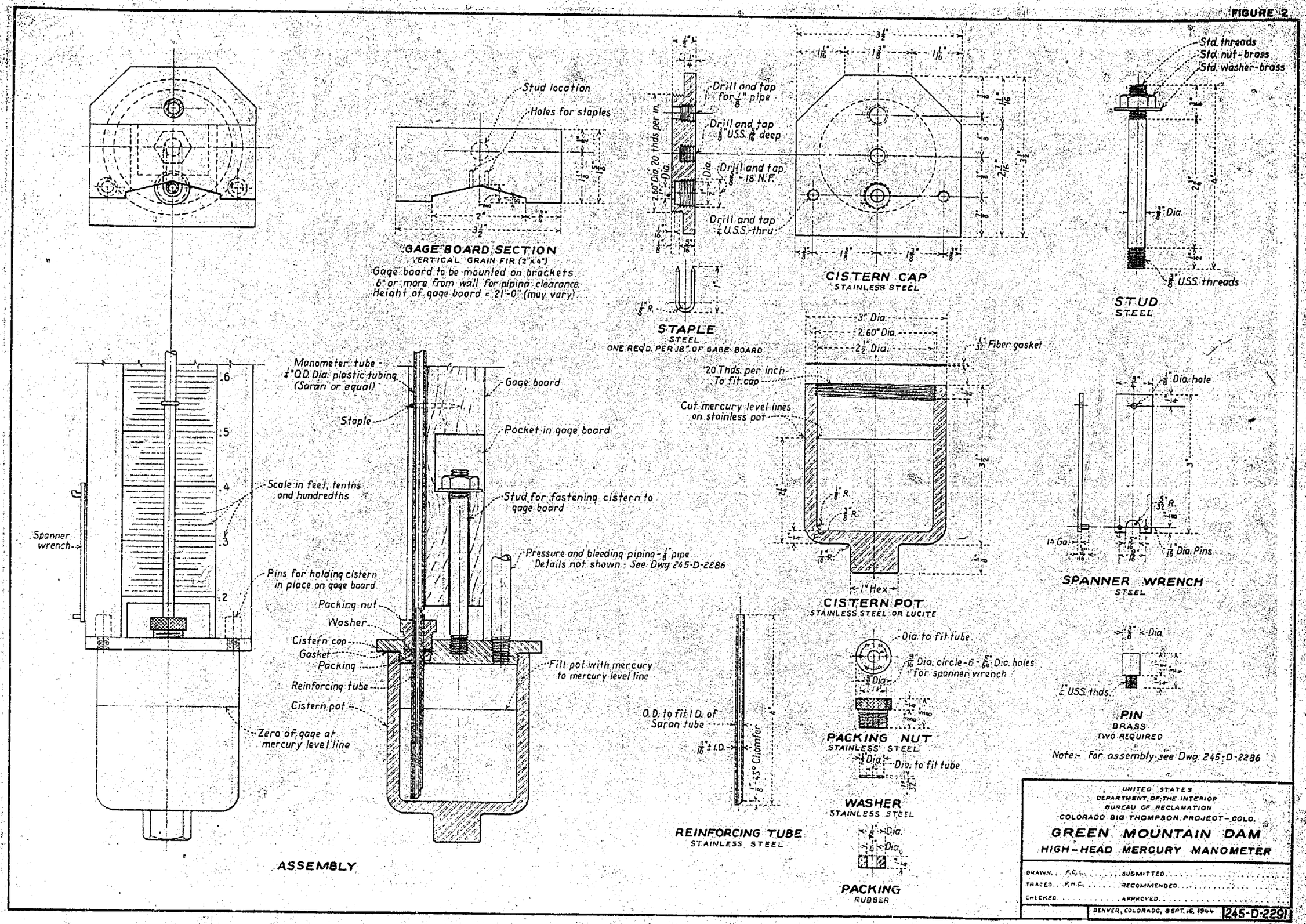
- - -

FIGURE 1



Note: For details of mercury gage see Dwg. 245-D-2291

FIGURE 2


Stud location
Holes for staples
GAGE BOARD SECTION
VERTICAL GRAIN FIR (2"x4")
Gage board to be mounted on brackets 6" or more from wall for piping clearance.
Height of gage board = 21'-0" (may vary)
Drill and tap for 1/8" pipe
Drill and tap 3/8" U.S.S. 7/16" deep
Drill and tap 3/8"-18 N.F.
Drill and tap 1/4" U.S.S. thru
2.60" Dia. 20 thds per in.
STAPLE
STEEL
ONE REQ'D. PER 1/8" OF GAGE BOARD
CISTERN CAP
STAINLESS STEEL
Std. threads
Std. nut - brass
Std. washer - brass
3/8" Dia.
3/8" U.S.S. threads
STUD
STEEL
Manometer tube - 1/4" O.D. Dia. plastic tubing (Saran or equal)
Gage board
Staple
Pocket in gage board
Stud for fastening cistern to gage board
Scale in feet, tenths and hundredths
Spanner wrench
Pressure and bleeding piping - 1/8" pipe
Details not shown. - See Dwg 245-D-2286
Pins for holding cistern in place on gage board
Packing nut
Washer
Cistern cap
Gasket
Packing
Reinforcing tube
Cistern pot
Fill pot with mercury to mercury level line
Zero of gage at mercury level line
ASSEMBLY
3" Dia.
2.60" Dia.
2 1/2" Dia.
1/32" Fiber gasket
20 Thds. per inch - To fit cap
Cut mercury level lines on stainless pot
1" Hex
CISTERN POT
STAINLESS STEEL OR LUCITE
3/8" Dia. hole
14 Ga.
1/16" Dia. Pins
SPANNER WRENCH
STEEL
O.D. to fit I.D. of Saran tube
45° Chamfer
REINFORCING TUBE
STAINLESS STEEL
Dia. to fit tube
9/16" Dia. circle - 6 - 5/64" Dia. holes for spanner wrench
PACKING NUT
STAINLESS STEEL
WASHER
STAINLESS STEEL
PACKING
RUBBER
1/4" USS thds.
PIN
BRASS
TWO REQUIRED
Note:- For assembly see Dwg 245-D-2286
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO BIG THOMPSON PROJECT - COLO.
GREEN MOUNTAIN DAM
HIGH-HEAD MERCURY MANOMETER
DRAWN F.C.L.
TRACED F.R.C.
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
DENVER, COLORADO, SEPT. 16, 1944
245-D-2291