UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

STUDY OF THE EFFECTS OF TURNOUT DESIGN ON REGISTRATION ACCURACY OF PROPELLER METERS PLACED IN DOWNSTREAM ENDS OF TURNOUT PIPES

Hydraulic Laboratory Report No. Hyd-478

DIVISION OF ENGINEERING LABORATORIES

OFFICE OF ASSISTANT COMMISSIONER AND CHIEF ENGINEER
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Office of Assistant Commissioner and Chief Engineer
Division of Engineering Laboratories
Hydraulic Laboratory Branch
Hydraulic Structures and Equipment Section
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Laboratory Report No. Hyd-478
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Subject: Study of the effects of turnout design on registration accuracy of propeller meters placed in downstream ends of turnout pipes

PURPOSE OF THE STUDY

The purpose of the study discussed in this report was to determine the effects of physical and hydraulic conditions of a pipe turnout on the registration accuracy of a propeller meter placed in the outlet end (Figure 1) and to determine what limitations would be required to assure acceptable accuracy for meters used in the various settings. Field tests were made also for correlation with laboratory tests and to investigate the effect of turnout pipe size on meter registration accuracy.

CONCLUSIONS

1. The registration accuracy of a propeller meter placed in the end of a pipe turnout is influenced by the velocity profile of the flow at the meter station.

2. The velocity profile in a pipe may be rather sharp or quite blunt depending on the pipe length, diameter, and relative wall roughness, and the flow turbulence (Figure 5B).

3. The relative diameter of pipe and meter propeller will have very little influence on the registration accuracy when the velocity profile is blunt.

4. The relative diameter of pipe and meter propeller will have considerable influence on the accuracy registration of a propeller meter when the velocity profile is sharp (fully developed), particularly in the smaller pipe sizes.

5. The larger the pipe diameter with respect to the diameter of meter propeller, the more the velocity profile is likely to influence the meter registration accuracy.

6. The influence of velocity profile shape on meter registration accuracy will be minor when the propeller diameter is 75 percent or more of the pipe diameter.

7. The propeller diameter is not as critical a factor in turnouts having large relative roughness factors. The difference in velocity profile for undeveloped and fully developed boundary flow is less for rough than for smooth pipe.

8. Where the turnout pipe slopes downward from the canal to a lower elevation, there should be a section of horizontal pipe, 7 diameters or more in length, placed upstream from the propeller meter.

9. The horizontal section of pipe ahead of the meter propeller should be placed at an elevation such that the hydraulic jump will form at the upstream end of the 7-diameter-long section. The momentum relationship based on the depth and velocity of the flow entering the horizontal section can be used to determine the proper elevation for the pipe (Figure 7).

10. When accuracy of registration is extremely important, meters should be rated in settings where velocity profiles are comparable to those to be encountered in the field. This is particularly important when the propeller diameter is less than about 75 percent of that of the pipe.

11. In the case of a relatively smooth 12-inch pipe, the boundary conditions appear to become fully developed in a length of about 30 pipe diameters.

12. The registration accuracy of most propeller meters falls off at low velocities. Registration accuracy is usually quite constant for pipe velocities above about 1.5 feet per second. The velocity is lower for the larger meter diameters.

13. For best registration accuracy, the meter propeller should be at the pipe centerline with its axis parallel with the pipe walls. Some variation will not introduce objectionable errors (Figure 11).

ACKNOWLEDGMENTS

The personnel of the Canals Branch, the Hydraulic Laboratory Branch, and the fieldoffices of Region 3 collaborated in the studies discussed in this report. The laboratory tests were made in 1951-52, and the field tests in June 1952.

INTRODUCTION

As use of water in fertile areas increases, it becomes more and more important that accurate and continuous measurement be made of individual releases. Numerous investigations of water-measuring devices have been made in recent years to determine whether or not these devices would satisfy the more exacting requirements. One of the devices investigated was a pipe turnout with a propeller meter placed just inside the downstream end (Figure 1). The meter used in this study had a propeller shaft supported in bearings in an L-shaped pipe housing with gears and shafting to operate a flow recorder. The L-shaped housing served as a support for the meter and held it on the headwall at the pipe outlet by brackets which permitted the meter to be moved easily from one turnout to another to measure flow releases. A typical 12-inch turnout was constructed in the Hydraulic Laboratory and tests made to determine the influence of the physical ahd hydraulic operational characteristics of the turnout on the registration accuracy of a propeller meter. Tests were made in the field on two 24-inch turnouts after the laboratory tests indicated that the registration accuracy of a meter would be influenced by turnout length. The laboratory and field tests are discussed in this report.

LABORATORY INVESTIGATION

Description of 12-inch Turnout

The laboratory test turnout consisted of a head box with baffles to quiet the flow, a section of canal with 1-1/4:1 side slopes and an adjustable weir at the downstream end to adjust the canal water surface, a regulating gate recessed in the canal bank and inclined at an angle of 45°, a section of 12-inch plastic pipe sloping downward to a 45° miter bend, a horizontal section of transparent plastic pipe below the bend, a headwall at the downstream end of the horizontal section of pipe for mounting the meter, a tail water box containing a transition from the pipe to a section of lateral and a hinged gate for adjusting water surface elevation (Figures 2 and 3). The model was arranged so that all or any part of the flow in the canal section could be diverted through the turnout.

Test Procedure

The amount of water entering the model was measured by volumetrically calibrated Venturi meters in the laboratory supply system, and that entering the model, but not passing through the turnout, by a calibrated weir at the end of a flume attached to the end of the canal section. The true discharge through the turnout was the difference between these two values. The accuracy of the propeller meter was the ratio of the flow recorded by the meter to the true flow, expressed in percent. Propellers of 6 and 9-3/4 inches in diameter were used in the tests. The 6-inch propeller was used extensively since the ratio of its diameter to the turnout pipe diameter (0.50) was that being considered for field installation. The 9-3/4-inch propeller was used only briefly to show the effect of the propeller-pipe diameter ratio on the meter accuracy. The amount of water released through the turnout was controlled by the slide gate at the entrance of the turnout pipe. The pipe outlet submergence was adjusted to confine the jump to the upstream end of the horizontal pipe section. The turnout was constructed so that the length of the horizontal pipe could be varied.

Turnout Flow Characteristics

Flow conditions at turnout inlet. --The initial tests were concerned particularly with the flow conditions in different parts of the turnout and their effect on the velocity distribution at the meter station. Spiral flow at the entrance caused by the formation of vortexes was present, particularly at the larger gate openings (Figure 4A). With the pipe immediately downstream from the gate vented, the effects of this spiral flow did not persist beyond the vertical bend. Closing the vent seemed to increase the vortex action at the entrance and induce pulsation in the turnout pipe. Vents were considered desirable for all except very low heads or where the gate was at the same elevation as the horizontal section of the turnout pipe.

Flow conditions in turnout pipe and at meter station. --The length of pipe in the horizontal section was 7 pipe diameters for the initial tests. The submergence of the pipe outlet was varied to determine the effect on the velocity distribution at the meter station. The velocity distribution at the meter station was quite uniform for all conditions where the upstream edge of the hydraulic jump remained at or upstream from the upstream end of the horizontal pipe section (Figure 4B). The velocity profile at the meter station for this short turnout was quite blunt (nearly constant velocity over entire flow area) (Curve A, Figure 5B).

The relationship of submergence and discharge which would keep the jump at the bend was determined from the model (Figure 6). Comparison of these results with values computed by momentum relationships indicated that the use of the momentum relationships would assure ample submergence (Figure 7).

Flow conditions in turnout exit channel. --Two currents of relatively high velocity were noted in the "broken back" exit transition downstream from the pipe. These currents persisted on each side of the transition and caused excessive scour in the sand and gravel immediately downstream. The transition design was changed to the warped-wall type to correct this condition. The warped transition improved the flow distribution materially and reduced the scour to a satisfactory minimum. The flow conditions and scour are shown on Figure 8.

Meter Registration Accuracy

Silt in meter. --During preliminary testing of the propeller meter at small discharges, it was noted that the registration accuracy gradually decreased with time. Upon close examination, it was found that very small sharp sand particles in the laboratory supply settled out in the gear and bearing enclosure. This fine silt increased resistance, slowed the meter slightly, and decreased registration accuracy. Also, it was discovered that the meter was being operated mainly at low velocities (about 1-1/2 feet per second) where friction was an important factor and where there was a drop in accuracy of lesser amount even without the silt deposit. Later tests were made at higher velocities and discharges to minimize the silt problem.

Effects of velocity profile. --The meter with a 6-inch-diameter propeller was first placed in a special setting (b, Figure 9) which was to serve as a standard for later comparison. A rating curve in this setting and one obtained for the same meter in the short turnout were compared. The rating curve for the standard setting (Curve b, Figure 9) showed consistently higher registration accuracy than that for the short turnout (Curve c, Figure 9). It was reasoned that because of the small propeller, which was half the diameter of the pipe, the difference might result from a variation of the velocity profile in the flow approaching the meter. Velocity profiles were found to be quite different (Curves A and B, Figure 5-B). The effective velocity at the propeller was much higher for the standard setting than for the short turnout when the flow quantity was the same. These tests proved that the registration accuracy of meters with small meter-to-pipe diameter ratios would be influenced by the velocity profile which would vary with turnout pipe length and size. Once the initial tests were made and it was determined that velocity distribution would be an important factor influencing registration accuracy, the investigation was continued to establish the limitations of a turnout design which would affect the performance of a propeller meter placed at its downstream end. The investigation included the determination of the minimum length of horizontal pipe upstream from the meter to provide a sufficiently uniform velocity distribution to give acceptable meter accuracy, whether or not straightening vanes would be required in the pipe upstream from the meter and whether or not angular or offset positions of the meter axis with respect to the pipe centerline were objectionable.

Effects of length of pipe. --The boundary influence in the turnout was disrupted by the hydraulic jump to produce a quite uniform velocity at the meter station when the length of pipe was short (7 pipe diameters). The velocity profile in this case was quite blunt (Curve A, Figure 5B). Observations indicated that the length of 7 diameters would be a minimum which would produce a satisfactory near uniform velocity. When the registration accuracy for the meter in this setting was determined to be much less than for the meter in the standard setting, an explanation was sought. The velocity profiles obtained for both settings were quite different. The profile for the standard setting was sharper (velocity less uniform) than for the 7-diameter-long turnout (Curve B, Figure 5B). This difference in profile explained the variance in registration accuracy (102 for the standard setting and 93 for the turnout). In the case of the standard setting, the boundary layer had developed to form the sharper profile and subject the meter propeller to higher velocities than in the short turnout, thus showing higher flow registration for an equivalent discharge.

Further tests with various pipe lengths were made to establish the influence of length on registration accuracy. The facilities used for these tests included the standard setting, a 40-diameter length of pipe with straightening vanes, originating from the laboratory supply and terminating in a box; a 20-diameter length of pipe with straightening vanes, originating from a metal tank and terminating in a box; a typical turnout with a 7-diameter length of horizontal pipe, originating from a canal section and terminating in a transition leading to a small channel representing a lateral; and a typical turnout with a 30-diameter length of horizontal pipe.

The results of the tests on these various facilities were plotted to show the effects of turnout length on the meter registration accuracy (Curve a, Figure 10). The 6-inch propeller meter in the standard 40-diameter-long pipe registered 102 percent of the true flow, or 9 percent more than in the 7-diameter-long turnout. The difference was attributed to the difference in velocity profile which resulted from boundary conditions induced by the variation in pipe length.

The propeller occupying the center of the pipe and having a diameter one-half that of the pipe size was subjected to higher velocities with the parabolic profile of the 40-diameter-long facility than with the "flat front" profile of the 7-diameter-long turnout for the same amount of water passing the meter.

The results indicated that the registration accuracy for a meter would be constant when the length of the turnout exceeded about 30 diameters (Curve a, Figure 10). Thus, the velocity effect for a meter having a propeller diameter half that of the pipe could be minimized by limiting the minimum length of turnout to about 30 diameters. This limitation was not considered practicable, particularly when it was considered that a larger propeller to pipe diameter ratio would decrease this difference and that the difference would be even less for turnouts with larger pipes. The effects of pipe size will be discussed in a subsequent section of this report.

Tests using the 9-3/4-inch propeller showed the difference in meter accuracy due to turnout length (velocity distribution) to be much less than with the 6-inch propeller (Curve e, Figure 10). This was attributed to the fact that the larger propeller integrates more of the velocity profile.

Some thought was given to the use of gears in the meter recording head to adjust for the length of turnout. In this case, a certain gear ratio would be used for a certain range of turnout lengths. Since one flow recording head is to be used for each turnout, this would seem feasible. This was not pursued further because of the complex problem of gearing such a large number of different size meters.

Attempts to provide uniform velocity at meter. --It was reasoned that some means might be designed into the turnout to disrupt the boundary layer and produce a near uniform velocity distribution for all turnouts. This would subject a meter to velocities nearer the average and eliminate a variation in profile due to pipe length. Moreover, the meter diameter to pipe diameter ratio would not be critical. A thin ring or other obstruction placed within the pipe upstream from the meter was considered. A ring was made of 1/16-inch sheet metal with an outside diameter equal to the pipe diameter (12 inches) and the inside diameter equal to 0.9 the pipe diameter (10.8 inches). The difference in accuracy in the two turnout settings was reduced to about 3.6 percent when the ring was placed 1 pipe diameter upstream from the headwall supporting the meter (Curve c, Figure 10). Placing the ring further upstream reduced the difference only slightly while moving it downstream to one-half diameter from the headwall again increased the difference.

Tests were made using air as a fluid with orifices 0.7, 0.8, and 0.9 the diameter of the pipe, and two different pipe lengths to determine whether or not the 0.9 ratio was most effective in producing uniform velocity downstream. The 0.9 ratio made a noticeable change in the velocity distribution and the ratios of 0.8 and 0.7 gave some additional change (Figure 5A). From these results, it was considered impracticable to use a ratio smaller than 0.9.

Since there appeared to be an advantage from the construction standpoint of using a short flow nozzle constructed integral with the pipe, a section 3 inches long with the upstream edge rounded and the inside diameter equal to 0.9 the pipe diameter was tested. This was not as effective as the ring having the same diameter (Curve b, Figure 10).

It was concluded that a simple sudden reduction in pipe diameter near the end of the turnout pipe would be desirable from the construction and maintenance standpoint, provided the section of reduced diameter was of reasonable length (preferably a length equal to the thickness of the headwall). Sleeves of different lengths, 7, 12, and 18 inches with inside diameters of 10.8 inches (0.9 of the pipe diameter), were inserted in the end of the turnout model with 7 and 30 diameters of straight pipe upstream. The 12-inch sleeve gave as small a difference as any for both turnout lengths, about 4.2 percent (Curve d, Figure 10). From these tests, it was concluded that a reduced section 1 pipe diameter in length and with an inside diameter of 0.9 the diameter of the pipe placed in the end of the turnout would be the most satisfactory of any of the boundary disrupting devices tested to date.

The effects of orifice rings and sleeves at and near the meter station for the various test facilities and different turnout lengths are shown on Figure 10. The treatments reduced but did not eliminate the influence of pipe length.

Effect of vertical placement of propeller meter.--Tests were made to determine the effect of placing the meter so that the propeller axis did not coincide but was parallel with the pipe centerline. The meter was raised above the centerline and lowered below it. The registration accuracy was reduced to either side of the pipe centerline, indicating a velocity profile influence (Figure 11A). This difference would be less for a meter of larger propeller to pipe diameter ratio so was not considered serious. Also, the amount of change was small for small displacements.

Effect of rotation of meter propeller axis with turnout pipe axis.--Tests were made to determine the importance of having the axis of the propeller parallel to the axis of the pipe. For these tests, the meter was rotated about the center of its vertical support column. The maximum rotation tested was 25° both clockwise and counterclockwise. The registration accuracy decreased for both directions of rotation but was quite small for small angles of rotation (Figure 11B).

Need of Straightening Vanes

During a part of the initial test program, the turnout was operated with and without straightening vanes immediately upstream from the meter. The same results were obtained in each case so the vanes were considered unnecessary for this particular turnout design. This was confirmed when velocity traverses indicated near uniform velocity at the turnout exit. Several operating conditions, with and without air admitted immediately downstream from the regulating gate, and with and without a vortex entering the pipe were investigated. The accuracy of the meter in the short (7 diameters long) turnout varied a maximum of 3 percent in these tests. A vortex at the pipe entrance is shown on Figure 4A, and conditions with the upstream end of the hydraulic jump in the vertical bend are shown on Figure 4B.

FIELD INVESTIGATION

Description of 24-inch Field Test Turnouts

Two turnouts in tandem were constructed in a 3-foot deep, 45-cubic-foot-per-second, troweled gunite-lined canal lateral with a 3.2-foot bottom width, 1-1/2:1 side slopes, and a 0.75-foot freeboard (Figures 12 and 13). The long and short turnouts were constructed with 24-inch concrete pipe laid in the lateral, using suitable timber headwalls and tail walls. The long turnout, 32.1 diameters in length, was upstream and 21 feet from two 3-foot slide gate controls in the bank of the main canal (Figure 13). The short turnout, 6.75 diameters in length, was placed 205.5 feet downstream from the long turnout. The long turnout was equipped with a circular leaf slide gate at the inlet. There was no gate on the short turnout. A current meter and point gage station were set up in the lateral 162 feet downstream from the short turnout and a stoplog check station was established 225 feet farther downstream.

Test Procedure

Flow into the lateral and to the turnouts from the canal was regulated by two wooden leaf slide gates, and submergence of the turnout exits was controlled by stoplogs at the check station.

Flow into the test turnouts was limited by irrigation delivery requirements and the turnout restricted to a maximum of 13 cubic feet per second. This discharge and another of 8 cubic feet per second were used for the tests to reduce delivery interference to a minimum. For each flow, it was important to maintain the rate of flow constant while the registration accuracies of the meters were being checked. A hook gage was installed between the lateral regulating gates and the entrance to the long turnout and a member of the test crew assigned to keep the head constant by adjusting the regulating gates. One of the test crew was stationed at each of the propeller meters placed in the ends of the test turnouts, and two were stationed at the current meter gaging station. The registration accuracy of each meter was determined by dividing the flow rate registered by the meter by the flow rate based on the current meter traverse. Current meter readings were taken at 0.2, 0.4, 0.6, and 0.8 of the depth for each foot of width, a total of 44 readings per traverse. A point gage was used to determine the water depth. An engineer's level and rod were used to obtain the section profile of the lateral at the gaging station. The water surface at the exit of the short turnout was held 3 inches above the crown of the pipe by adjustments at the stoplog check. Nine runs were made. A description of each is given by the test results summary sheet (Table 1). The lateral flow was obtained from the velocity traverses and the meter registration by averaging from ten to twenty 1- to 2-minute records from the respective recorders.

Test Results

Effect of turnout length.--The percent difference in meter registration accuracy for the long and short turnouts was obtained from the meter flow records and velocity traverses. The meters were switched from one turnout to another in some of the tests to eliminate any influence of meter differences. This proved to be an important factor in the analysis of the test data. The percent difference column of Table 1 is the difference in the two meter registrations for the two turnouts. A plus sign indicates a greater registered quantity in the long turnout and a minus sign indicates a lesser registered quantity in the long turnout. The meter registration accuracies with respect to each other were obtained by subsequently rating both in a standard facility. Meter No. 1 registered 3 percent more than Meter No. 2. From Table 1, it is concluded that the same meter would register from 2 to 6 percent more in the long than in the short turnout. It was also concluded that less difference was obtained in the field tests for the 24-inch turnouts than in the laboratory for the 12-inch turnouts because: The larger pipe gave a relatively flatter velocity profile; the 24-inch concrete pipe had much greater relative surface roughness than the 12-inch steel and plastic pipe used in the laboratory tests; mortar joints in the 24-inch concrete pipe protruded from 1/4 to 3/4 inch into the pipe tending to disrupt the boundary conditions, and the entrance conditions to the laboratory and field facilities were different.

Effect of gate opening.--Where the gate on the long turnout was closed to 33 percent open, the meter registration was reduced by about 9 percent. This was attributed to the flow conditions in the pipe immediately downstream from the gate. The partial gate opening disrupted the boundary conditions and may have altered the velocity profile uniformity otherwise.

Effect of vertical placement of propeller meter.--A limited number of tests were made to determine the effects of vertical displacement of the meter propeller. A 1-inch displacement of the meter center above the pipe center indicated a decrease in accuracy registration of 1.2 percent and a displacement of 1 inch below the center indicated a 0.2 percent increase. These data indicated that off-center displacement of small amounts will have little influence on meter registration accuracy. The points are plotted on Figure 11A.

Effect of rotational displacement.--Readings were taken on two occasions to determine the influence of rotating the meter axis with respect to the turnout pipe axis. A rotation of the 2-1/2-inch support pipe 1/4 inch on the circumference counterclockwise (11-1/2°) gave a reduction in registration accuracy of about 4 percent, while a rotation of 1/2 inch (23°) clockwise gave a reduction in accuracy of about 16 percent. These tests indicated that the axis of the meter propeller should have as little rotation as possible with respect to the turnout pipe axis. The points are plotted on Figure 11B.

Head losses in test turnouts.--Total loss through each of the two field test turnouts was recorded for a discharge of about 13.1 cubic feet per second. The losses for the long and short turnouts respectively were 0.608 and 0.325 foot or 2.24 and 1.2 velocity heads.

Table 1

24-INCH PIPE TURNOUT TEST RESULTS--YUMA, ARIZONA, JUNE 1952

Run No.	Water depth (point gage) current meter sta	Current meter flow cfs	Meter No. 1			Meter No. 2			Acc diff per-cent	Gate opening long turn-out	Remarks
			Turnout	Meter record cfs	Per-cent acc	Turnout	Meter record cfs	Per-cent acc			
1	3.327	12.87	Short	13.36	103.8	Long	13.52	105.0	+1.2	F open	6-3-52 p.m.
2	3.341	13.12	Long	13.48	102.7	Short	13.24	100.8	+1.9	Full open	6-4 a.m. switched meters. Meter No. 1 reads higher and lower Meter No. 2.
3	3.344	12.58	Long	12.74	100.4	Short	12.55	99.8	+0.6	Full open	6-4 p.m. Only run with vanes, 6 ft long installed both pipes, 2 ft from outlet. Vanes de-creased acc 1 to 2.3 percent.
4	3.233	8.37	Long	8.81	105.2	Short	8.38	100.1	+5.1	1/3	6-5 a.m. Flow reduced by closing gate. Head on gate same.
5	3.225	8.48	Short	8.79	103.6	Long	8.66	102.0	-1.6	1/3	6-5 p.m. switched meters. Meter No. 1 reads greater Meter No. 2, Run 4. Acc diff percent trend changed from + to -. Decided to open gate full again.
6	3.356		Short	13.53		Long	13.58			Full open	6-5 p.m. acc diff percent trend back to + again.
7	3.356		Short	13.56		Long	13.04	Offcenter data taken		Full open	6-5 p.m. Meter No. 1 raised 1 inch 2-1/2-inch-diameter drop pipe housing rotated 1/4 inch ccw on Meter No. 2. Compare to Run 6.
2A	3.341		Long	11.30		Short	13.08			Full open	6-4 a.m. 2-1/2-inch diameter drop pipe housing rotated 1/2 cw on Meter No. 1. Meter No. 2 lowered 1 inch. Compare to Run 2.
8	3.235	7.87	Short	8.65	109.8	Long	8.81	111.9	+2.1	Full open	6-6 a.m. Run No. 5 repeated, but gate full open, reduced head.
9	3.228	8.11	Long	9.20	113.4	Short	8.60	106.0	+7.4	Full open	6-6 a.m. Run No. 4 repeated, as in 8. Full open gate in long turnout increased meter regis-tration. Meter No. 1 reads greater Meter No. 2, Run 8.

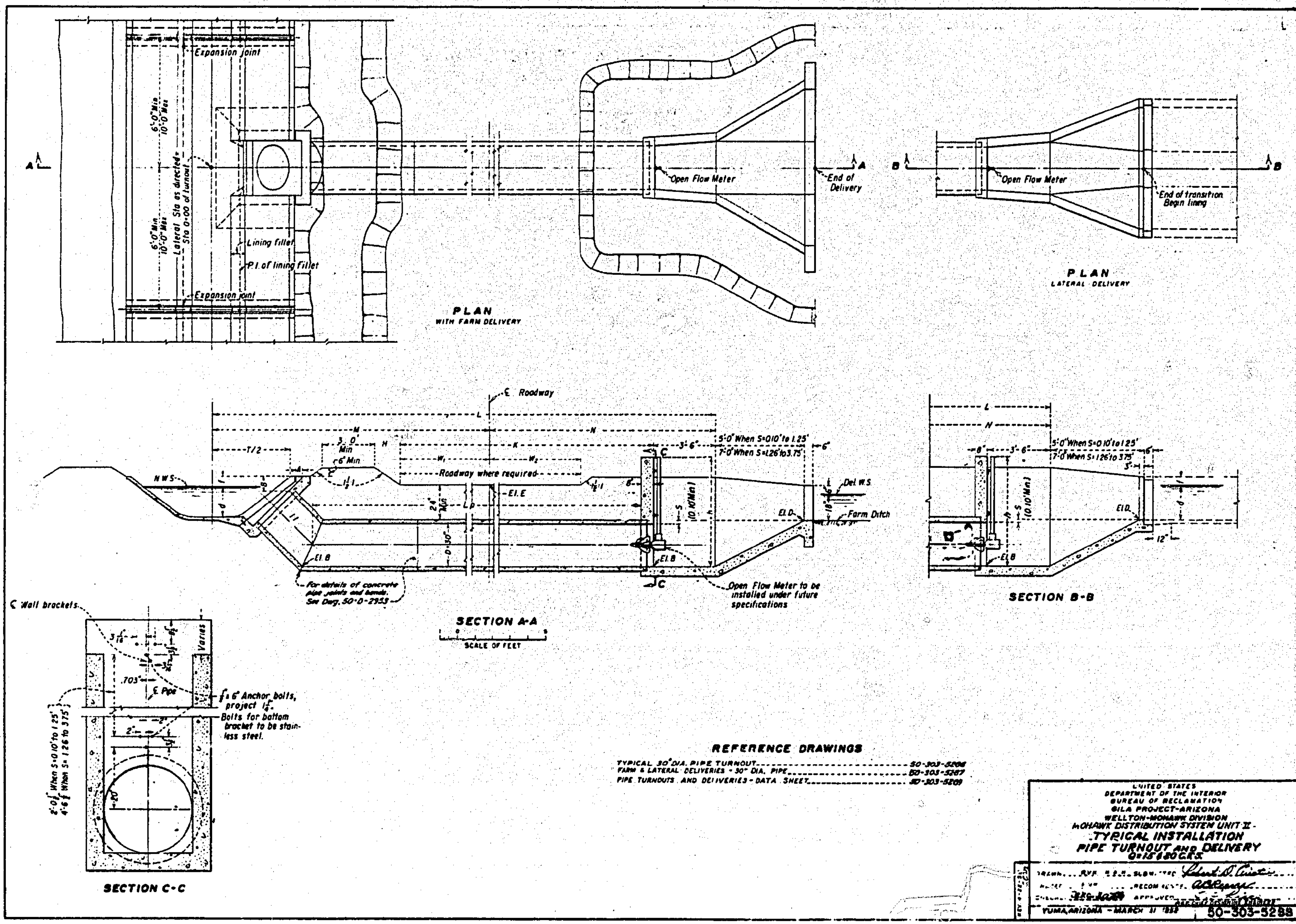

FIGURE 1
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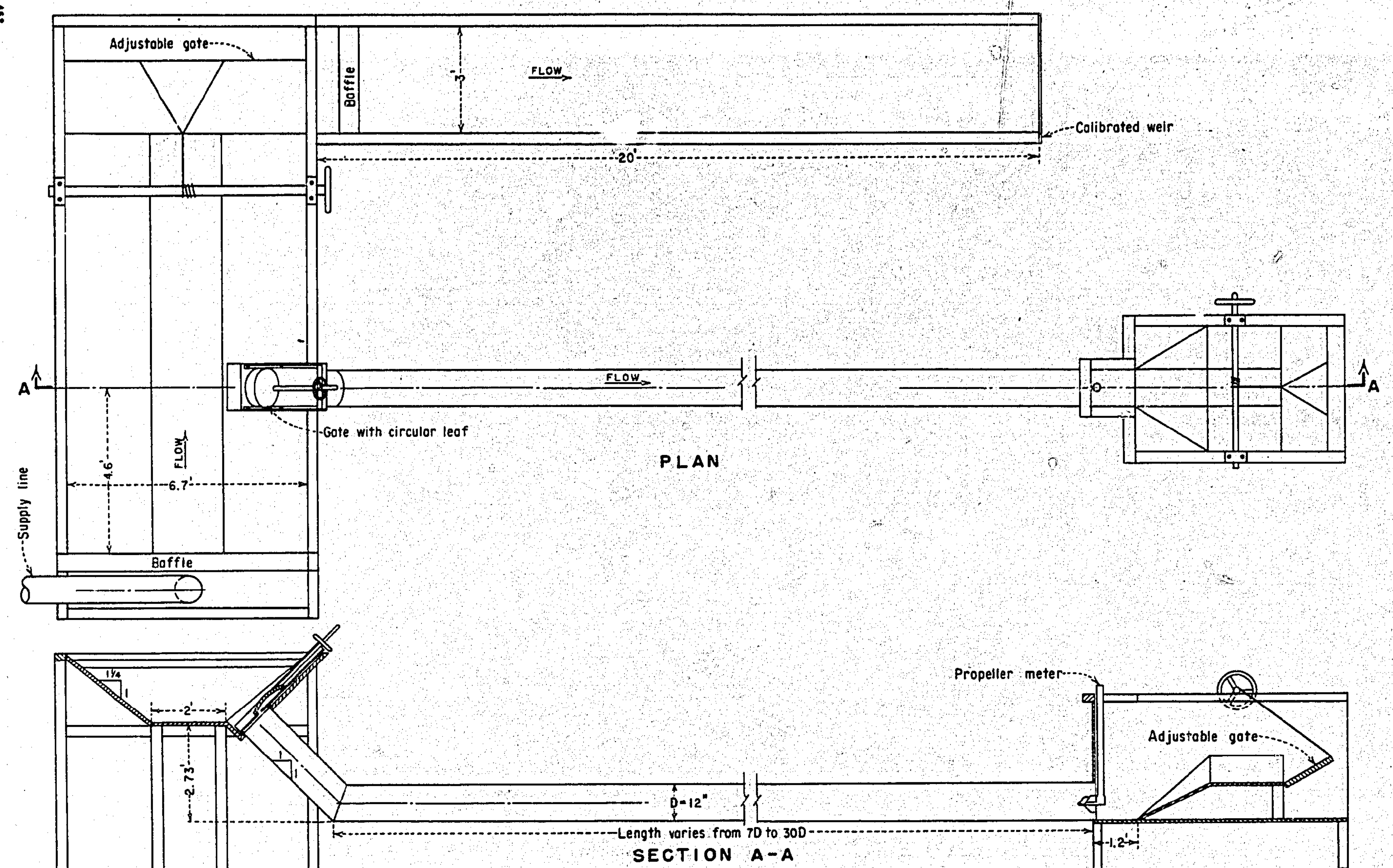
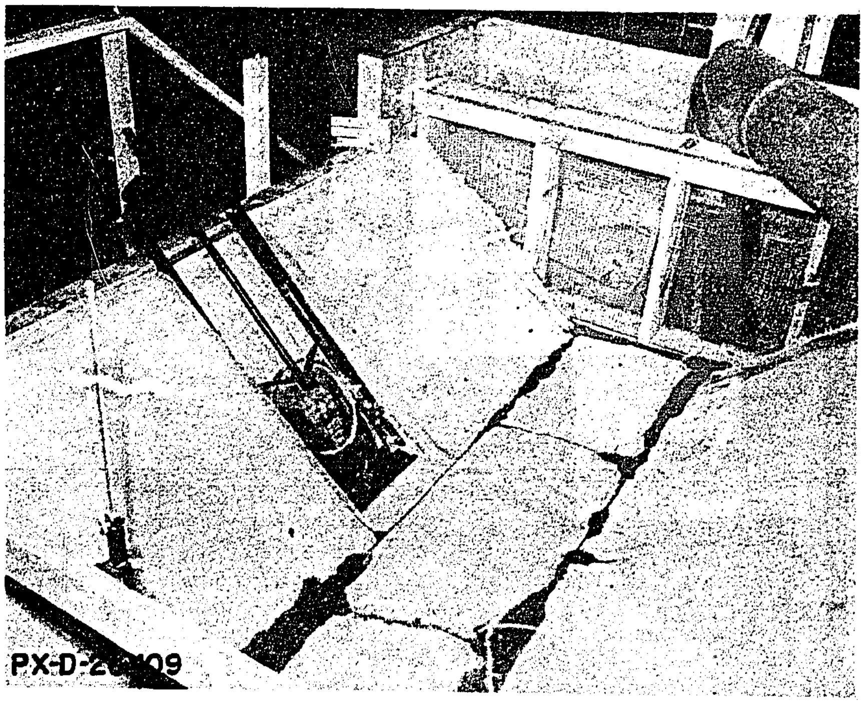


STUDY OF IRRIGATION TURNOUTS

PIPE TURNOUT WITH PROPELLER METER

FIGURE 2
REPORT HYD. 478

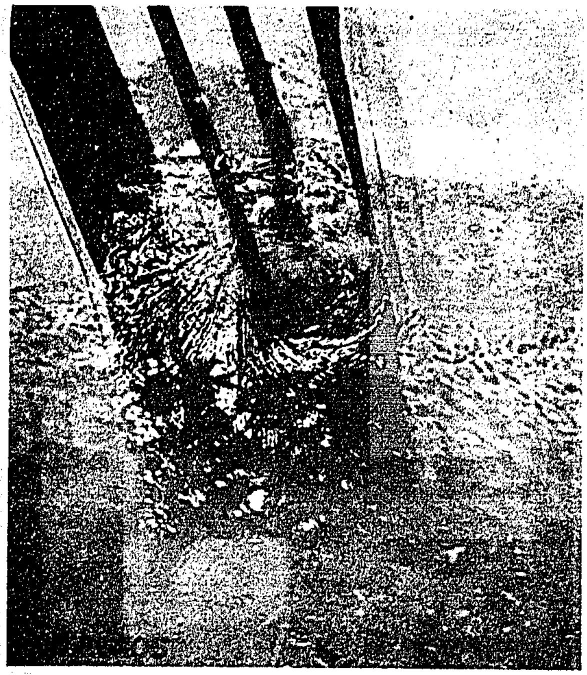
12-inch Test Turnout



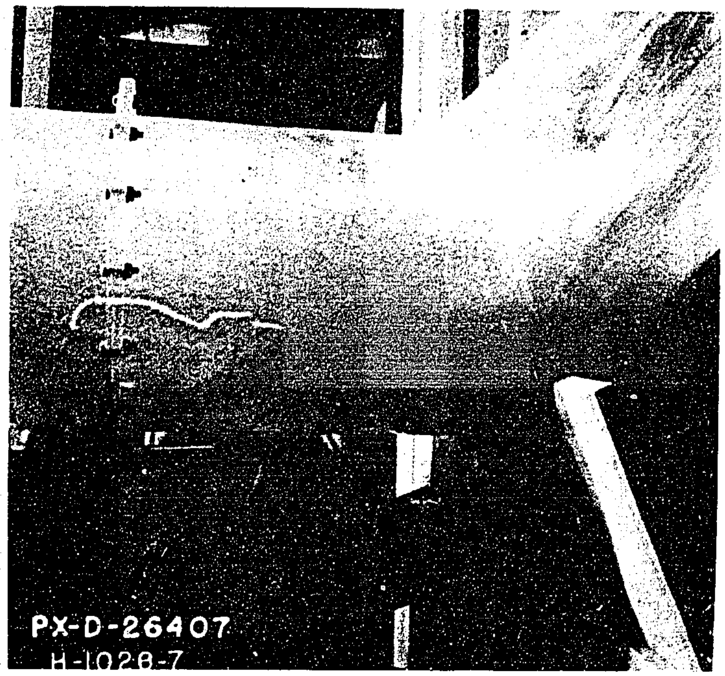
Control Gate at Turnout Inlet

Study of Irrigation Turnouts

12-inch Turnout Test Facility



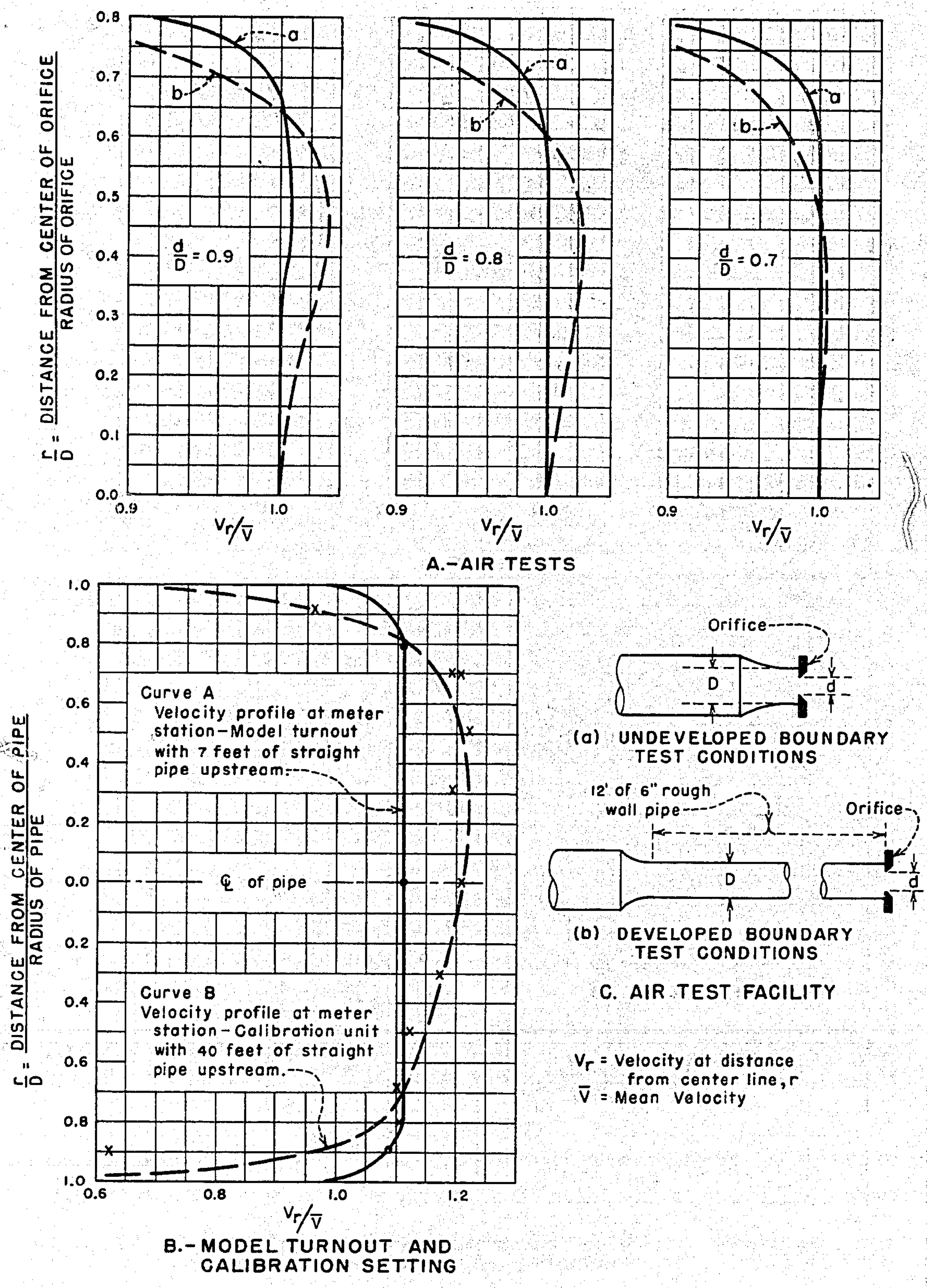
Vortex at 12-inch Turnout Inlet



Flow in Turnout Vertical Bend - Hydraulic Jump at Bend

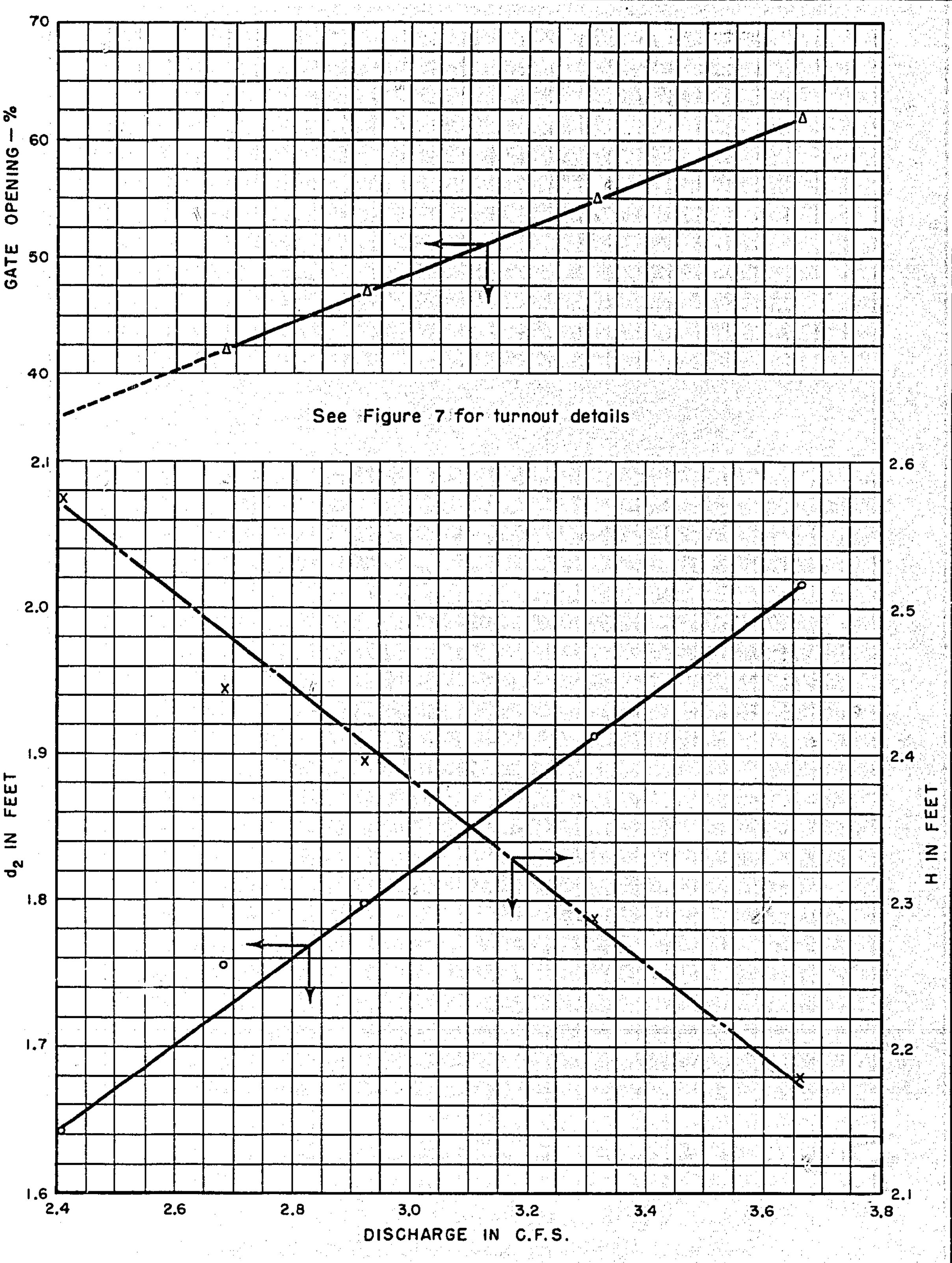
Study of Irrigation Turnouts

Flow Conditions at Inlet and in Vertical
Bend of 12-inch Turnout



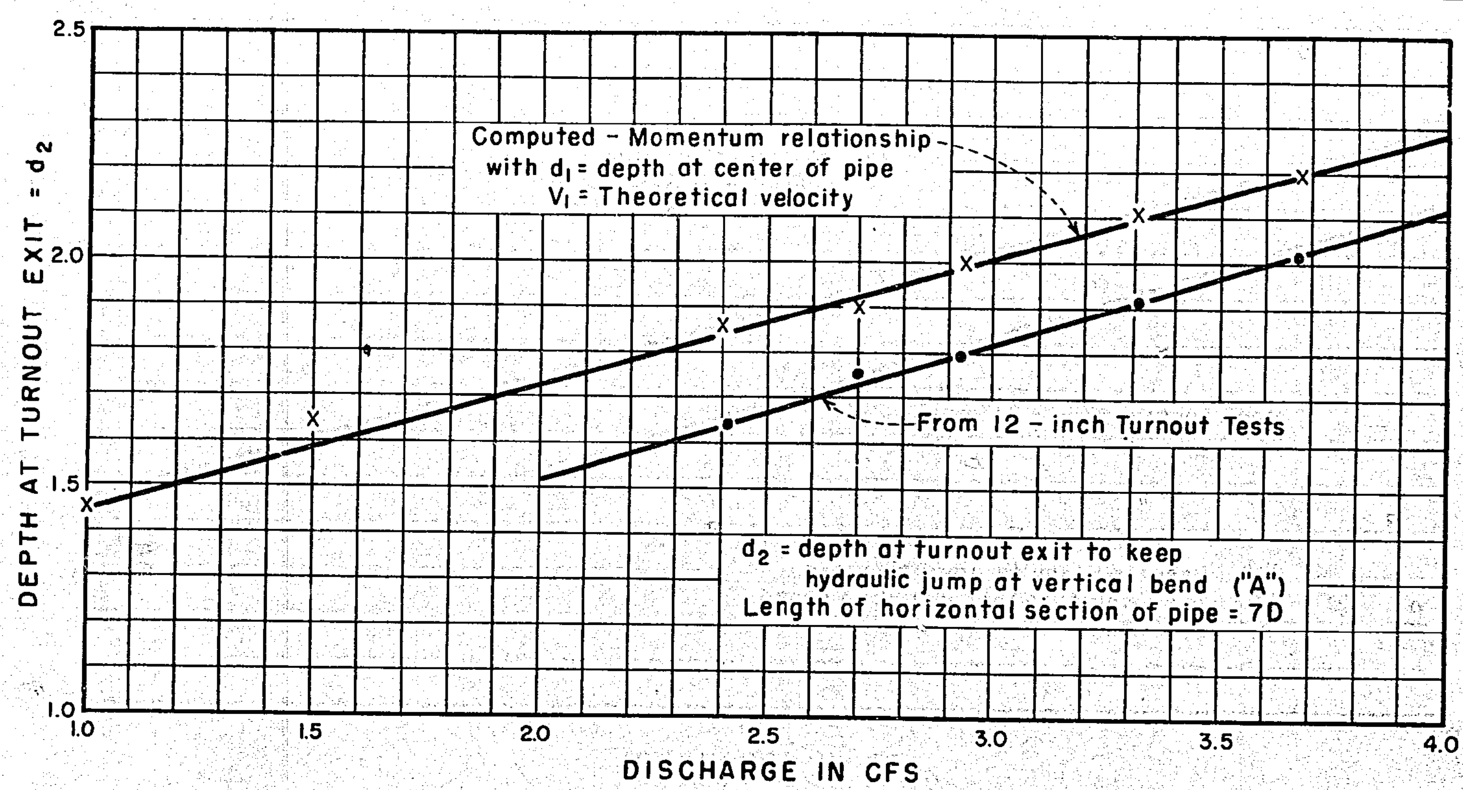
STUDY OF IRRIGATION TURNOUTS

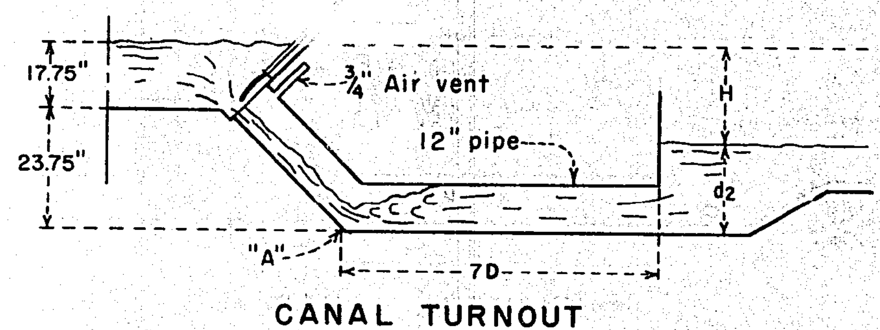
EFFECT OF BOUNDARY CONDITIONS ON VELOCITY PROFILES



STUDY OF IRRIGATION TURNOUTS

HYDRAULIC CHARACTERISTICS OF 12-INCH TURNOUT





STUDY OF IRRIGATION TURNOUTS
WATER DEPTH REQUIREMENT AT EXIT OF 12-INCH TURNOUT

FIGURE 7
REPORT HYD. 478

United States Department of the Interior

Bureau of Reclamation

CORRECTION

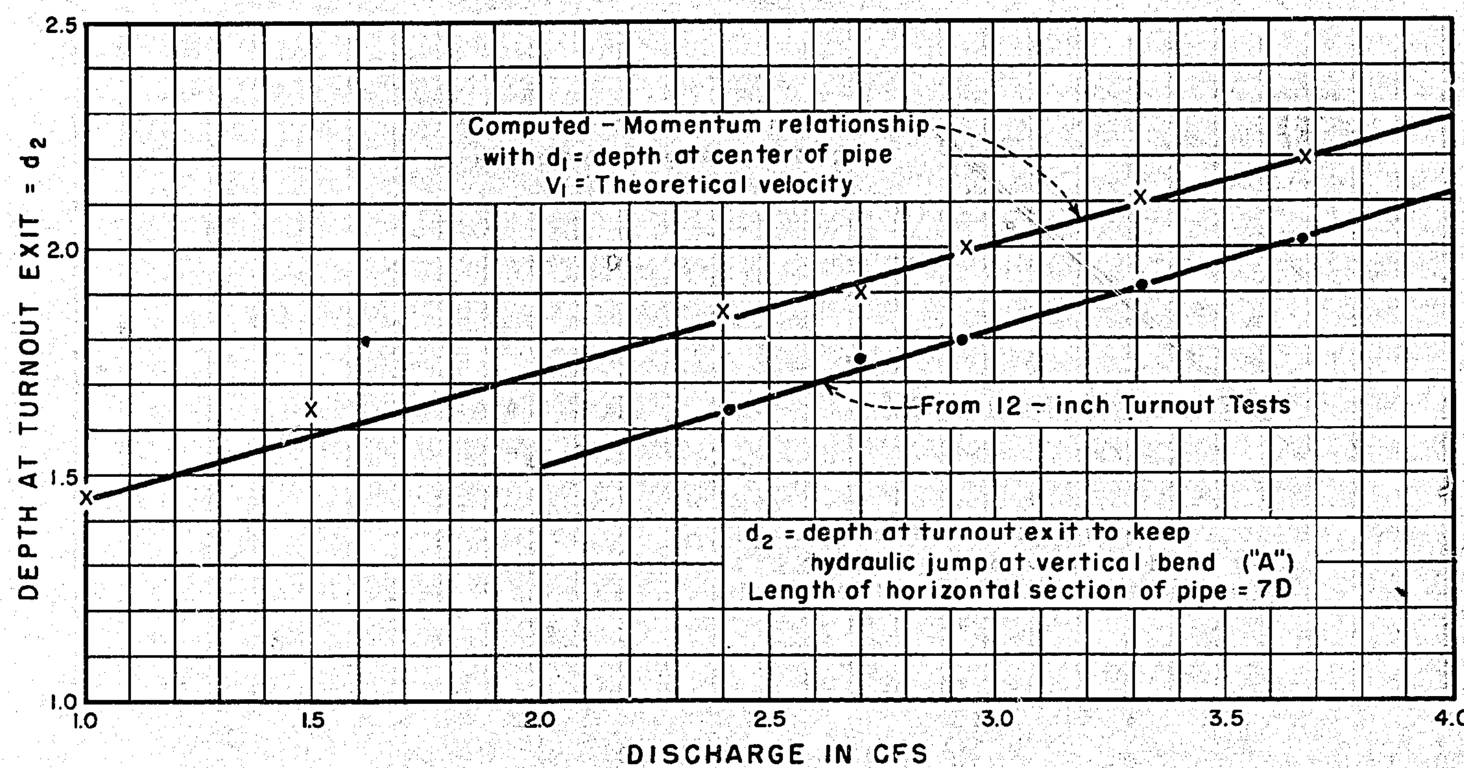
THE PRECEDING DOCUMENT

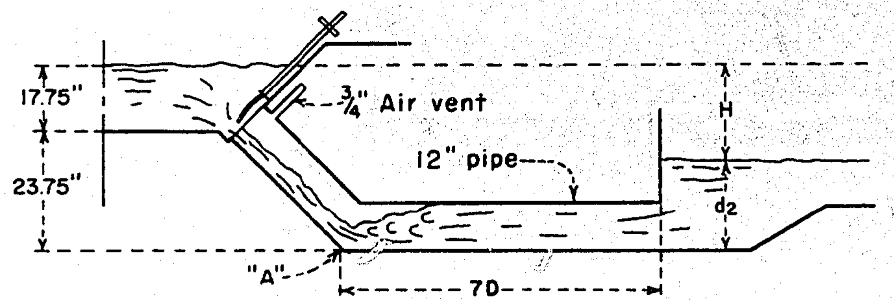
HAS BEEN REFILMED

TO ENSURE LEGIBILITY

7-2004 (12-75)
Bureau of Reclamation

GPO 833-814





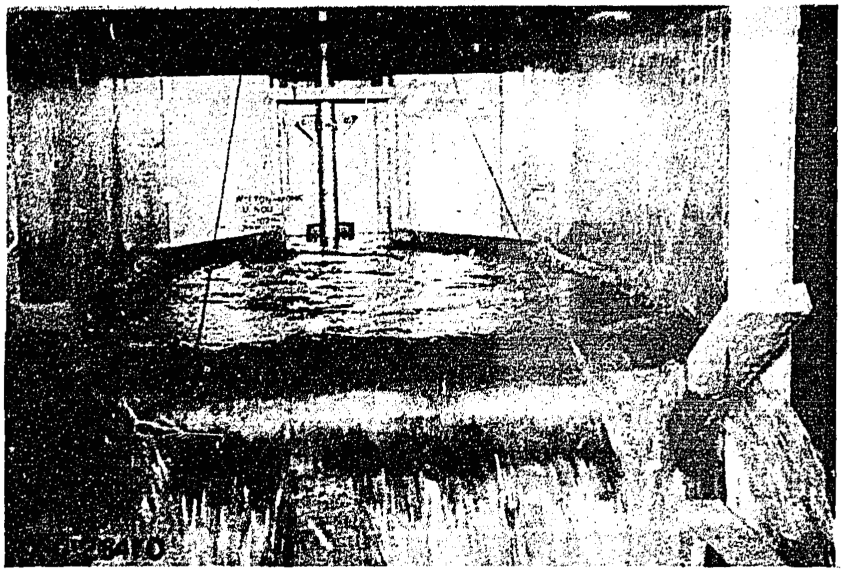
CANAL TURNOUT

STUDY OF IRRIGATION TURNOUTS

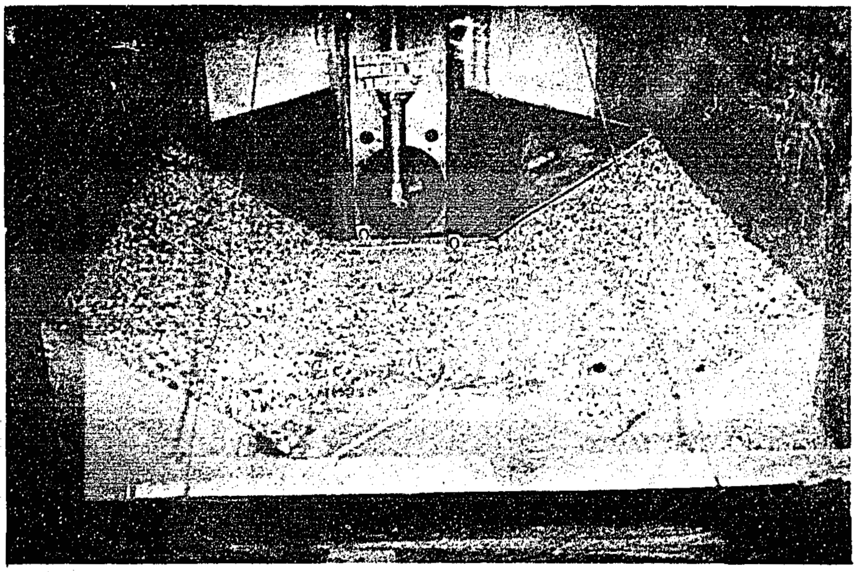
WATER DEPTH REQUIREMENT AT EXIT OF 12-INCH TURNOUT

FIGURE 7
REPORT HYD. 478

Figure 8
Hyd-478



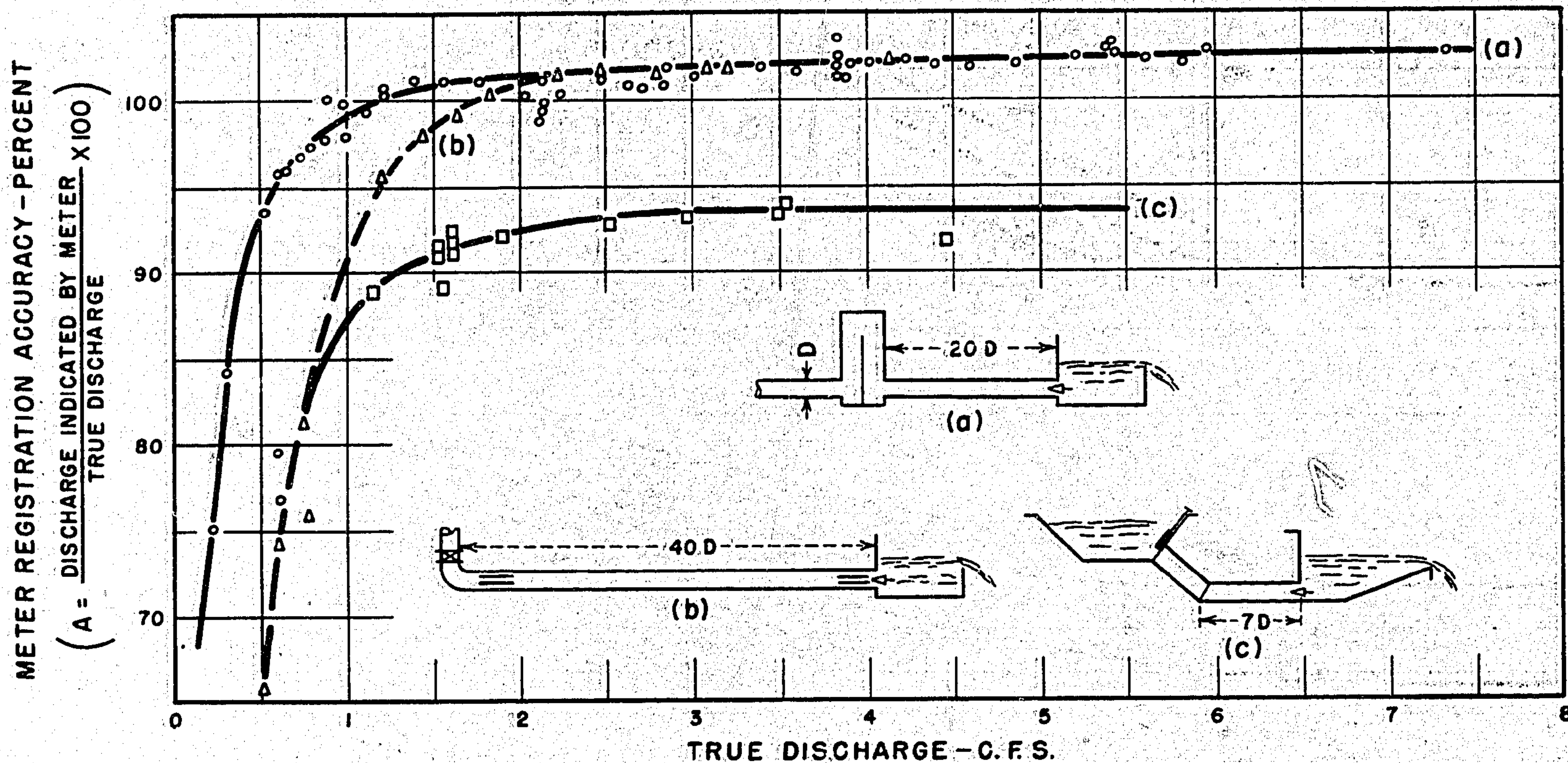
Flow in Turnout Exit Transition - Discharge 1.55 cfs



Surfaces of Lateral Downstream From Exit Transition
After Flow of 1.55 cfs for 1 hour

Study of Irrigation Turnouts

Flow and Erosion in Lateral Downstream From 12-inch Turnout Exit Transition With 2:1 Upward Sloping Floor, Warped Walls, and Propeller Meter



NOTES

- o (a) Calibration with surge tank, straightening vanes, and 20 diameters pipe.
- Δ (b) Calibration with straightening vanes and 40 diameters pipe.
- □ (c) Calibration in model turnout with 7 diameters pipe.

Meter with 6-inch propeller.

STUDY OF IRRIGATION TURNOUTS

EFFECT OF METER SETTING ON REGISTRATION ACCURACY

FIGURE 9
REPORT HYD. 478

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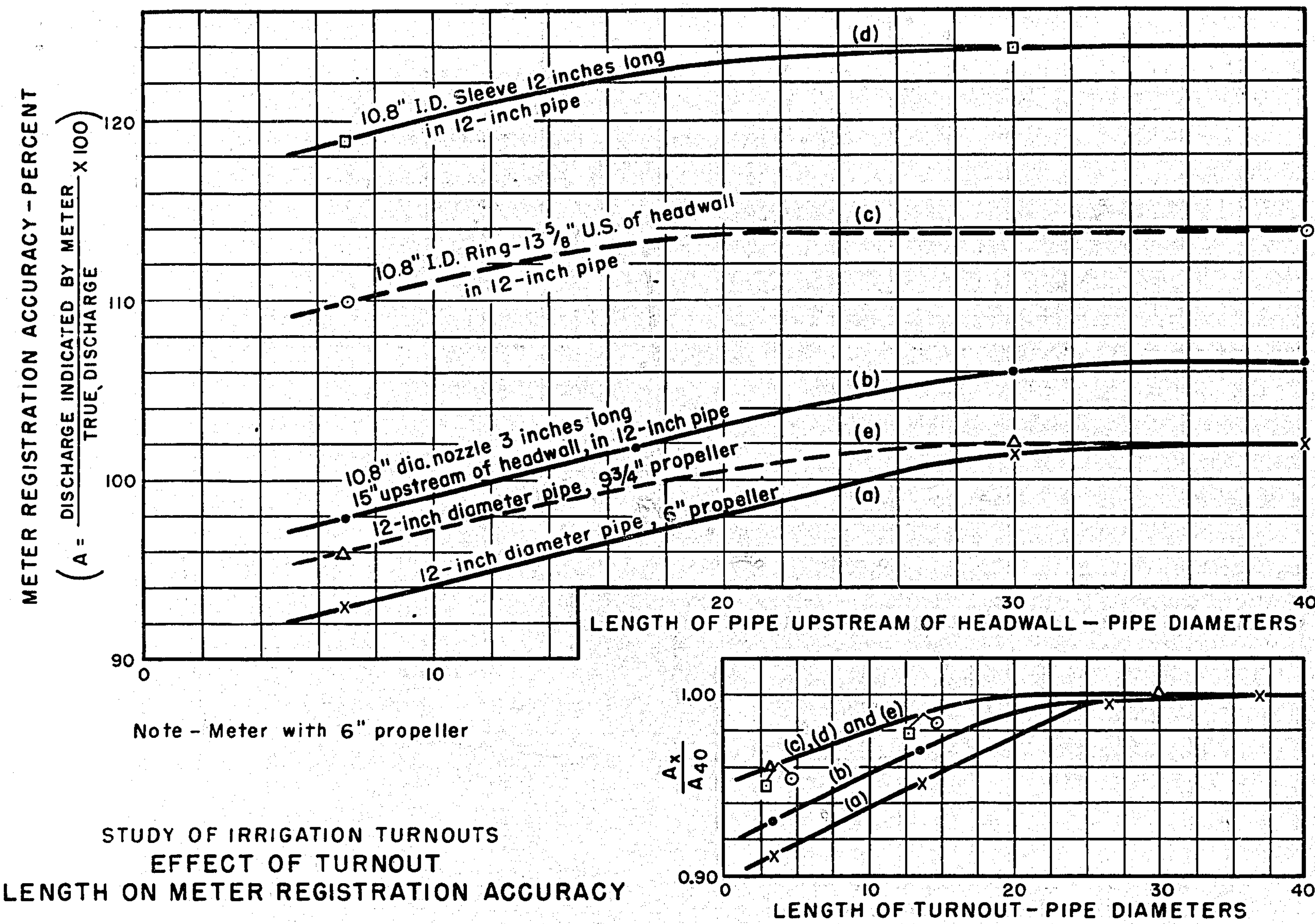
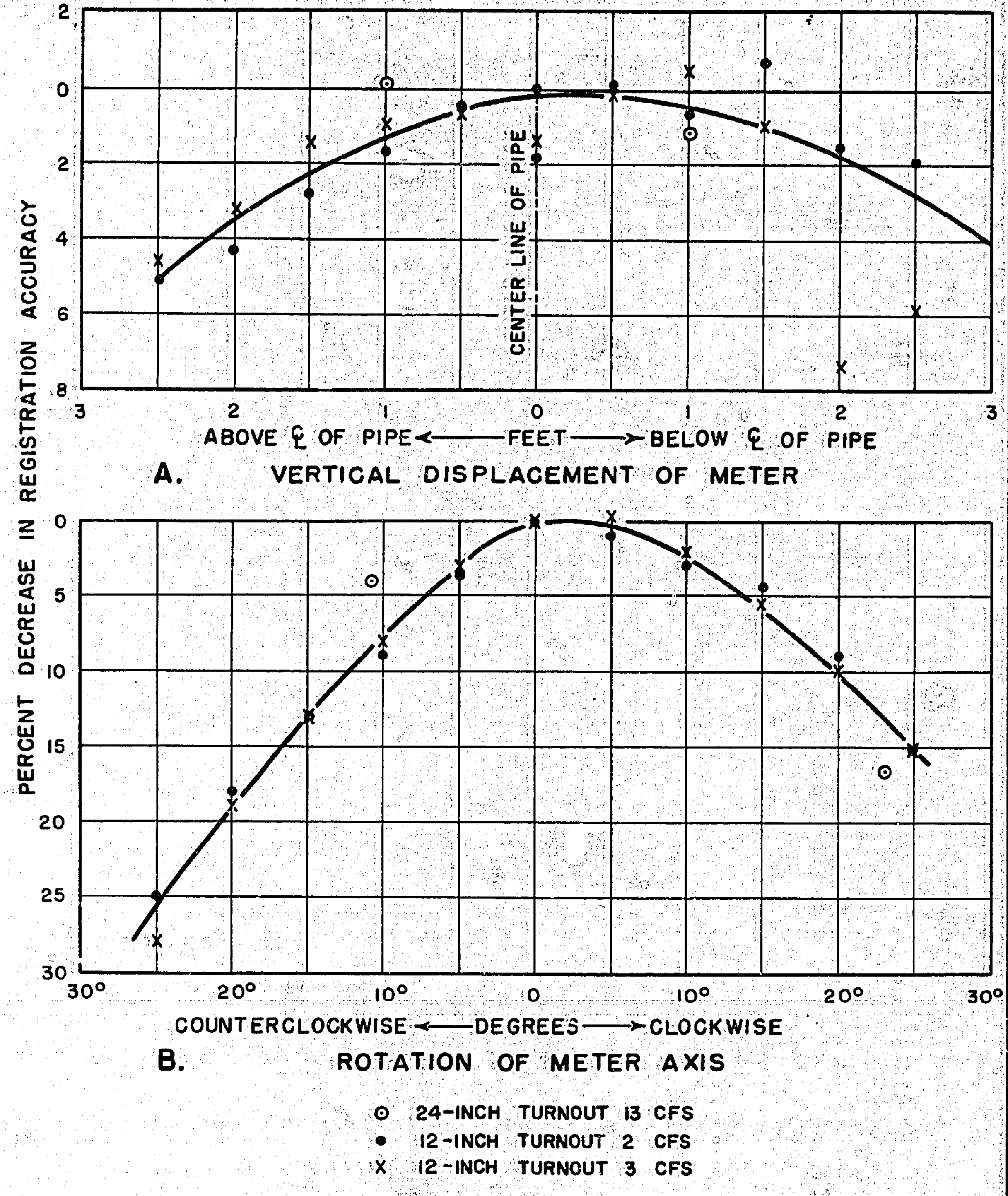


STUDY OF IRRIGATION TURNOUTS

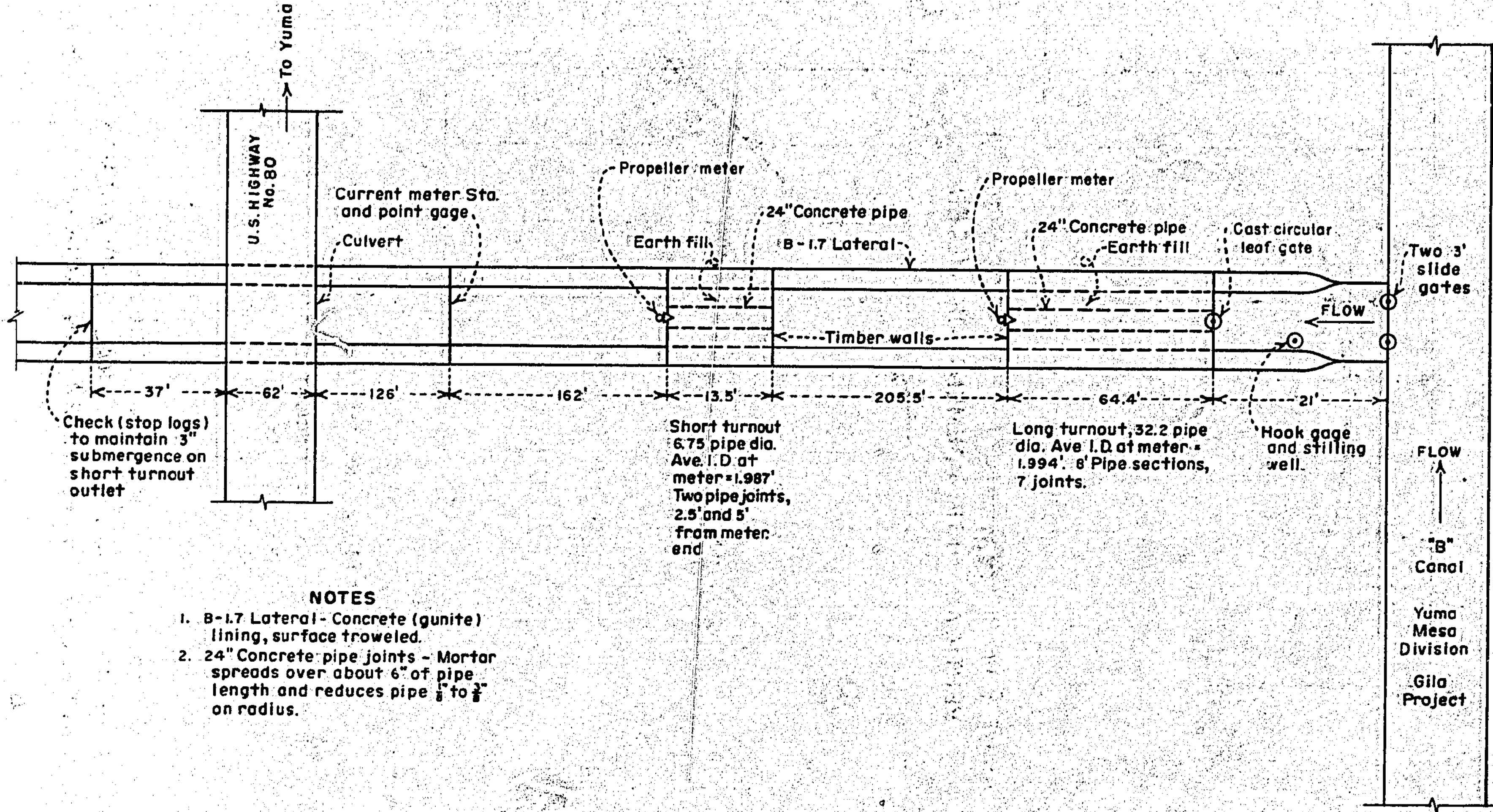
EFFECT OF TURNOUT LENGTH ON METER REGISTRATION ACCURACY

FIGURE 10
REPORT HYD. 478



STUDY OF IRRIGATION TURNOUTS

EFFECTS OF ROTATION AND LATERAL DISPLACEMENT OF PROPELLER ON REGISTRATION ACCURACY



NOTES

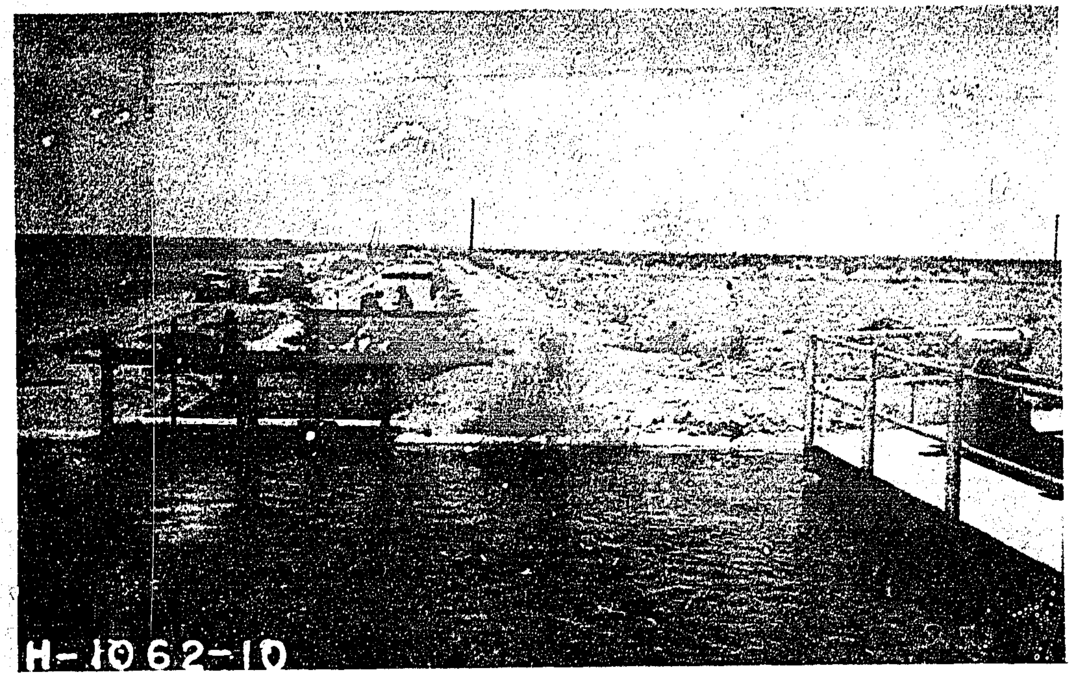
1. B-1.7 Lateral - Concrete (gunite) lining, surface troweled.
2. 24" Concrete pipe joints - Mortar spreads over about 6" of pipe length and reduces pipe $\frac{1}{8}$" to $\frac{3}{8}$" on radius.

STUDY OF IRRIGATION TURNOUT

24" TURNOUT INSTALLATION FOR FIELD TESTS

FIGURE 12
REPORT HYD. 478

Figure 13
Hyd-478



Test Installation Looking Downstream

Downstream End of Long Turnout

Study of Irrigation Turnouts

Field Test Installations - Short and
Long Pipe Turnouts

GPO 846738