UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

OPERATING CHARACTERISTICS OF VERTICAL FLOWMETER STAND TURNOUT WITH 10-INCH PROPELLER METER

Hydraulic Laboratory Report No. Hyd-374

DIVISION OF ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
DENVER, COLORADO

January 17, 1956

CONTENTS

CONTENTS--Continued

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Commissioner's Office, Denver
Division of Engineering Laboratories
Hydraulic Laboratory Branch
Hydraulic Structures and Equipment Section
Denver, Colorado
January 17, 1956

Laboratory Report No. HYD-374
Written by: H. W. Price
J. W. Ball
Checked and reviewed by: J. W. Ball
Submitted by: H. M. Martin

Subject: Operating characteristics of vertical flowmeter stand turnout with 10-inch propeller meter

PURPOSE

The objectives of this investigation were to determine whether or not the throttling of valves under high heads would affect the accuracy of propeller meters placed in vertical riser turnouts, to evaluate the hydraulic losses for various turnout installations, and to study the performance of a 10-inch propeller meter in silty water.

CONCLUSIONS

1. The accuracy of a propeller meter will not be affected by the Type L turnout structure shown on Figure 1 when the controlling gate valve is throttled under differential heads up to 35 feet. The accuracy will be good at differential heads greater than 35 feet but the Type T structure should be used because the L type may be damaged by cavitation.

2. The accuracy of a propeller meter will not be affected by the Type T-2 turnout structure shown on Figure 2 when the controlling gate valve is throttled under heads up to 150 feet. No cavitation damage is expected on this type turnout at heads to 150 feet.

3. An 8-inch bellmouth control valve will have less loss than an 8-inch waterworks valve when both are operated wide open in turnouts with propeller meters, so the bellmouth valve or a larger size valve should be used where head losses must be kept to a minimum.

4. The loss through the Sparling irrimeter can be decreased by raising the meter dome. If the dome is raised the meter propeller shaft should be lengthened to keep the propeller inside the pipe, otherwise the accuracy of the meter will be affected. The reduction in losses due to raising the dome 3/4 of an inch is shown on Figure 5A.

5. The loss chargeable to the irrimeter should be defined as the loss in excess of that for a vertical pipe with the exit at the same elevation as the top edge of the irrimeter tube. This loss can be determined from the curves of Figure 5.

6. The hub shaft housing recess of a Sparling irrimeter forms a settling and collecting basin for any silt contained in the flow, but the silt accumulation in the space between the propeller hub and the propeller shaft housing will be practically eliminated when three holes are drilled through the hub wall into the hub shaft housing recess (Figure 9A).

With the meter and dome at its initial height and a flow of 3 cfs, the loss chargeable to the meter would be 0.86 foot of water. With the dome raised 3/4 of an inch the loss would be 0.65 foot (Figure 5A).

INTRODUCTION

The Delano-Earlimart Irrigation District is an area of land served by the Friant-Kern Canal distribution system of the Central Valley Project. The district is located about 30 miles north of Bakersfield, California. The district's distribution system is of the closed conduit type with valve controlled vertical riser flowmeter stands for turnouts (Figures 1 and 2). Propeller meters in the risers measure and totalize the volume of water delivered to the land. The normal turnout flow is from 2 to 3 cfs.

Excessive heads at many of the turnouts make it necessary to provide a means of dissipating the energy in the high velocity jets discharged by the valves before the water reaches the meters at the top of the riser pipes. At other turnouts very small available heads make it necessary to keep head losses to a minimum to assure normal releases. For simplicity of design, construction and maintenance it is desirable to have a minimum number of designs that will fulfill the requirements of both the high head and the low head installations and, therefore, the structures must provide both good energy dissipation and a minimum loss in head while providing good metering accuracy at all flow conditions. Hydraulic tests were made in the laboratory on full size turnout structures to obtain turnout designs which would meet these requirements. In addition, the problem of preventing accumulation of silt in the irrimeter propeller hub was included in the test program when it was found that the accuracy of meters in field structures was reduced and the meter parts became worn due to silt deposits.

The laboratory tests concerning the valve-controlled turnouts with vertical risers and with propeller meters as the measuring devices are discussed in this report. The designs developed from the tests are shown on Figures 1 and 2.

ACKNOWLEDGMENT

These studies were accomplished through the cooperative efforts of members of the Canals Branch and the Hydraulic Laboratory Branch of the Commissioner's Office, Denver. The 10-inch propeller meter used for the studies was loaned by the Ray C. Sparling Company, El Monte, California. The 8-inch bellmouth gate valve was loaned by Waterman Industries, Incorporated, Exeter, California.

THE INVESTIGATION

Test Facilities

The first turnout design tested consisted of an 8-inch bellmouth valve at the end of a 12-inch pipe, a 12- by 12- by 10-inch plastic tee attached to the valve, a blank flange on the downstream end of the tee and a 10-inch vertical plastic riser pipe with a 10-inch Sparling Irrimeter at the top (Figure 3). Water was supplied to the turnout by two 12-inch centrifugal pumps operated in series to provide heads up to 150 feet. Volumetrically calibrated venturi meters in the laboratory supply system were used to measure the flow quantities which varied from 0.13 to 4.00 cfs. The test structure was altered from time to time to represent other turnout designs. These variations are discussed in appropriate sections of this report.

Turnout with 8-inch Bellmouth Valve, 12- by 12- by 10-inch Tee, and 10-inch Riser with Propeller Meter

Flow conditions within the tee of this (Type T-1) turnout were quite turbulent when the valve was discharging at partial openings under high heads. The turbulence decreased as the head was reduced and the valve opening increased. Flow conditions in the riser seemed very uniform. Accuracy tests on the 10-inch irrimeter indicated this to be so. The irrimeter registered about 100 percent accuracy for 2.0 cfs under heads from 10 to 135 feet, and about 100.5 percent for 3.0 cfs over the same range of heads (Figure 4A).

Excessive noise due to cavitation occurred at partial valve openings at the higher heads, and at the end of the tests slight cavitation-erosion was noted on the invert of the downstream bell of the valve and bottom surface of the plastic tee. The cavitation seemed to start with an upstream head of about 45 feet.

Pressure head losses for various parts of the turnout are shown on Figure 5A. The pressures within the tee for full valve opening gradually increased from B to D. The lower pressure at B indicated the presence of a contraction immediately below the valve and the higher pressure at D indicated a buildup of pressure at the closed end of the tee. Losses for the valve are approximated by the drop in pressure from A to C, and the loss for the riser by the pressure drop from C to F, minus the difference in velocity heads in the 10- and 12-inch pipe sections.

This turnout was satisfactory insofar as the accuracy of the propeller meter was concerned, but protection against cavitation is needed if the structure is used under high heads. Moreover, the losses were believed to be high compared to those for an L-shaped turnout. Further studies were therefore made.

Turnout with 8-inch Bellmouth Valve, 12-inch, 3-piece, Miter Elbow, 12- to 10-inch Reducer and 10-inch Propeller Meter

A 12-inch, 3-piece, lightweight mitered elbow was placed immediately downstream of the 8-inch bellmouth valve (Figure 6B). A short section of 12-inch plastic pipe, an 8-inch long reducer from 12- to 10-inch pipe, a short 10-inch riser, and a 10-inch propeller meter completed the (Type L-1) turnout. The smaller head loss of this design, as compared with the tee design, makes it more suitable for use where conservation of head is important and the valve must be fully opened (Figure 5B). In this case the heads would be low and there would be no danger of cavitation.

Tests at various heads and valve openings showed that the accuracy of the propeller meter was good and that the head loss for the elbow turnout was less than for the tee (Figures 4A and 5B). The design is therefore desirable for installations where conservation of head is important.

Cavitation was observed immediately downstream of the valve when the turnout valve was throttled under high heads and this characteristic made the design unsuitable for these heads. A test was made to determine the head at which cavitation would begin. For the range of flow from 1 to 3 cfs a total head of 43.5 feet was required on the partially open valve to produce incipient cavitation. In this case the top of the turnout riser was 8.16 feet above the centerline of the valve, the vapor pressure was 27 feet of water below atmospheric pressure and the differential head across the turnout was about 35 feet. This turnout design was therefore considered satisfactory for flows up to about 4 cfs under differential heads up to 35 feet.

Turnout with 8-inch Standard Waterworks Valve, 14- by 14- by 11-inch Tee, 12-inch Riser with 12- to 10-inch Reducer and 10-inch Propeller Meter

It was believed that a sudden enlargement immediately below the valve would remove the boundary surfaces from the zone of cavitation and do much to reduce the cavitation tendencies and thus prevent cavitation damage to the turnout. A 14- by 14- by 11-inch tee was made up by attaching an 11-inch diameter riser pipe 1-1/2 inches long to a short section of 16-inch pipe which was fitted at each end with 14-inch inside diameter flanges (Figure 6A). The 16-inch pipe was lined with a 1-inch-thick layer of sand-cement concrete to form a 14- by 14- by 11-inch tee with easily erosible surfaces. The downstream end of the tee was closed with a blank flange coated with sand-cement mortar. A section of 12-inch concrete pipe was grouted over the 11-inch riser and the 10-inch propeller meter transite pipe section was grouted into the end of the 12-inch pipe. The grout was shaped to form a reducing transition from the 12-inch pipe to the 10-inch transite pipe and this completed the Type T-2 turnout (Figure 5C).

This design was operated at various valve openings at heads up to 150 feet with back pressures of about 15 feet. A definite decrease in the cavitation tendency over the other designs was noted. After tests of 3 hours duration at discharges of 2, 3, and 4 cfs at partial valve openings under differential heads of 150, 150, and 118 feet, a total of 9 hours operation, there was no cavitation damage to any portion of the valve or concrete surface within the tee section, although some noise similar to that which accompanies cavitation was present at heads in excess of about 90 feet. Incipient cavitation occurred at the same 90-foot head for a wide range of discharges and valve openings. The top of the transite pipe section of the turnout meter was 10.85 feet above the centerline of the valve. Although the meter registration accuracy was somewhat erratic, the variation was small and did not change with valve opening. Since this characteristic was present regardless of head and opening, it was not attributed to the turnout design but to some unknown cause. The pressure head losses for this turnout were slightly less than for the 12- by 12- by 10-inch tee used in the first tests (Figure 5C). A turnout of this design would be used where differential heads in excess of 35 feet are encountered. The tee section of such a design would not be lined with concrete, as was done in the test structure, but sufficient surface protection should be provided to minimize corrosion. It is believed that this design would be satisfactory under heads as high as 150 feet unless vibration from cavitation proved objectionable. Vibration of the test structure at this head was considered to be mild.

A valve design developed by the Bureau is best for high heads. The downstream passage, particularly the invert, is shaped to cause separation of flow and prevent cavitation damage to the valve. This valve, with a sudden enlargement placed downstream as shown on Figure 7, will be very effective in preventing cavitation damage for valves operating at small openings under high heads.

Head Loss for Turnout with 10-inch Irrimeter

When reports from the field indicated that valve-controlled vertical riser turnouts in which Sparling irrimeters were being used to measure the flow were not delivering the required amount of water, a study was made to determine the head loss for various parts of the turnout flow passage to ascertain if the losses could be reduced. It seemed that losses through the valve section could not be altered appreciably except by increasing the valve size to that of the pipe, that the losses in the turnout below the valve would depend on the water passage shape in this region (whether T- or L-shaped), and that some reduction in the meter head loss might be realized by alteration of the meter.

Hydraulic tests using tee and ell sections below the valve indicated a much smaller head loss in the 3-piece miter elbow than in the tee (Figure 5). However, the field turnouts with inadequate capacity were of the miter elbow design and in many cases contained a valve the size of the delivery pipe, so it was necessary to investigate other parts of the structure for possible reduction in losses. Since very little could be accomplished by further streamlining of the turnout flow passage downstream of the valve, the possibility of altering the meter to reduce its head loss and permit release of the required flow was investigated. In this investigation it was necessary to isolate the meter loss from other losses in the turnout, determine its source and make alterations which would reduce it. The loss for the meter, based on pressures measured at piezometers placed 16 and 28 inches from the end of the transite meter tube, was determined (Figure 5). The meter propeller and deflector dome was then removed and the loss (based on the piezometer 16 inches from the end of the transite tube) was determined for the open end vertical pipe (Figure 5). New dome brackets were made to raise the deflector dome 3/4 of an inch. This distance was selected because it was the maximum the dome could be raised and still keep the propeller of the test meter within the transite meter tube. The loss for 3 cfs was reduced by about 0.25 of a foot (Figure 5A). It was still questionable whether this reduction in loss would permit full capacity releases from the field turnouts. However, the manufacturing company decided to raise the meter domes 1-1/2 inches and alter the dome slightly so that the water would still be deflected downward around the turnout riser pipe. This change permitted the turnouts to deliver water at full capacity.

Effect of Silty Water and Registration Accuracy of Propeller Meter

Observation at some of the field installations using the Sparling irrimeter disclosed that silt in the turnout flow accumulated in the shaft housing recess in the back of the propeller and entered the bearing where it caused wear and binding that affected the meter registration accuracy. Holes had been drilled through the propeller hubs into the recess of some field meters to permit circulation of water through the recess and prevent the accumulation. Since it was difficult to evaluate the effectiveness of this treatment in the field where the amount of silt in the water was relatively small, laboratory tests were conducted on meter propellers with and without holes in the hub, using water with a high silt content (average 5,000 parts per million). The composition of the silt was similar to that found in the Friant-Kern Canal distribution system (Figure 8).

In less than 2 hours operation enough silt had collected in the undrilled propeller hub to permit particles to enter the bearing and to bind the hub and bearing sufficiently to cause a decrease in registration accuracy (Figure 4B).

A total of 22 grams (dry weight) of silt was collected in the propeller hub and shaft housing after 5 acre-feet of water had been released through the turnout (Figure 9B).

Tests with three holes drilled in the hub, using the same silt concentration, flow rate, and test period, failed to show any accumulation of silt in the hub or bearing (Figure 9A). No change in meter registration accuracy was noted after 5 acre-feet of silty water passed through the turnout.

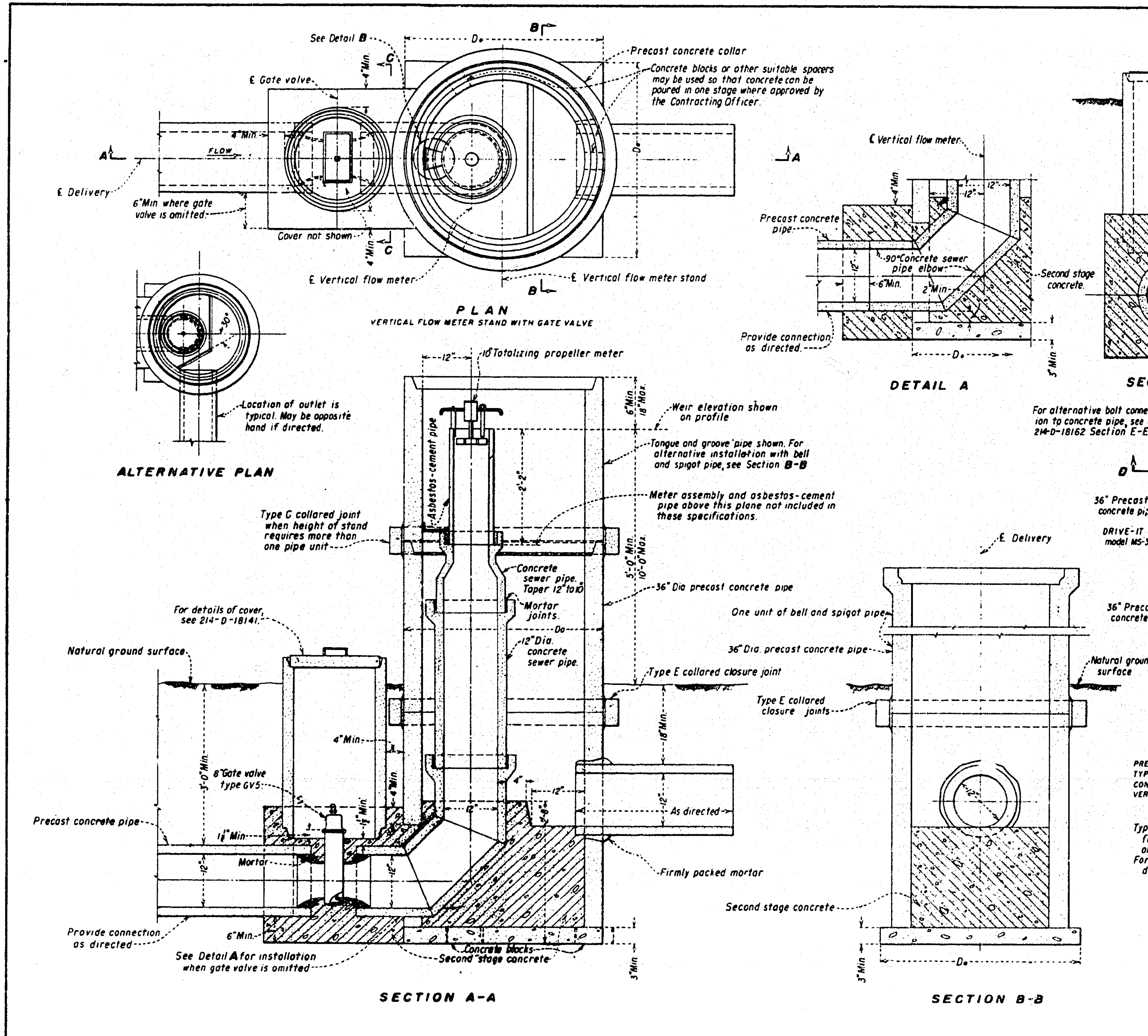
Two propellers with holes drilled differently were tested. In one the holes were perpendicular to the axis of the propeller, and in the other the holes were pointed 45 degrees into the flow. No difference in silting conditions was detected. However, it is believed better to have the holes pointed into the flow while the turnout was in operation and to have them pointed downward so that any silt in the hub would fall from the hub as the turnout flow stopped or receded into the pipeline.

Two other experiences with silt in propeller meters tested in the laboratory are cited in this report to point out that flow, heavily laden with silt, will likely introduce an operation and maintenance problem whenever moving parts are exposed to the silt particles.

In tests on a turnout using an open flow meter (horizontal shaft), it was found that a small amount of silt in the water of the laboratory supply system resulted in a wearing and binding of the bearing such that the propeller would rotate intermittently at very slow velocities (below about 0.5 of a foot per second). A small deposit of silt was found in and near the front shaft bearing. When the meter was disassembled and examined the bearing showed signs of wear (Figure 10). These conditions were discovered after the meter had registered 45 acre-feet of water from the laboratory circulating system. Apparently the water contained a small amount of silt which entered and deposited in the meter during each of the many times the test system was shut down and placed in operation. The meter tube filled with water when the turnout was placed in operation, and drained when the turnout was shut off. Silt settling from the water contained in the tube would not be removed by the draining action so there was an accumulation of material in the lower portion of the meter on the propeller shaft worm gear, worm wheel, and in the three bearings. No studies were made with holes drilled in the hub of the propeller because the axis is horizontal and no sediment should collect inside the hub; however, these holes would no doubt help to minimize any tendency for silt to collect in the hub.

An 8-inch Sparling Main Line meter was used to measure silty water in a sediment study. The meter handled about 6.3 acre-feet of silty water and 6.6 acre-feet of relatively clear water. An excessive amount of fine sediment collected in the shaft housing during the test (Figure 11). Registration accuracy tests made without disturbing the sediments showed a slightly low registration, particularly at low flows. In attempting to clean the meter for a recheck, the parts were disturbed to such an extent that the recheck was not satisfactory.

Interior - Reclamation - Denver, Colo.



REFERENCE DRAWINGS

PRECAST CONCRETE PIPE JOINTS-TYPES A,B,C,D,E,F AND G	214-D-18160
TYPICAL GATE VALVE INSTALLATION TYPE GV5 AND TYPE GV5R	214-D-18141
CONNECTION JOINTS PIPELINE TO STRUCTURE	214-D-18158
VERTICAL FLOW METER STAND INSTALLATION TYPE T	214-D-18169

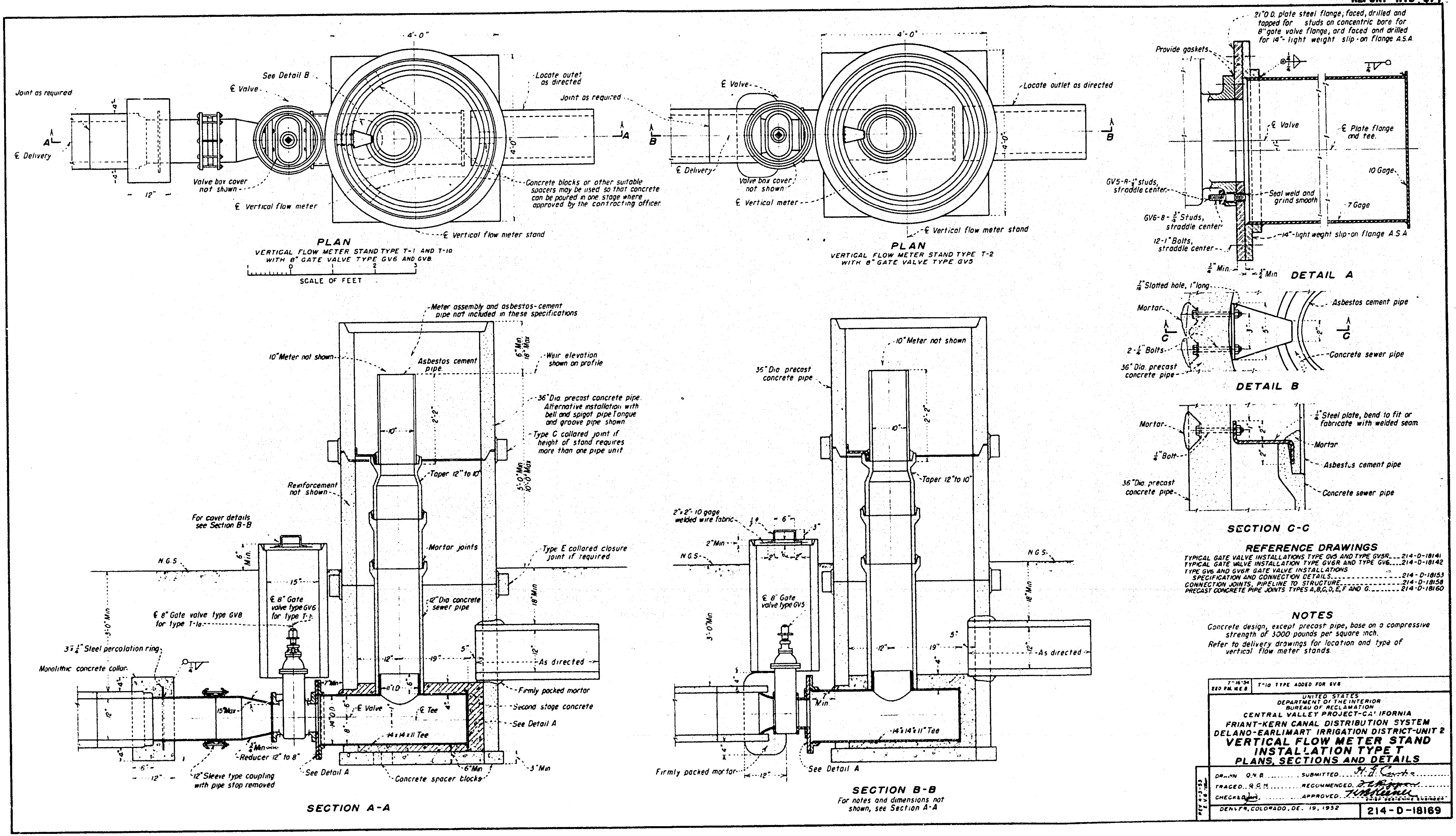
NOTES

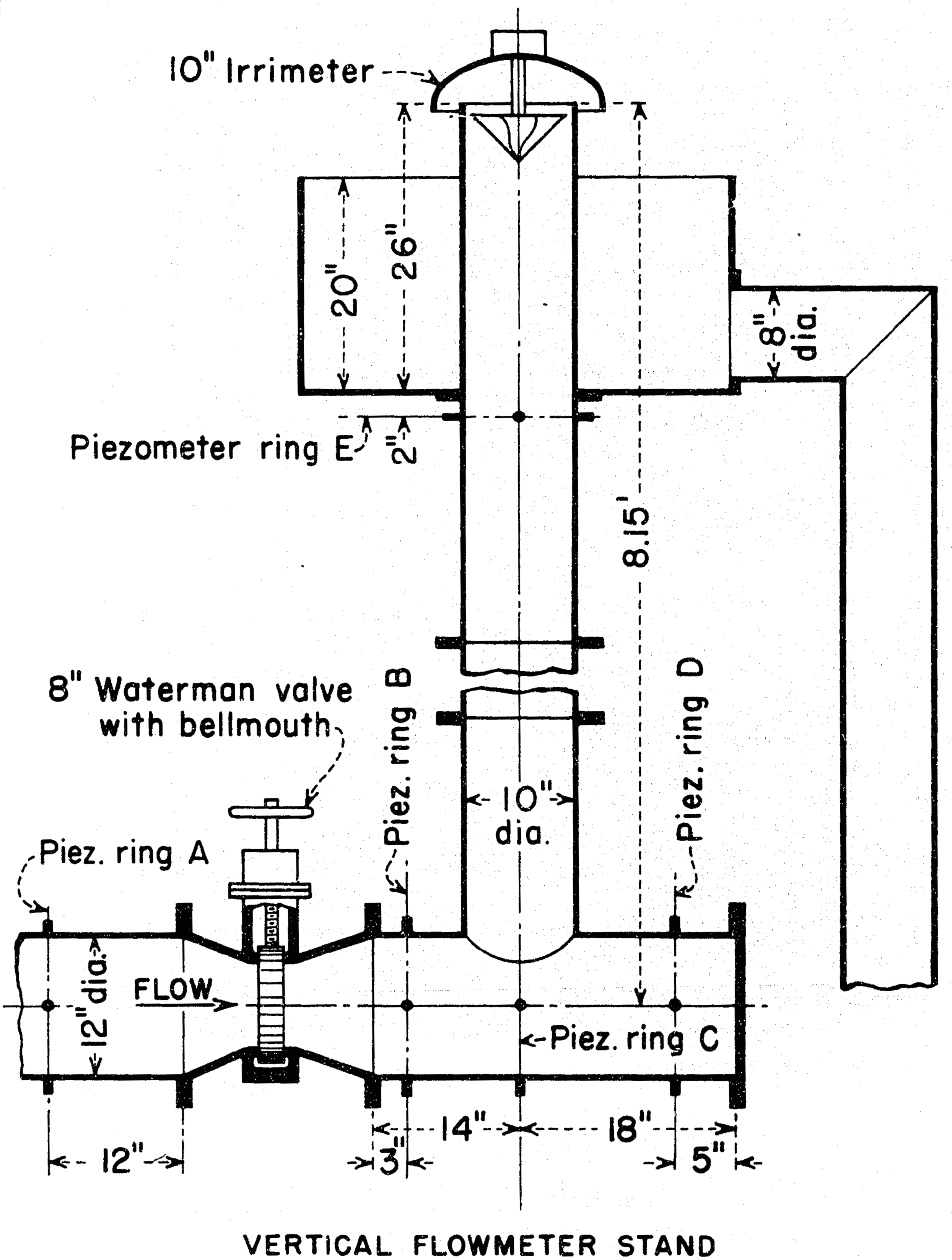
Type L installation used when head on upstream side of valve is 50 feet or less and when differential head across valve is 30 feet or less.
For type of vertical flow meter stand in deliveries, see delivery drawings.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT-CALIFORNIA
FRIANT-KERN CANAL DISTRIBUTION SYSTEMS
DELANO-EARLIMART IRRIGATION DISTRICT-UNIT-2
VERTICAL FLOW METER STAND
INSTALLATION TYPE L

DRAWN J.R.S. SUBMITTED
TRACED M.U.S. RECOMMENDED
CHECKED APPROVED CHIEF DESIGNING ENGINEER

DENVER, COLORADO DEC 8, 1952 — 214-D-18168

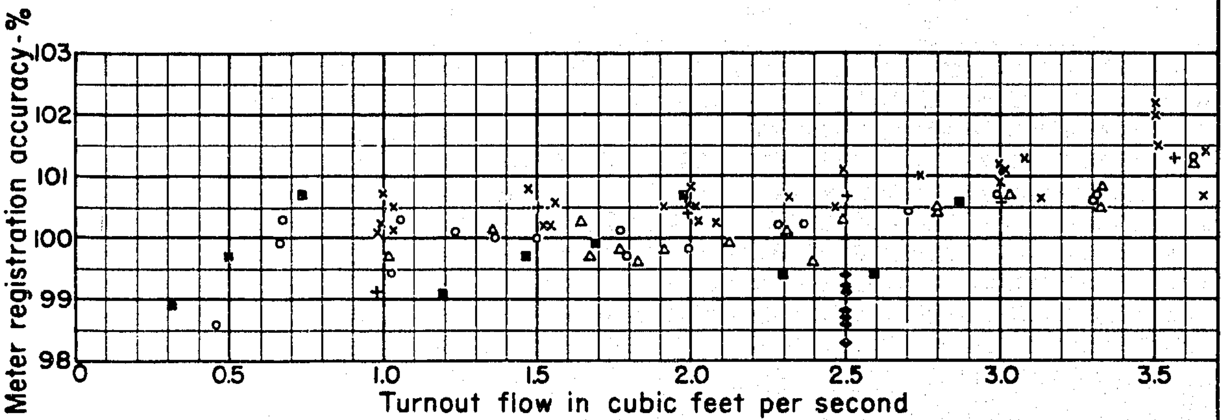

PLAN
VERTICAL FLOW METER STAND TYPE T-1 AND T-1a
WITH 8" GATE VALVE TYPE GV6 AND GV8
SCALE OF FEET
PLAN
VERTICAL FLOW METER STAND TYPE T-2
WITH 8" GATE VALVE TYPE GV5
DETAIL A
DETAIL B
SECTION C-C
SECTION A-A
SECTION B-B
For notes and dimensions not shown, see Section A-A
Joint as required
See Detail B
Locate outlet as directed
Valve box cover not shown
Vertical flow meter
Vertical flow meter stand
Concrete blocks or other suitable spacers may be used so that concrete can be poured in one stage where approved by the contracting officer.
Meter assembly and asbestos-cement pipe not included in these specifications
10" Meter not shown
Asbestos cement pipe
Weir elevation shown on profile
36" Dia. precast concrete pipe. Alternative installation with bell and spigot pipe. Tongue and groove pipe shown
Type C collared joint if height of stand requires more than one pipe unit
Taper 12" to 10"
Reinforcement not shown
For cover details see Section B-B
Mortar joints
Type E collared closure joint if required
12" Dia concrete sewer pipe
8" Gate valve type GV8 for type T-1a
8" Gate valve type GV6 for type T-1
3"x1/4" Steel percolation ring
Monolithic concrete collar
As directed
Firmly packed mortar
Second stage concrete
See Detail A
14x14x11 Tee
Reducer 12" to 8"
12" Sleeve type coupling with pipe stop removed
Concrete spacer blocks
2"x2"-10 gage welded wire fabric
8" Gate valve type GV5
21" O.D. plate steel flange, faced, drilled and tapped for studs on concentric bore for 8" gate valve flange, and faced and drilled for 14"-light weight slip-on flange A.S.A.
Provide gaskets
Plate flange and tee.
10 Gage
7 Gage
Seal weld and grind smooth
GV5-8-1/2" studs, straddle center
GV6-8-3/4" Studs, straddle center
12-1" Bolts, straddle center
14"-light weight slip-on flange A.S.A.
3/4" Slotted hole, 1" long
Asbestos cement pipe
Concrete sewer pipe
2-1/2" Bolts
36" Dia. precast concrete pipe
1/4" Steel plate, bend to fit or fabricate with welded seam
REFERENCE DRAWINGS
TYPICAL GATE VALVE INSTALLATIONS TYPE GV5 AND TYPE GV5R....214-D-18141
TYPICAL GATE VALVE INSTALLATION TYPE GV6R AND TYPE GV6....214-D-18142
TYPE GV6 AND GV6R GATE VALVE INSTALLATIONS SPECIFICATION AND CONNECTION DETAILS....214-D-18153
CONNECTION JOINTS, PIPELINE TO STRUCTURE....214-D-18158
PRECAST CONCRETE PIPE JOINTS TYPES A,B,C,D,E,F AND G....214-D-18160
NOTES
Concrete design, except precast pipe, base on a compressive strength of 3000 pounds per square inch.
Refer to delivery drawings for location and type of vertical flow meter stands.
T-1a TYPE ADDED FOR GV8
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT-CALIFORNIA
FRIANT-KERN CANAL DISTRIBUTION SYSTEM
DELANO-EARLIMART IRRIGATION DISTRICT-UNIT 2
VERTICAL FLOW METER STAND
INSTALLATION TYPE T
PLANS, SECTIONS AND DETAILS
DRAWN
TRACED
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
DENVER, COLORADO, DEC. 19, 1952
214-D-18169



VERTICAL FLOWMETER STAND

LABORATORY TEST INSTALLATION
TYPE T-1

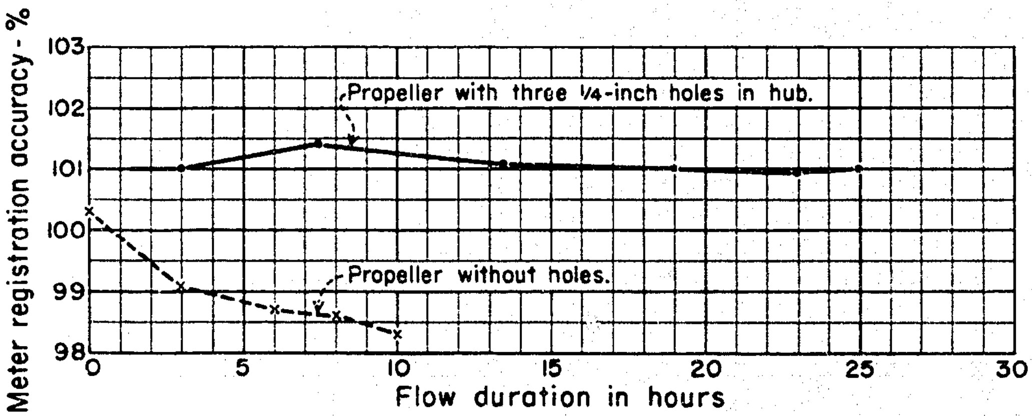
533



- + 12-inch miter bend to riser, 8-inch bellmouth valve fully open.
- × 12-inch miter bend to riser, 8-inch bellmouth valve under various heads and openings.
- ○ 12-by 12-by 10-inch tee to riser, 8-inch bellmouth valve fully open.
- △ 12-by 12-by 10-inch tee to riser, 8-inch bellmouth valve under 135-foot head and various openings.
- ■ 14-by 14-by 11-inch tee to riser, 8-inch standard gate valve under various heads and openings.
- ♦ 14-by 14-by 11-inch tee to riser, silty water at flow rate of 2.5 c.f.s.

Note: Tests were made using 10-inch propeller meter without holes drilled in propeller hub.

A. TURNOUTS WITH TEE AND MITER BEND RISERS



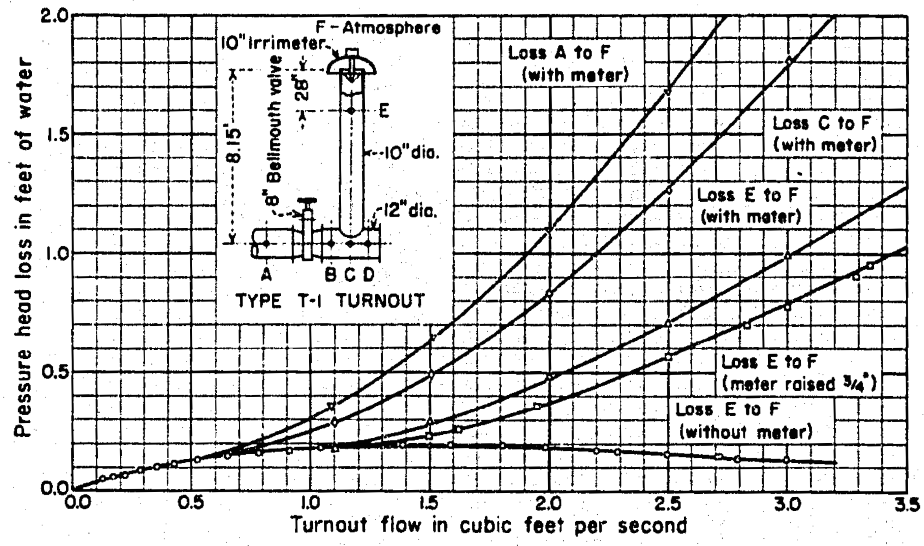
Notes: Rate of flow = 2.5 cubic feet per second.
Silty water approximately 5000 parts per million by volume used in tests.

B. EFFECT OF SILT ON REGISTRATION ACCURACY

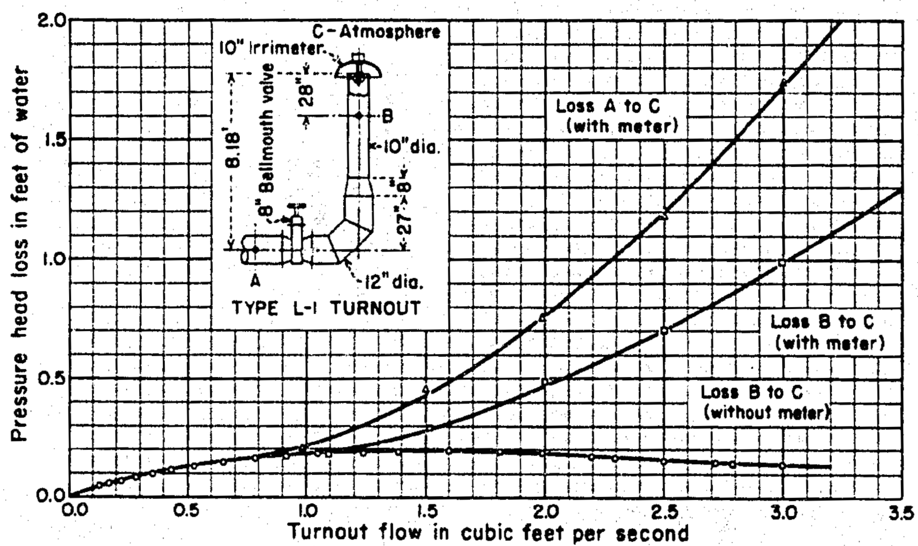
VERTICAL FLOWMETER STAND

METER REGISTRATION ACCURACY

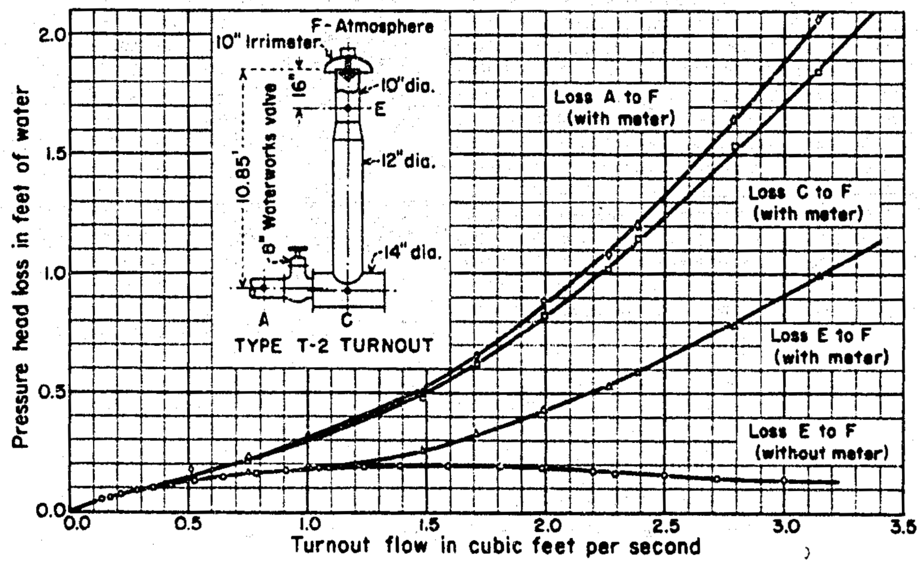
A.
TYPE T-1
TURNOUT



B.
TYPE L-1
TURNOUT



C.
TYPE T-2
TURNOUT

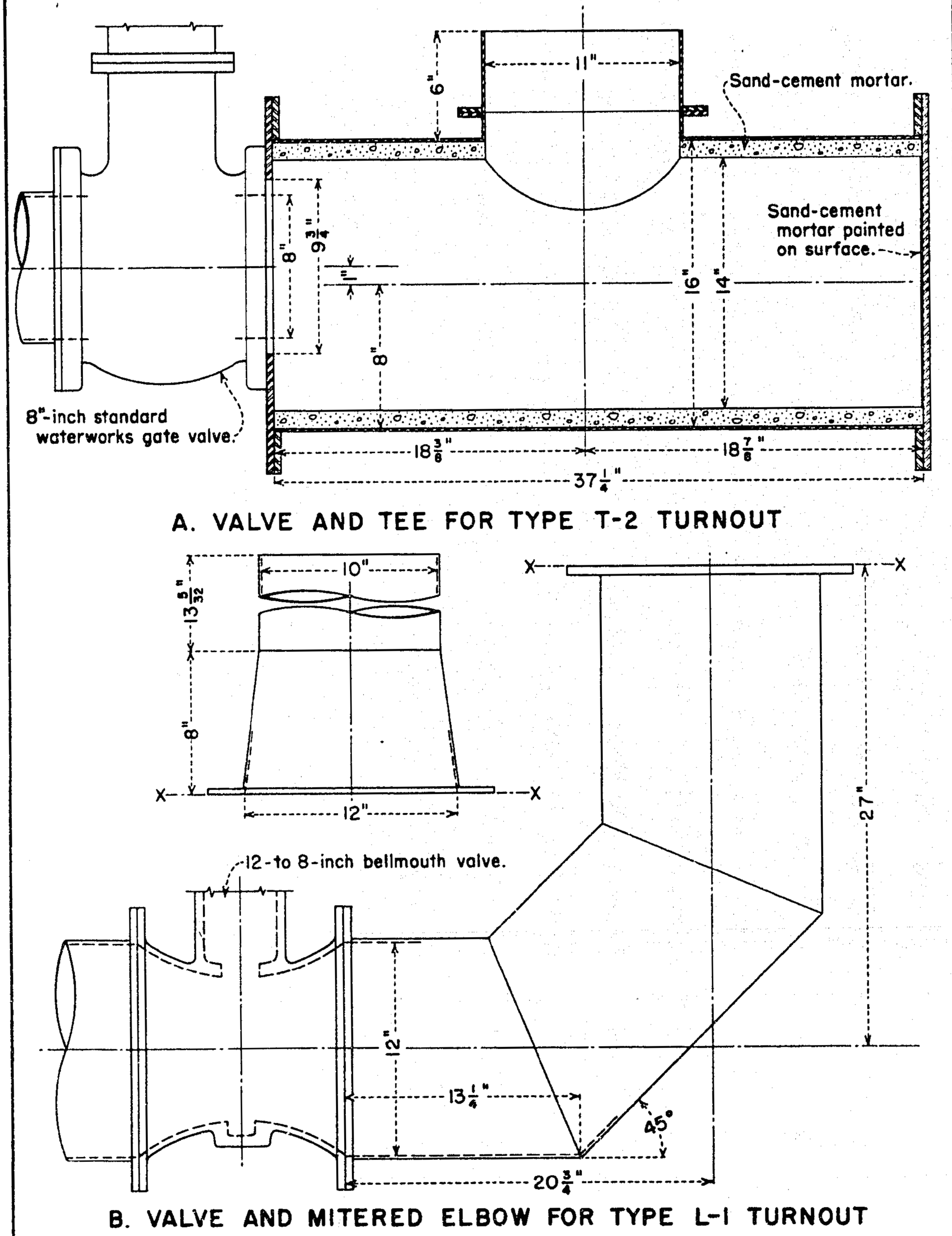


VERTICAL FLOWMETER STAND

PRESSURE HEAD LOSS CURVES

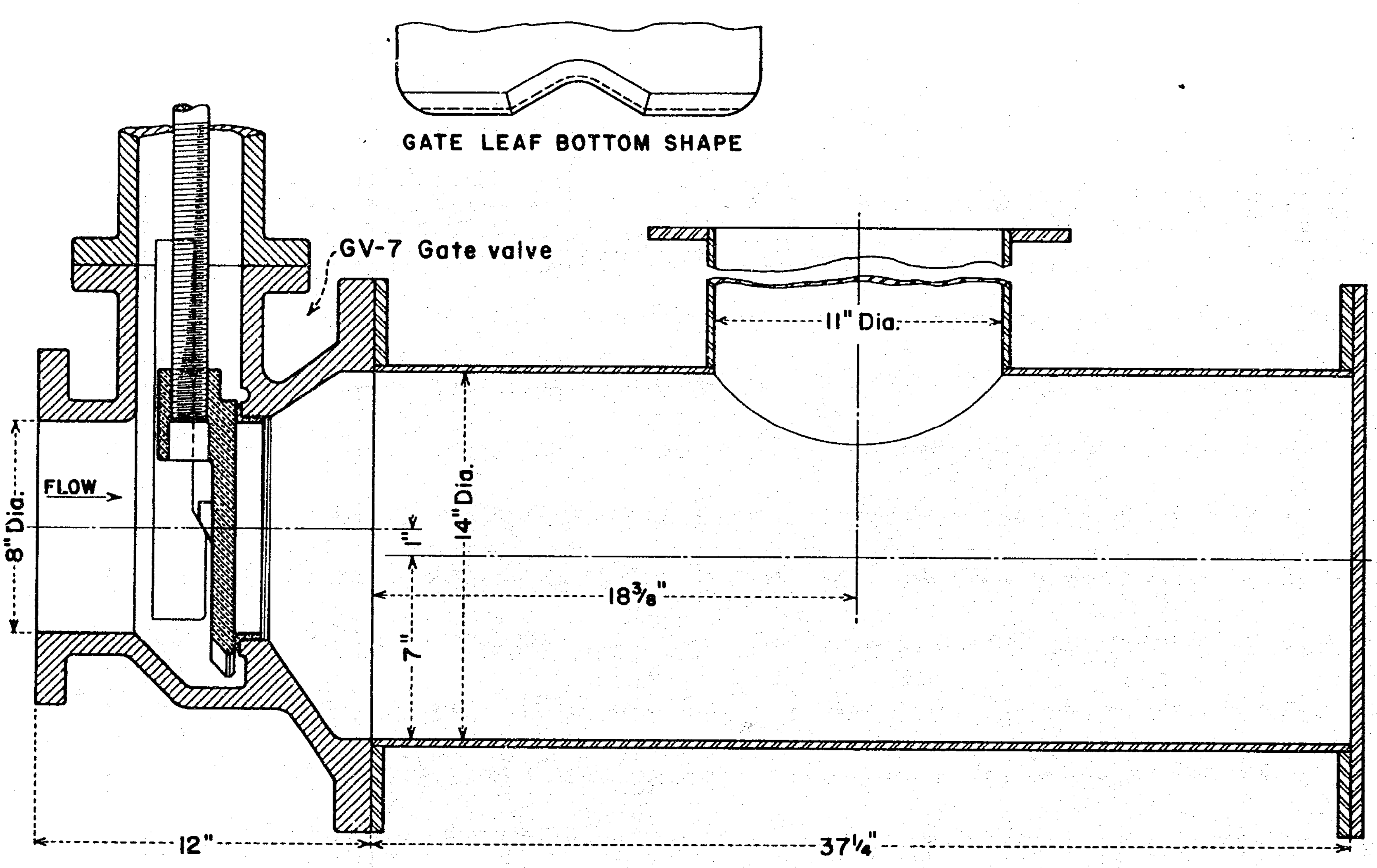
533

FIGURE 6
REPORT HYD 374



VERTICAL FLOWMETER STAND
LABORATORY TEST INSTALLATION
TYPES T-2 AND L-1 TURNOUTS

533

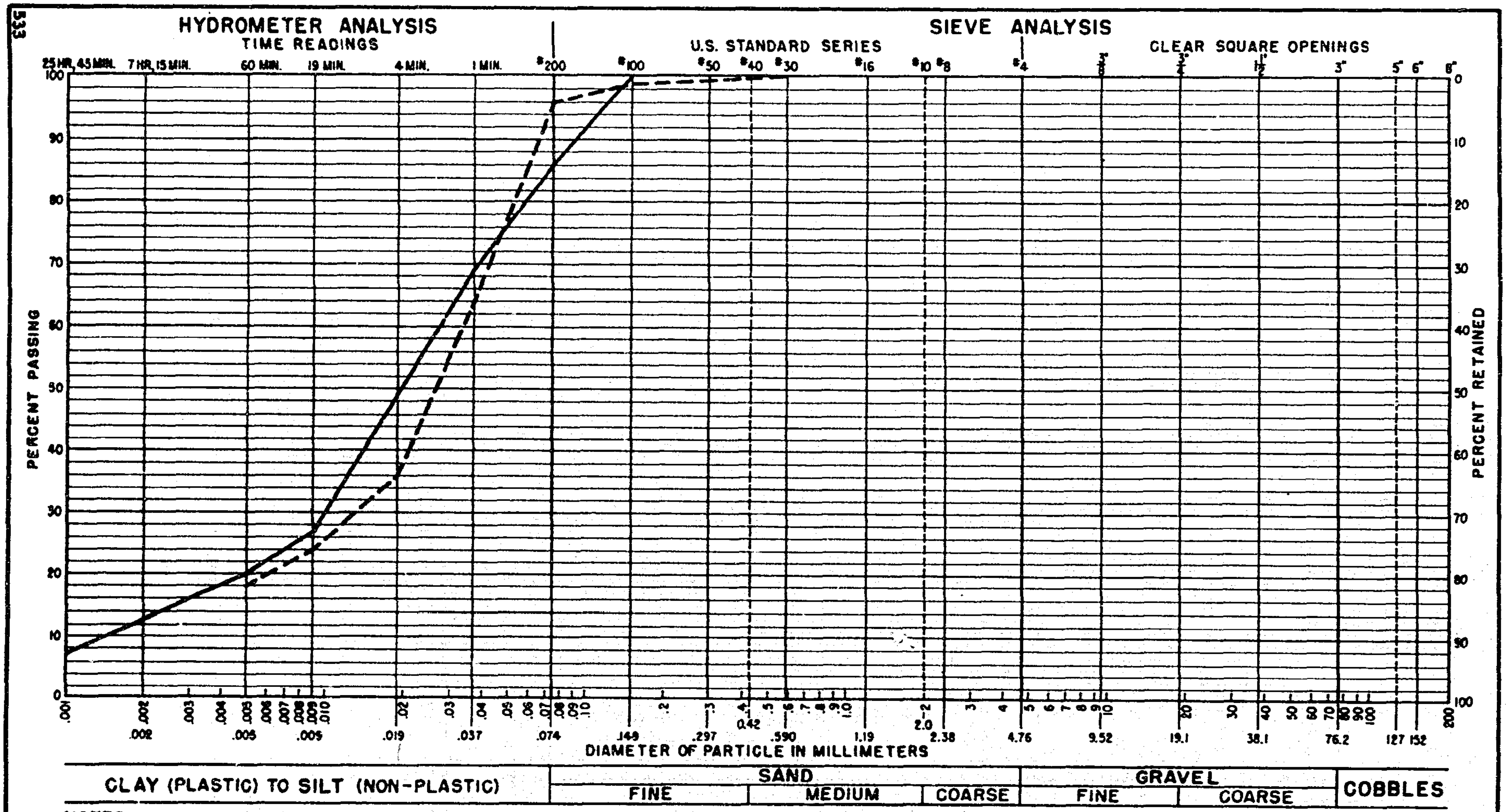


IRRIGATION VALVE STUDY

GV-7 VALVE WITH SUDDEN ENLARGEMENT

533

FIGURE 7
REPORT HYD 374



NOTES:

——— Soil sample scraped off the concrete lining one foot below the water surface.

– – – – (Bonny loess) Soil used in laboratory silting tests.

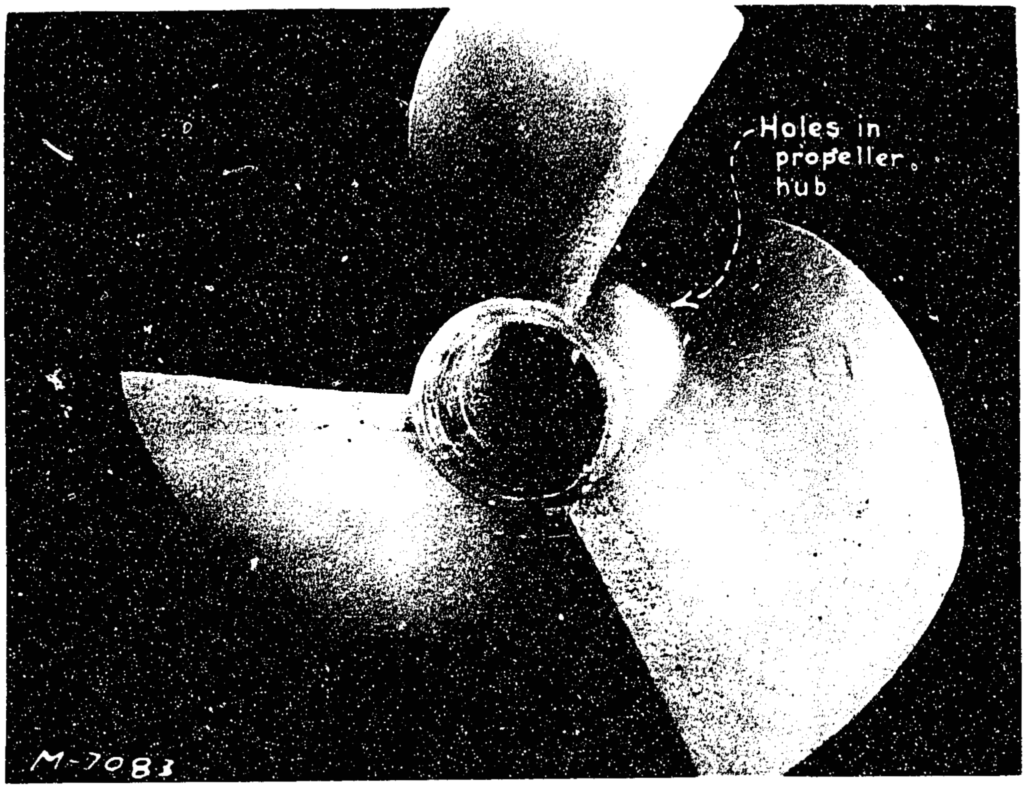
GRADATION OF MATERIAL USED IN SILTING TESTS ON PROPELLER METERS

LABORATORY SAMPLE No.________ FIELD DESIGNATION________ EXCAVATION No.________ DEPTH________ FT.

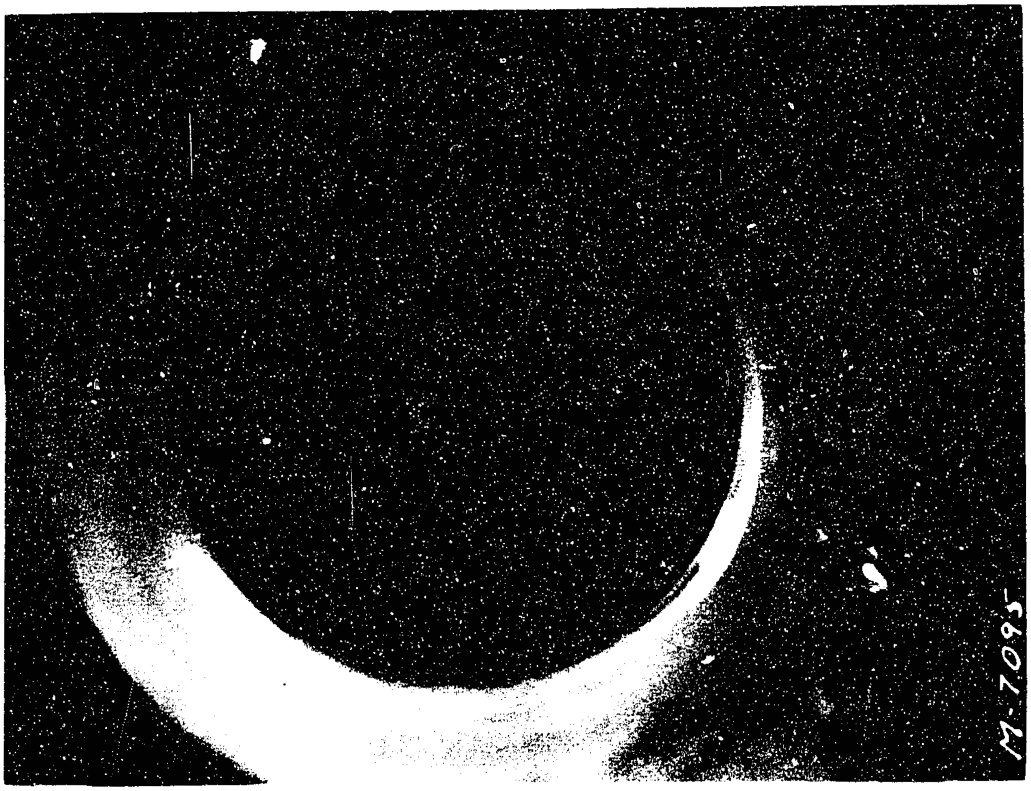
533

FIGURE NO.

FIGURE 8
REPORT HYD 374

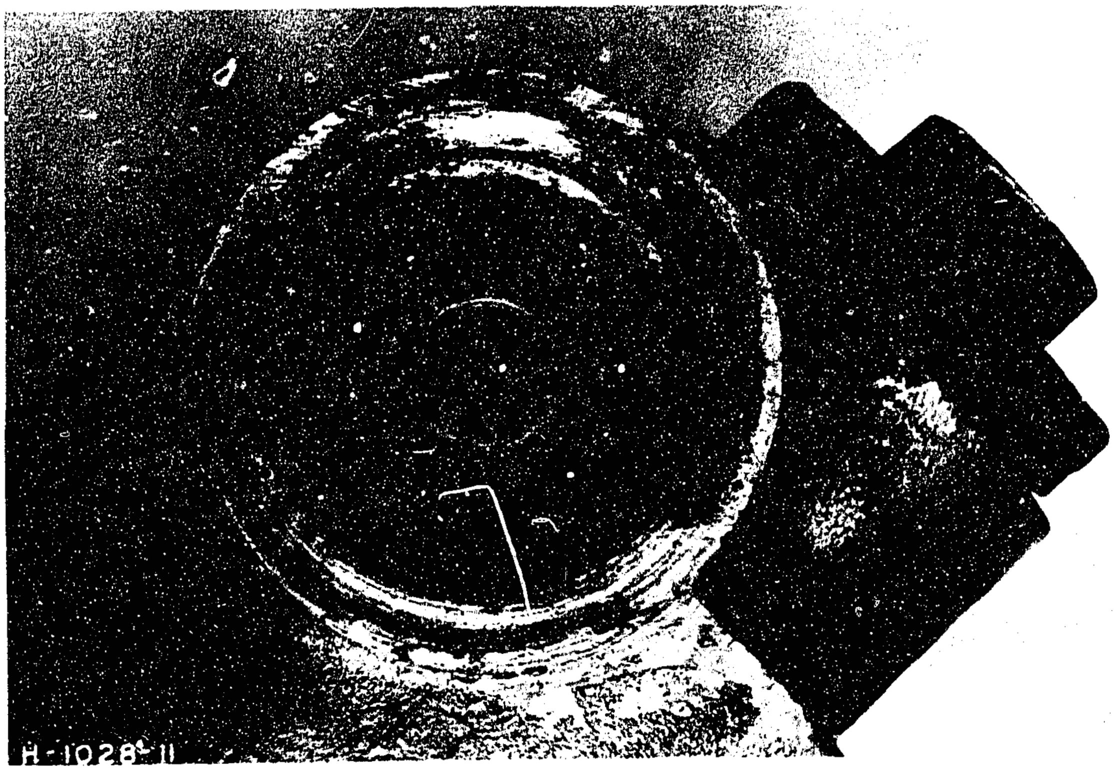


A. Meter Propeller with three 1/4-inch holes in hub - Note absence of silt inside of hub.

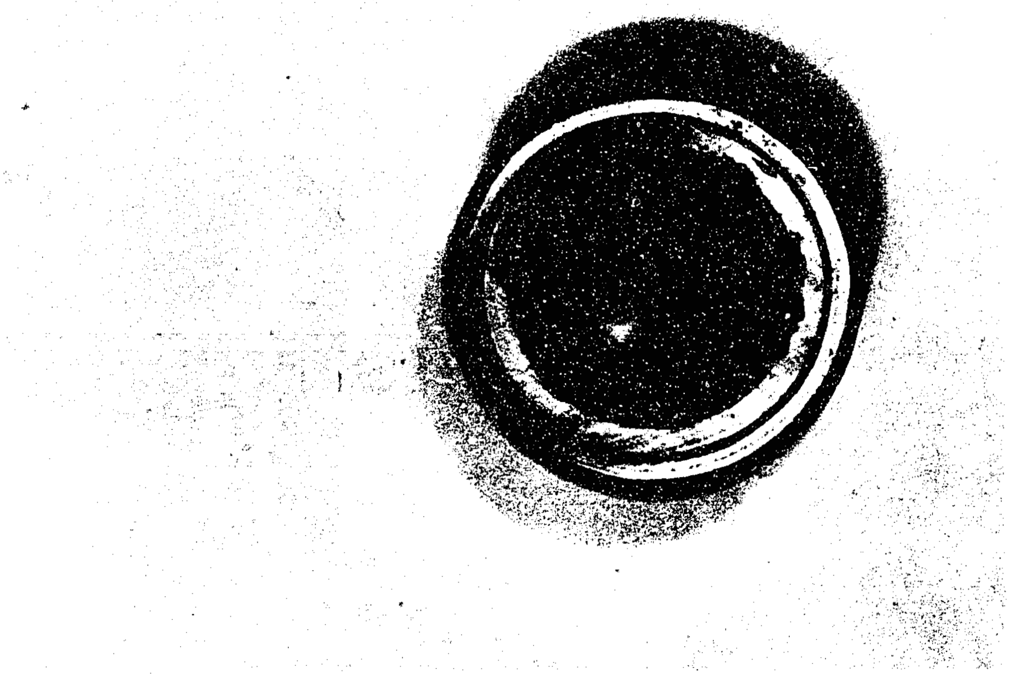


B. Meter Propeller without holes in hub. Silt deposit of 22 grams inside of hub.

Vertical Flow Meter Stands
Silting conditions for vertical shaft propeller meter with and without holes in hub

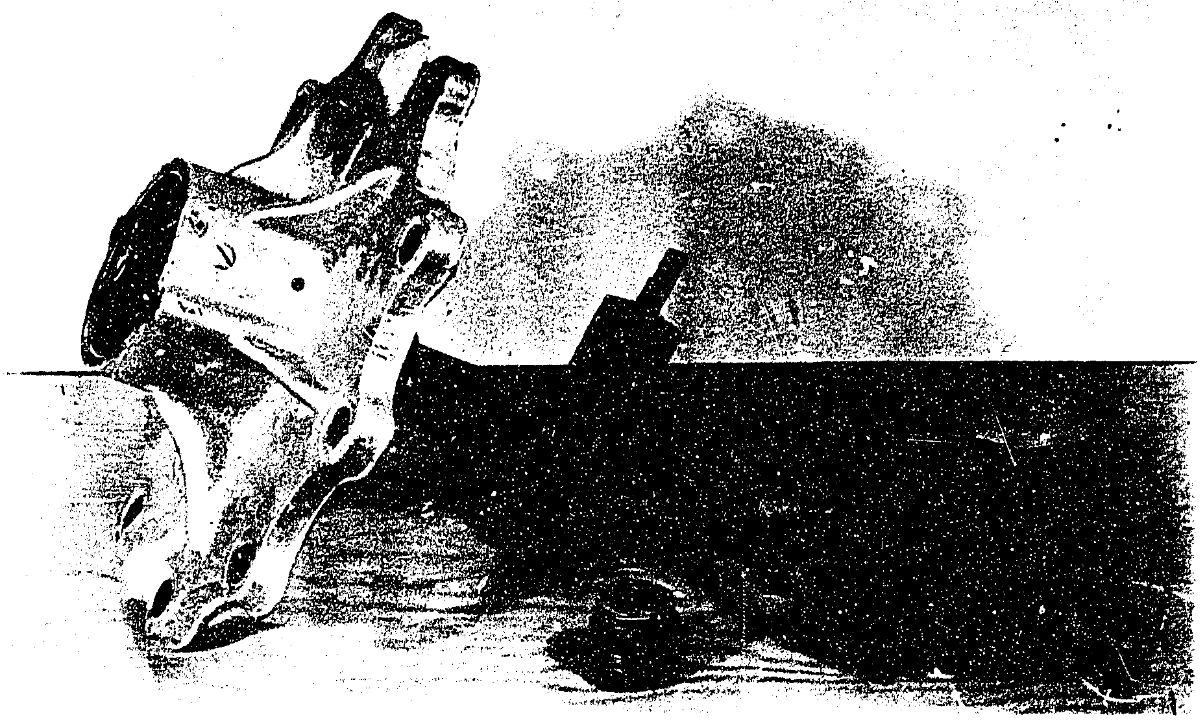


A. Silt deposit in front bearing

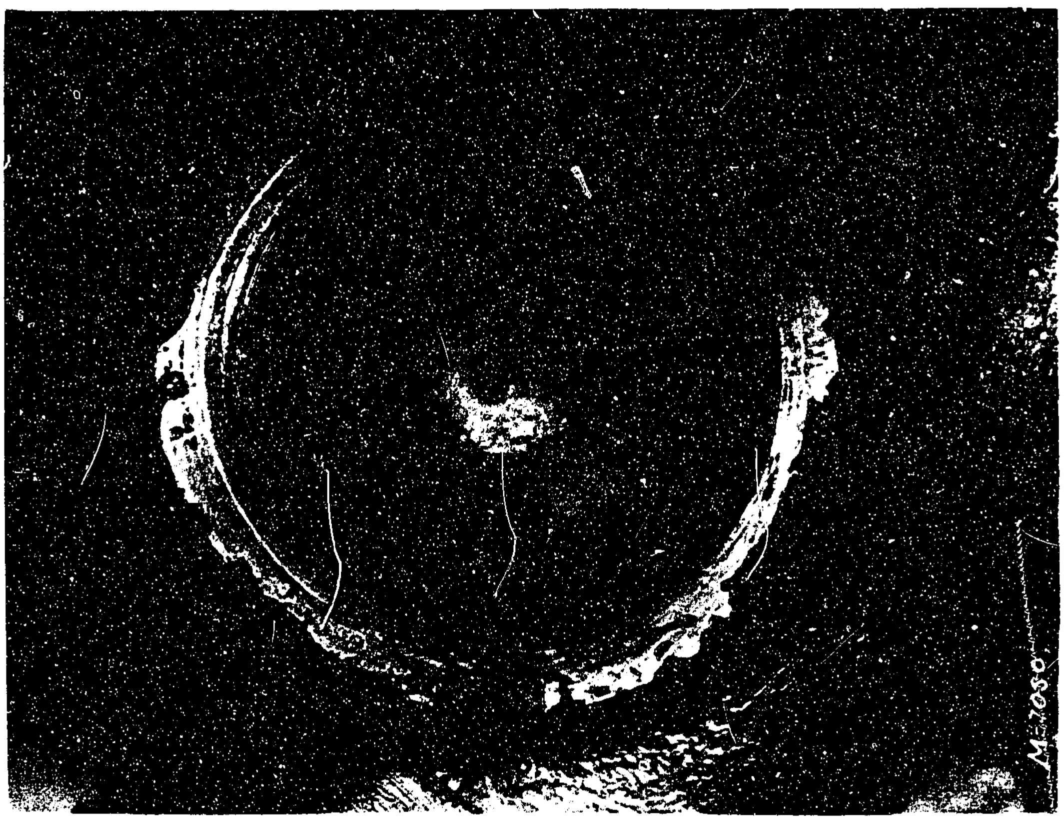


B. Clearance in front bearing

Vertical Flowmeter Stands
Silt deposit in front bearing of horizontal shaft propeller meter



A. Disassembled main line meter



B. Silt deposit in meter backbearing

Vertical Flowmeter Stands
Material deposited in back bearing of 8-inch main line meter