UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

- - -

HYDRAULIC LABORATORY REPORT NO. 183

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MODEL TESTS OF GILA VALLEY CANAL HEADWORKS AND BALL CHECK VALVES FOR THE DESILTING BASIN

IMPERIAL DAM
ALL-AMERICAN CANAL PROJECT

By

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- - -

Denver, Colorado
October 1, 1945

UNITED STATES
DEPARTMENT OF THE INTERIOR
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Branch of Design and Construction
Engineering and Geological Control
and Research Division

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Hydraulic Laboratory
Compiled by: C. W. Thomas
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Reviewed by: J. N. Bradley

Subject: Model tests of Gila Valley Canal Headworks and Ball Check Valves for the Desilting Basins - Imperial Dam - All-American Canal Project.

Model of Gila Valley Canal Headworks

1. Construction and Operation of Model. A model of the All-American Canal Headworks was constructed at the Montrose Hydraulic Laboratory during the season of 1935. This model was built on a scale ratio of 1:40 and included the headworks, the overflow weir and three miles of river, of which approximately one and three quarter miles was upstream and one and one quarter miles downstream from the dam. Testing was not completed during the 1935 season and it was necessary to open the laboratory in the spring of 1936. The model of Imperial Dam, as constructed lent itself quite readily to the addition of the Gila Valley Canal Headworks. It was therefore decided to complete a model of the Gila Canal headworks, but consisting of only the initial development or one desilting basin and appurtenant works, figure 1. The model is shown on figures 2 and 3. The scale ratio was necessarily the same as the rest of the structures.

At the time the model was constructed, detailing of certain features of the structure had been intentionally delayed until some model work could be completed to aid in the designing. The parts of the structures that had not been detailed were completed by the laboratory staff in order to have something definite for the initial tests. Exclusive of these details, the model was constructed as shown on drawing 50-D-151, and on drawings contained in the specifications for Imperial Dam and desilting works.

The model was completed and a few preliminary runs were made before the meeting of the All-American Canal consulting board at the laboratory July 26 and 27, 1936. The model was operated in the presence of the board and others at the laboratory at that time. After viewing this operation it was generally agreed:

(1) That as a whole the action was very satisfactory; and

(2) The sluicing of the desilting basin should be effected by controlling the inlet gates to maintain shooting velocity along the bottom of the basin with a small volume of water and not by flushing with a large volume admitted at low velocity.

The discussion following the operation disclosed that several features of the model should be given further study. These features may be enumerated as follows:

(1) Study of the design of the crest under the inlet gates to the desilting basin to improve conditions of flow when the gates are open only a small amount and the water level in the desilting basin is very low.

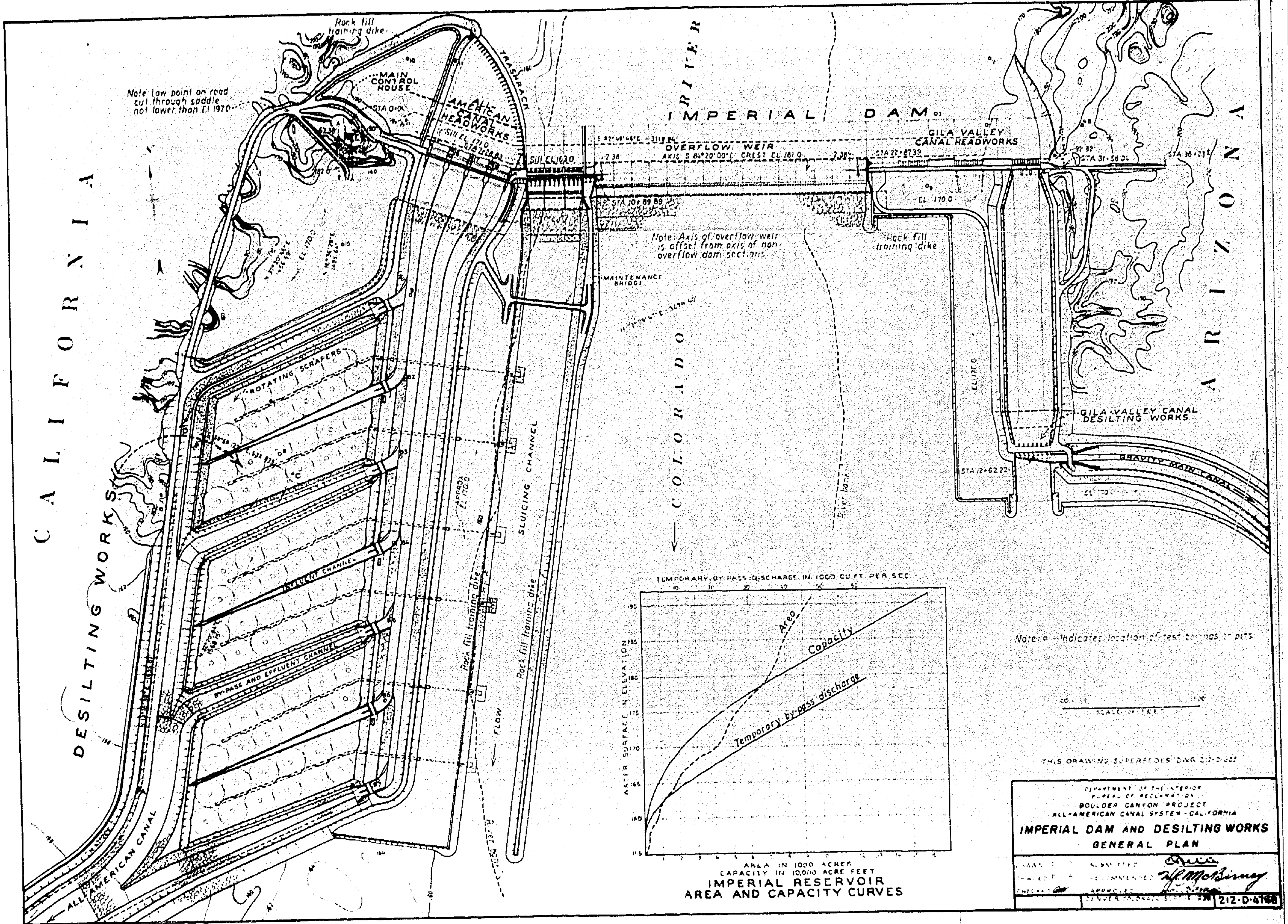
(2) Study of the upstream ends of the piers of the sluiceway structure to improve flow conditions during the sluicing operations.

(3) Study of the downstream end of the wide center pier of the sluiceway structure to improve flow conditions during the sluicing operation.

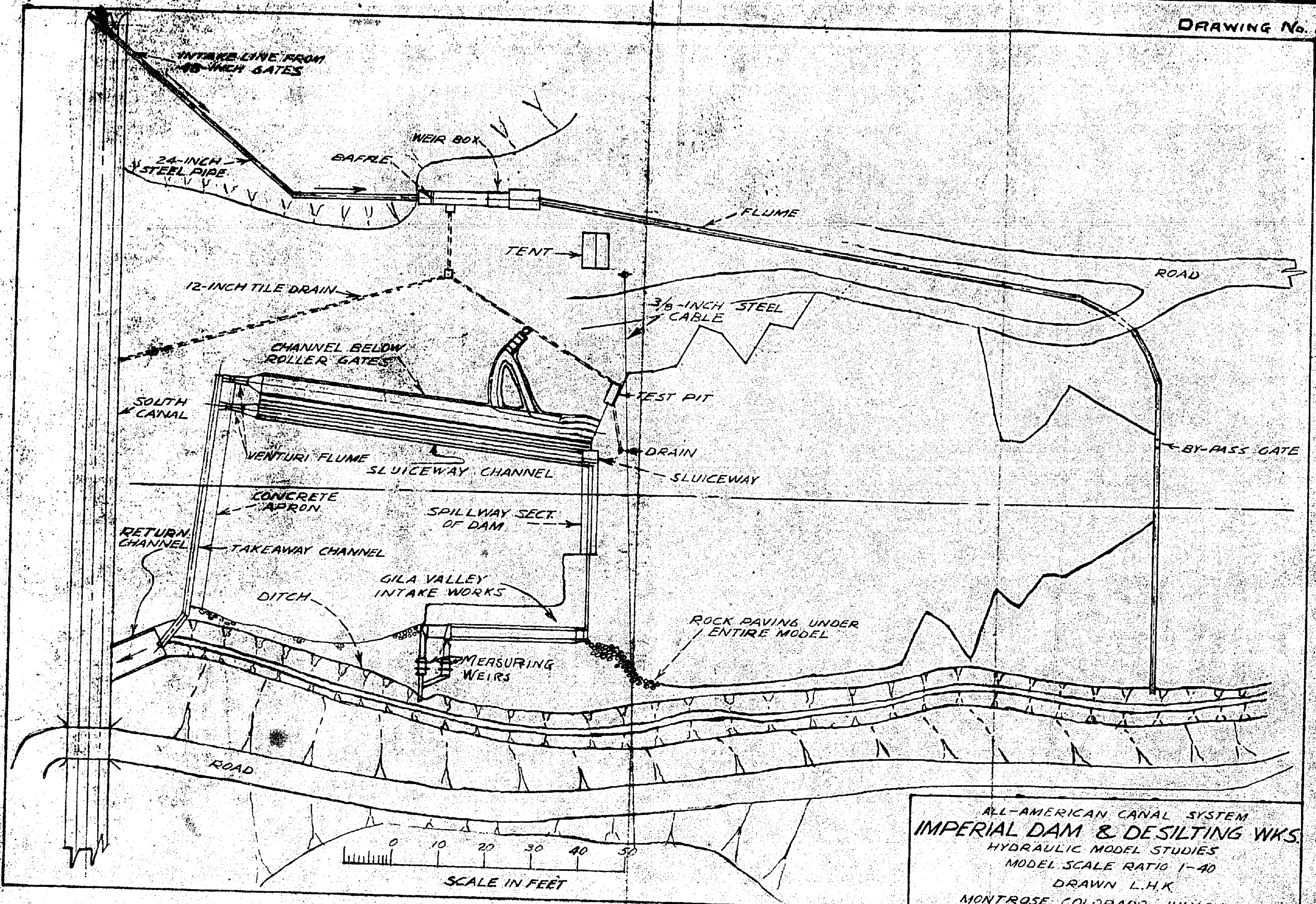
(4) Study of the curved downstream ends of the piers for the headgates to the canal to complete the design and effect good flow conditions. (This study to include the location of the wall downstream from these gates).

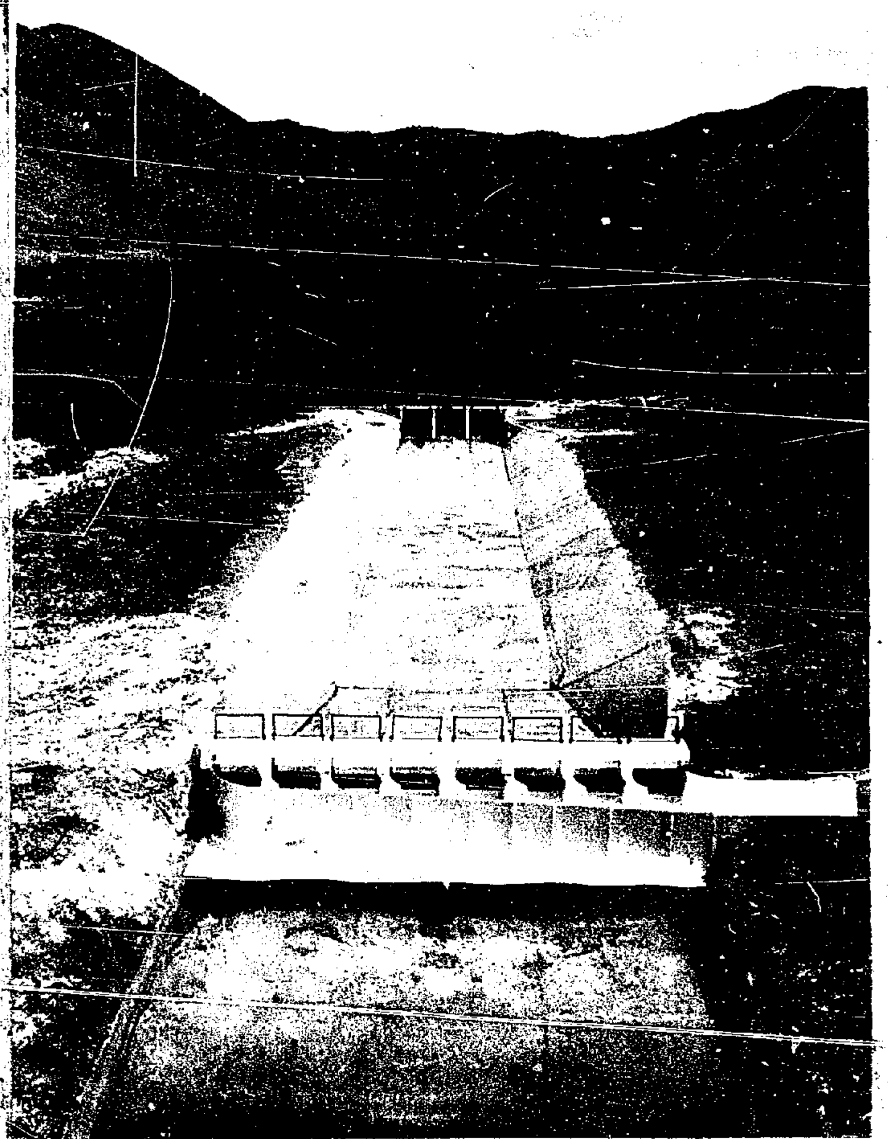
(5) Study of flow through the headgates to the canal to determine if the best conditions of flow are obtained with the water entering over or under this set of gates.

FIG. 1

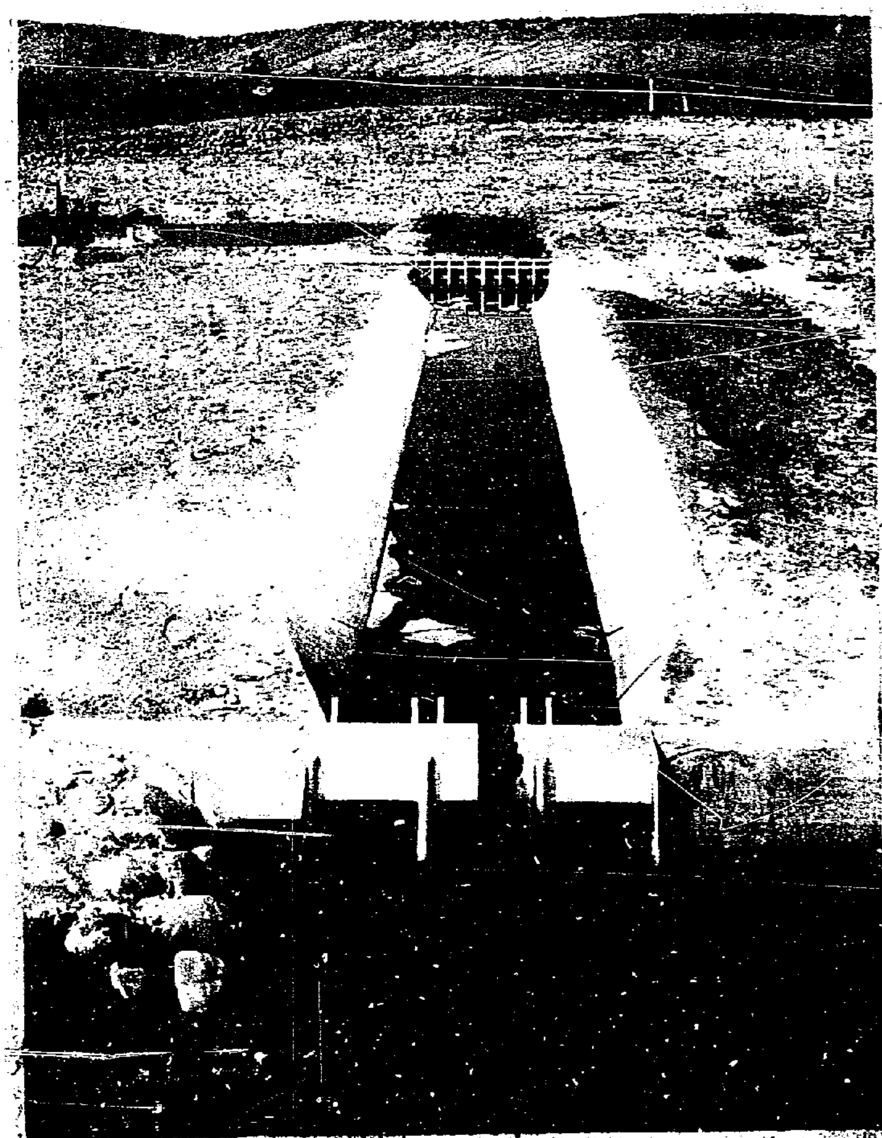

CALIFORNIA
ARIZONA
COLORADO
RIVER
IMPERIAL DAM
OVERFLOW WEIR
GILA VALLEY CANAL HEADWORKS
ALL-AMERICAN CANAL HEADWORKS
MAIN CONTROL HOUSE
TRASHRACK
Rock fill training dike
Note: low point on road cut through saddle not lower than El 197.0
Note: Axis of overflow weir is offset from axis of non-overflow dam sections.
MAINTENANCE BRIDGE
SLUICING CHANNEL
Rock fill training dike
FLOW
River bank
ROTATING SCRAPERS
INFLUENT CHANNEL
BY-PASS AND EFFLUENT CHANNEL
DESILTING WORKS
ALL-AMERICAN CANAL
GILA VALLEY CANAL DESILTING WORKS
GRAVITY MAIN CANAL
EL. 170.0
TEMPORARY BY-PASS DISCHARGE IN 1000 CU. FT. PER SEC.
WATER SURFACE IN ELEVATION
Area
Capacity
Temporary by-pass discharge
AREA IN 1000 ACRES
CAPACITY IN 10,000 ACRE FEET
IMPERIAL RESERVOIR
AREA AND CAPACITY CURVES
THIS DRAWING SUPERSEDES DWG
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BOULDER CANYON PROJECT
ALL-AMERICAN CANAL SYSTEM - CALIFORNIA
IMPERIAL DAM AND DESILTING WORKS
GENERAL PLAN
212-D-4168

DRAWING No. 2


INTAKE LINE FROM
-INCH GATES
24-INCH
STEEL PIPE
BAFFLE
WEIR BOX
FLUME
TENT
ROAD
12-INCH TILE DRAIN
3/8-INCH STEEL
CABLE
CHANNEL BELOW
ROLLER GATES
TEST PIT
SOUTH
CANAL
VENTURI FLUME
SLUICEWAY CHANNEL
DRAIN
BY-PASS GATE
SLUICEWAY
CONCRETE
APRON
SPILLWAY SECT.
OF DAM
RETURN
CHANNEL
TAKEAWAY CHANNEL
GILA VALLEY
INTAKE WORKS
DITCH
ROCK PAVING UNDER
ENTIRE MODEL
MEASURING
WEIRS
ROAD
0 10 20 30 40 50
SCALE IN FEET
ALL-AMERICAN CANAL SYSTEM
IMPERIAL DAM & DESILTING WKS.
HYDRAULIC MODEL STUDIES
MODEL SCALE RATIO 1-40
DRAWN L.H.K.
MONTROSE, COLORADO JULY 24 1936.



Looking Upstream



Looking Downstream

GILA VALLEY CANAL HEADWORKS

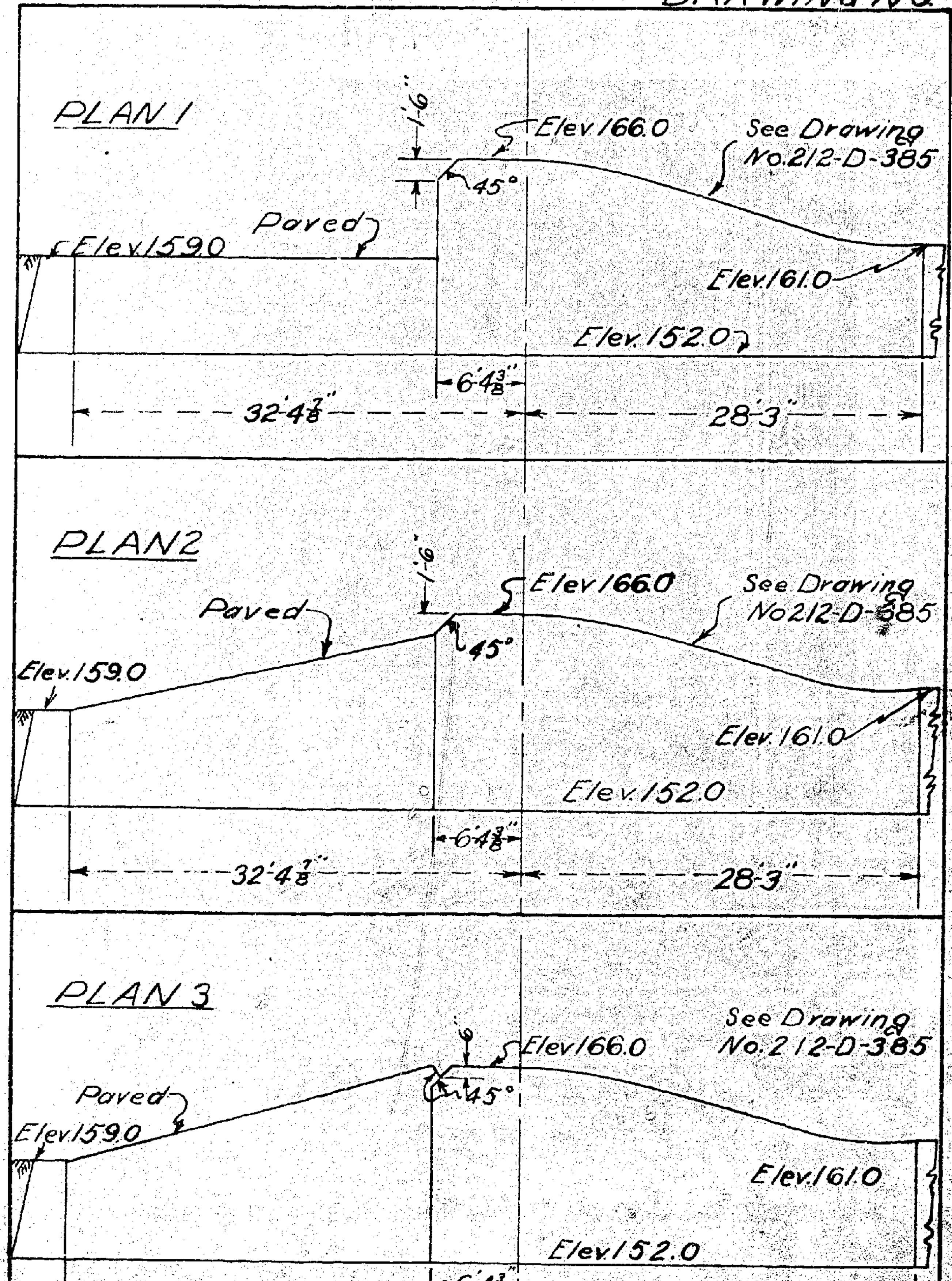
Figure 3

Each of these studies has been considered separately.

Before the testing program was begun some runs of short duration were made for visual observation to assist in planning a detailed study. These runs yielded very little information of technical value but furnished a basis for further observation and assisted in detecting any peculiarities that might be present during the operation of the structure.

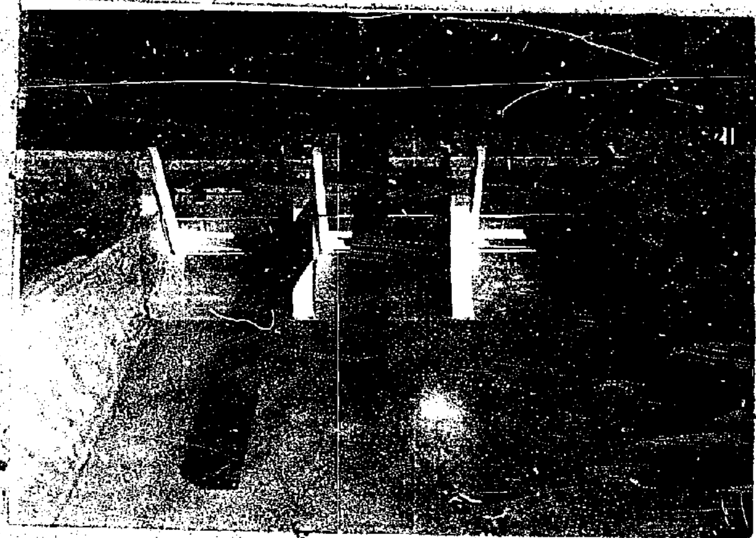
Throughout this series of tests the discharge through the structure was maintained at 2,000 second-feet. The flow was along the left bank of the reservoir, thus the water approached the inlet structure normal to the gate structure. The reservoir water surface was maintained at elevation 179.5 and the water surface in the discharge canal was held constant at elevation 178.0. The other factors were variable, depending upon the test, and will be mentioned in the discussion. Careful observations were made during the tests and a complete set of notes were recorded. A photographic record was made when practicable.

2. Improvement of Inlet Gate Crest. Preliminary runs on the original design of the crest of the inlet structure plan 1, figure 4, had indicated that very bad entrance conditions existed under the lip of the gate when these gates were opened only a small amount and the water in the desilting basin was low, figure 5. Consequently, runs were made on this design and on the several proposed changes by raising the water surface in the desilting basin by one-foot steps beginning at elevation 161.0 and ranging to elevation 179.5. The adverse condition consisted of a shooting jet of water which broke

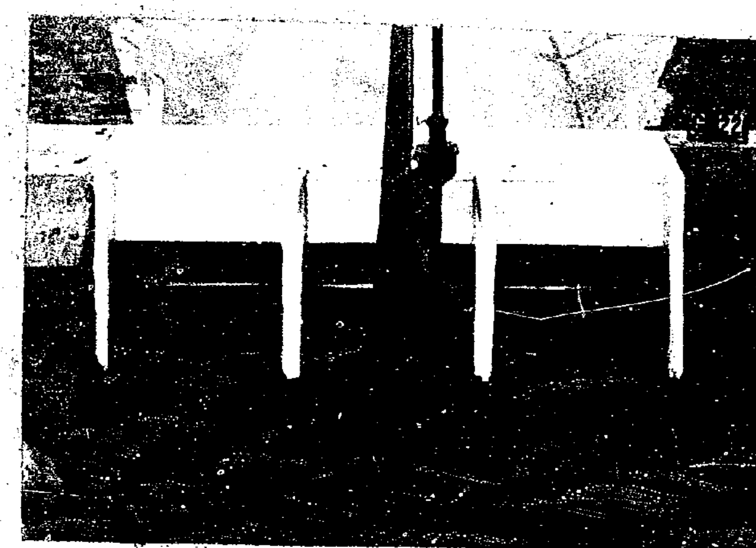

PLAN 1
1'-6"
Elev. 166.0
See Drawing No. 212-D-385
45°
Paved
Elev. 159.0
Elev. 161.0
Elev. 152.0
6'-4 3/8"
32'-4 7/8"
28'-3"
PLAN 2
1'-6"
Elev. 166.0
See Drawing No. 212-D-385
Paved
45°
Elev. 159.0
Elev. 161.0
Elev. 152.0
6'-4 3/8"
32'-4 7/8"
28'-3"
PLAN 3
See Drawing No. 212-D-385
Elev. 166.0
45°
Paved
Elev. 159.0
Elev. 161.0
Elev. 152.0
6'-4 3/8"
32'-4 7/8"
28'-3"

H.D. BRILEY

Figure 5

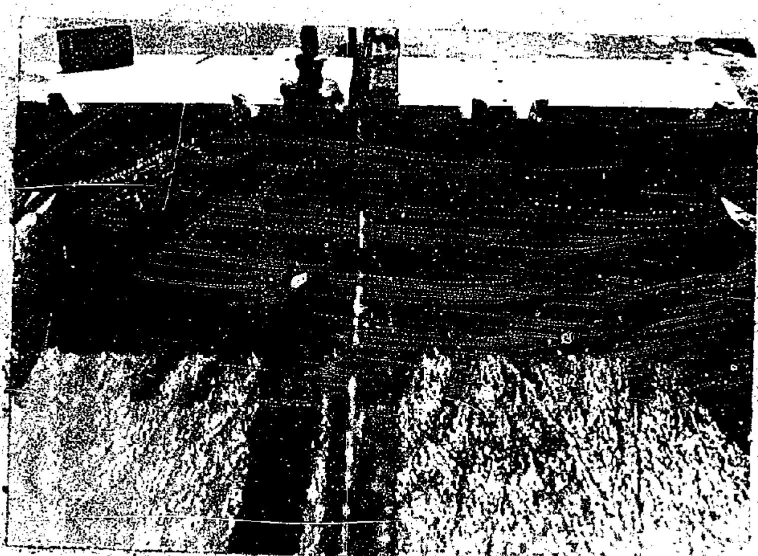


Looking Upstream

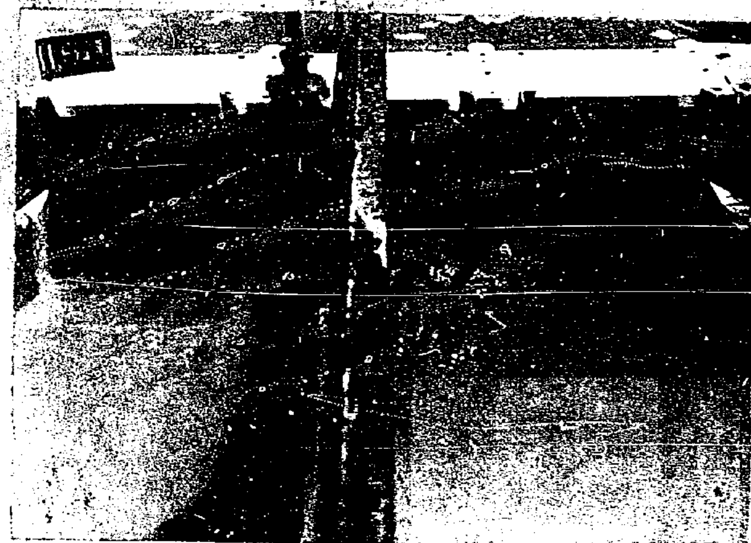


Looking Downstream

Inlet Structure



Low Tailwater



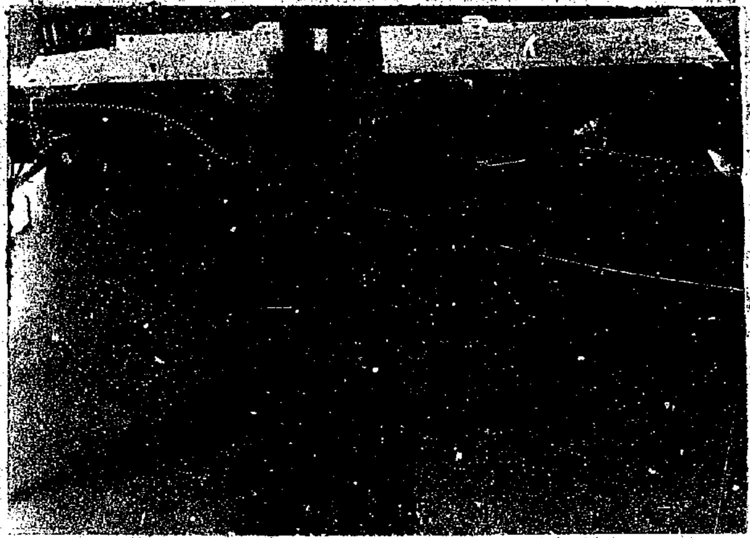
Medium Tailwater

Flow Conditions - Plan 1

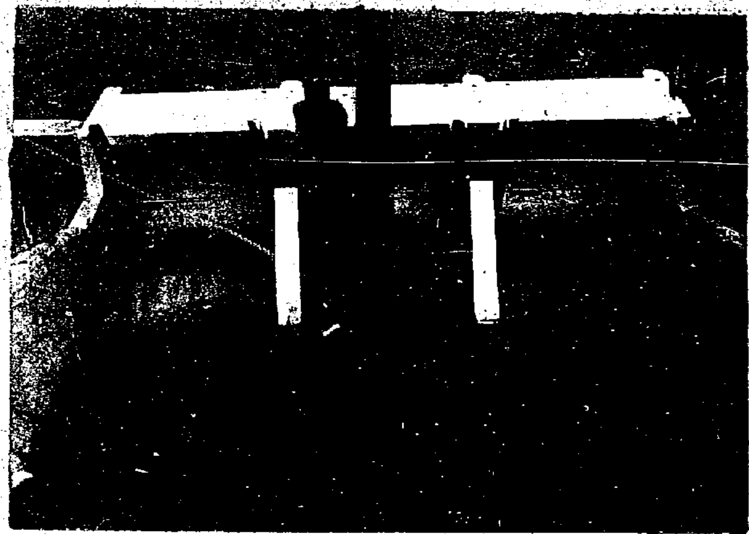
free of the crest at the lip of the gate and impinged on the crest at the extreme downstream end, figure 5. This condition existed until the water in the desilting basin gained an elevation of 171.0, at which point the jet became drowned and various forms of surges and rolls existed until the water surface reached an elevation of 179.5, figures 5 and 6. With the maximum water surface the flow was fairly smooth. In an effort to eliminate this jet condition the area above the inlet gates was paved for a distance of about 32 feet upstream, on a slope beginning at elevation 159.0 and rising to elevation 164.5 at the crest, plan 2, figure 4. This plan did not improve the flow conditions over the crest as is shown by the pictures on figure 6. A comparison of the pictures on figures 5 and 6, show that practically the same conditions exist with or without the paving in this area. In a further attempt to improve this flow condition the upstream paving was changed as shown on plan 3, figure 4. With a low water level in the desilting basin the water did not tend to leave the crest but flowed smoothly over it, figure 7. At medium water surface elevation the flow was very much improved, being smoother and quieter than in previous tests. With the maximum water surface elevation in the desilting basin the flow entered so evenly that scarcely a ripple was visible on the surface, figure 7. Unless construction or operation conditions warrant otherwise, it is recommended that this plan be considered as the solu..on to the problem.

3. <u>Upstream Ends of Piers of Sluiceway Structure</u>. The next problem to be studied consisted of changing the upstream ends of the piers of the sluiceway structure to improve flow conditions during sluicing. The preliminary runs had shown that with a discharge of 2,000 second-feet, sluiceway gates wide open, and a low water surface

Figure 5



Plan 1 - High Tailwater



Plan 2 - Low Tailwater

Flow Conditions

Medium Tailwater

High Tailwater

Flow Conditions - Plan 2

Low Tailwater

Medium Tailwater

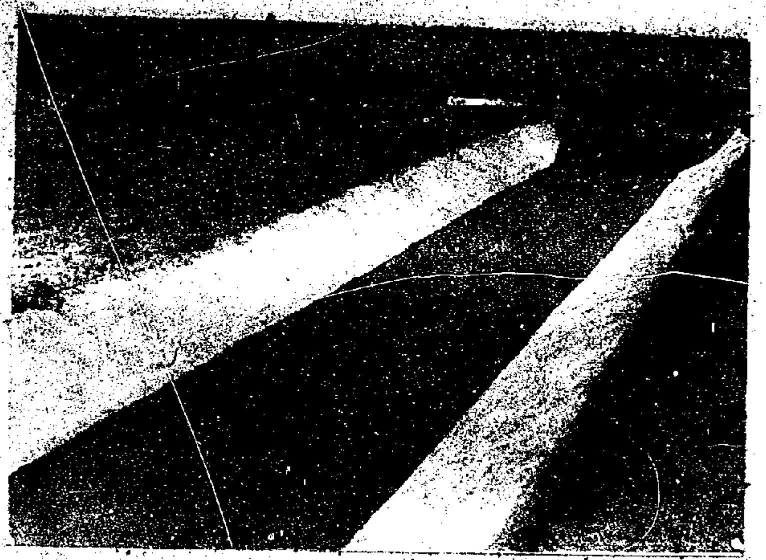
High Tailwater

FLOW CONDITIONS - PLAN 3

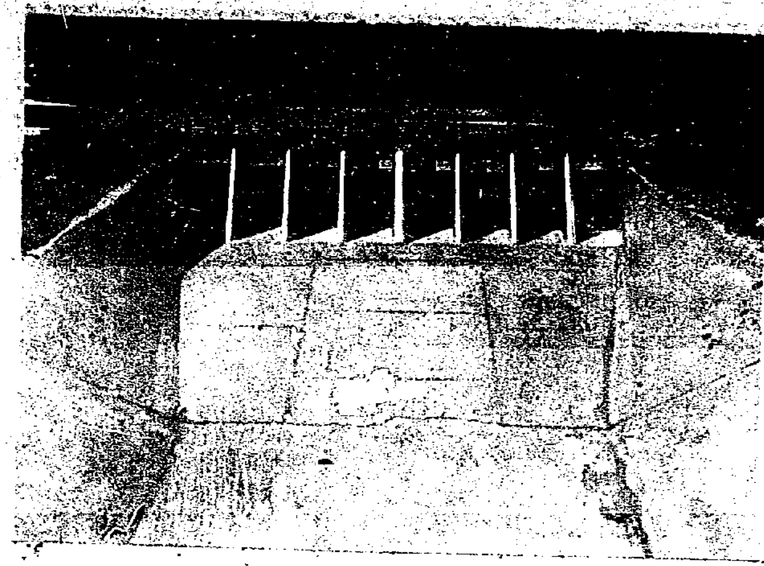
in the desilting basin (the recommended conditions for the sluicing operation) the water had a tendency to climb the face of these piers and to interfere with the formation of the roller at the foot of the crest above the sluice structure, figure 8. In order to eliminated these undesirable conditions part of the pier was removed and was replaced by a section as shown on figure 9. This design is symmetrical and blends well with the general shape of the structure. Observation of resulting conditions indicated that there was no rough flow through the gates, no surge of climb against the pier face and that the desired roller was not interfered with by this surge, figure 10. Since flow conditions were improved so much with this type of a pier, further study was deemed unnecessary and it is recommended that this type of pier be incorporated in the final design.

4. Downstream End of Wide Center Pier of Sluiceway Structure. Preliminary tests had indicated that with the original design undesirable hydraulic conditions existed downstream from the wide center pier of the sluiceway structure. A wide fin of water was spread over practically the entire paved area below the structure and caused undesirable rough waves on this surface due to flow from the other openings striking this larger fin of water. The worst condition existed with the water surface in the desilting basin at the top of the sluice gates and a discharge of 2,000 second-feet, figure 11. The first attempt to improve this condition consisted of extending this pier 20 feet downstream in the shape of a wedge, plan 1, figure 12. This pier addition improved the flow distribution and entirely eliminated any disturbance below the structure, figure 11, but due to the narrowness of the pier it was believed that the same results might be obtained with a short section which

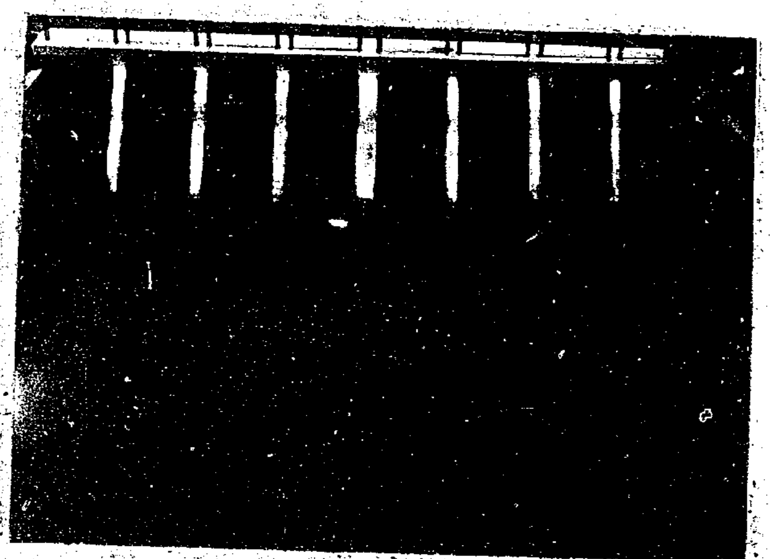
Figure 8



Structure & Desilting Basin



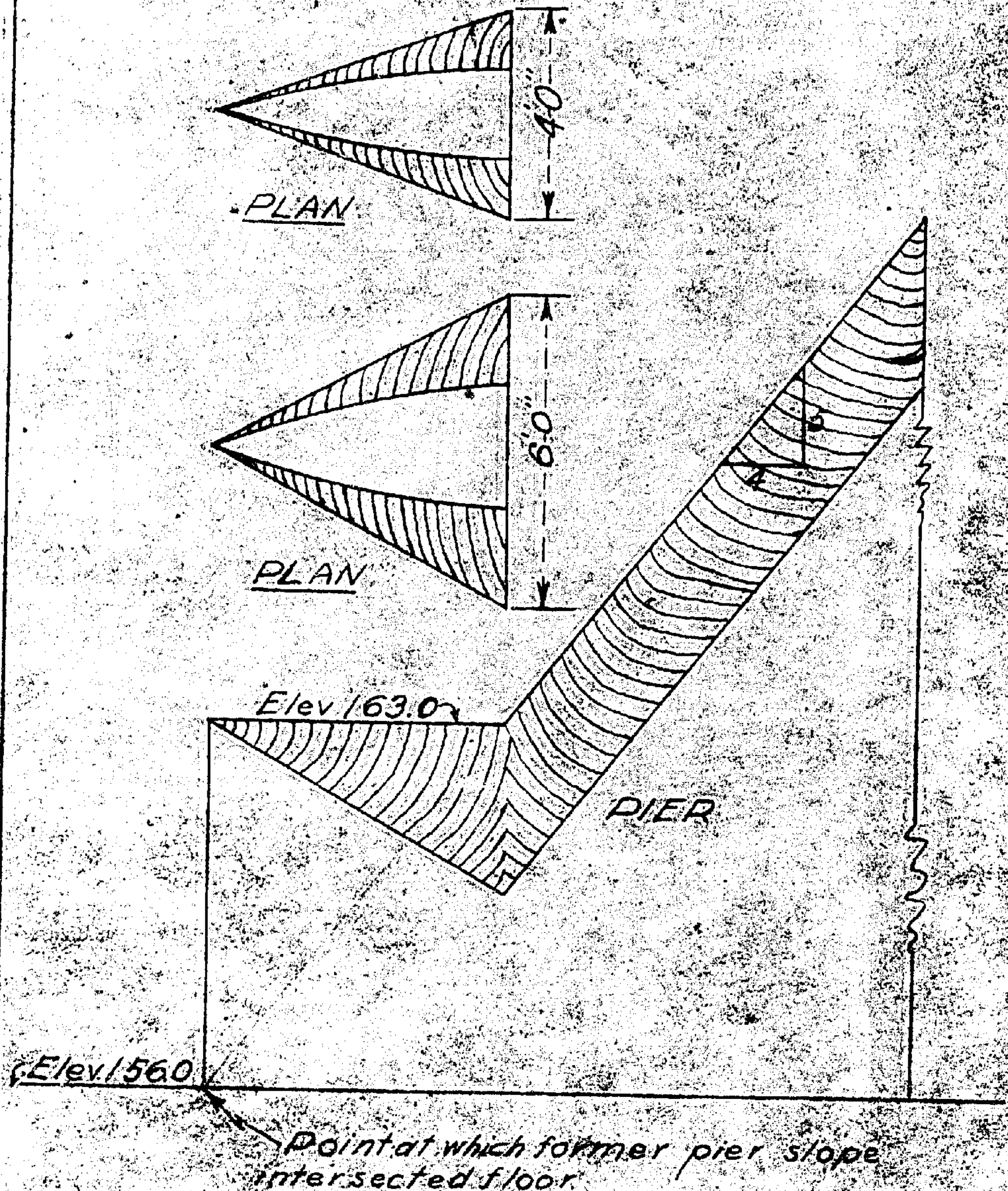
Looking Downstream



Flow Conditions - Looking Downstream

SLUICEWAY STRUCTURE [illegible]AL DESIGN

DRAWING NO. 9



ELEVATION

HDBAILEY

would conform better to the general shape of the structure. With this thought in mind the next section tested was of the same general shape but only 10 feet in length, plan 2, figure 12. This addition did not give quite as good results as the longer section but since it conforms more to the general shape of the structure it is considered satisfactory, figure 11.

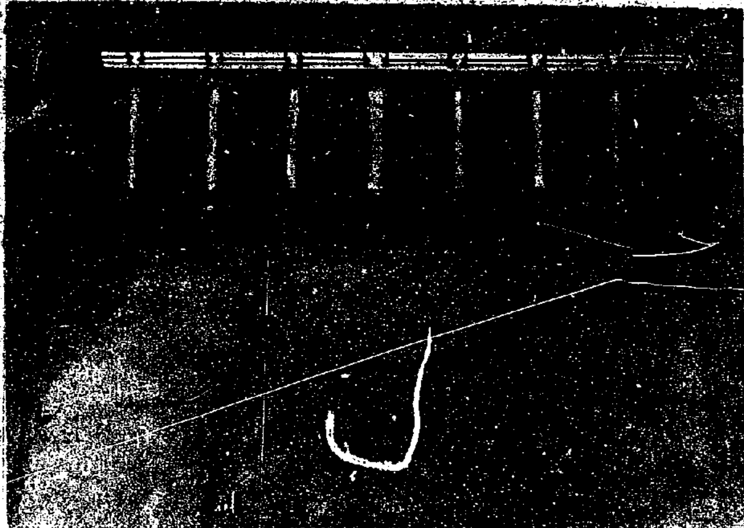
5. Curved Downstream Ends of Piers in Canal. Operation of the model with the curved downstream ends of the piers of the diversion structure removed was not satisfactory and indicated clearly that some type of curve should be included in the final design. Runs made on the original curved design of the pier tails, plan 1, figure 13, indicated that the area between the canal wall and the ends of the pier tails was too small, figure 14. That is, there was a tendency for the water to crowd or build up along the canal wall and to form swirls or eddies which flowed back and forth across the channel striking first the wall and then the pier tails. Possible changes to eliminate this condition were:

(1) Move the wall farther away from the ends of the curved pier tails,

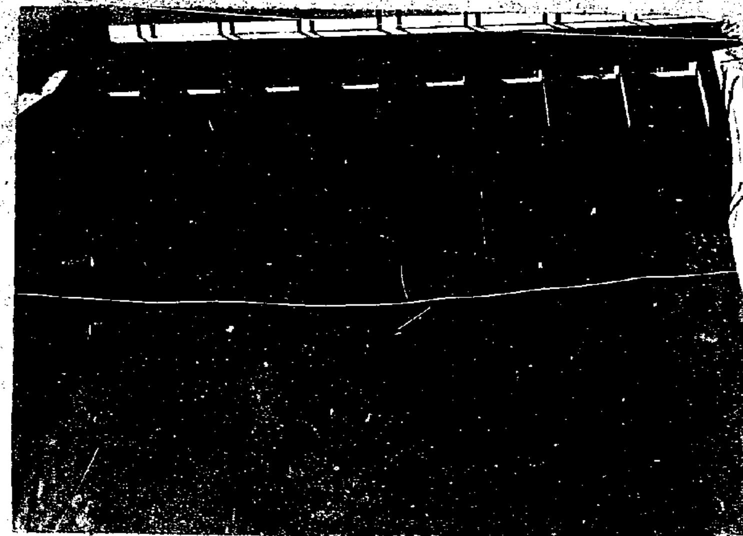
(2) Shorten the pier tails, or

(3) Straighten the pier tails.

The water surface in the desilting basin was held at elevation 179.5. The first attempt to improve the conditions in the channel consisted of shortening the three pier tails on the right, plan 2, figure 13. Some improvement was noted in the flow, especially between the second and third gates from the right, figure 14, and some of the whirl was quieted in the canal channel. There was also an evident drop in head



New pier shape - Looking Downstream

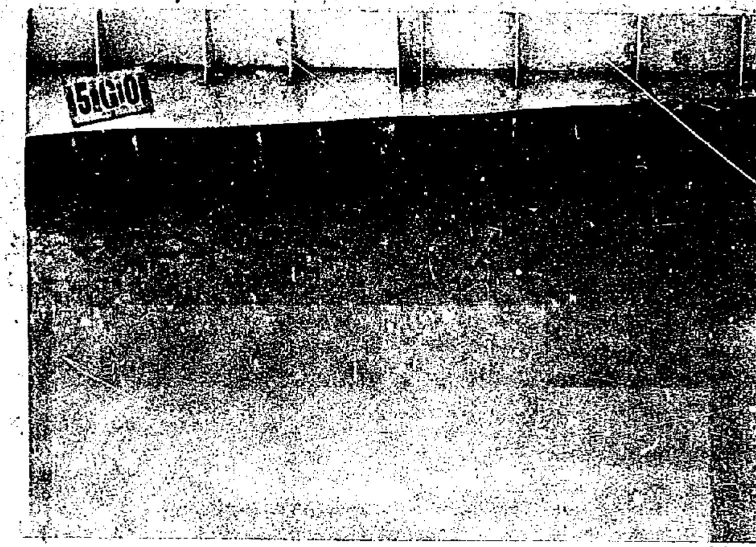


Flow conditions - Looking Downstream

Flow conditions around one pier

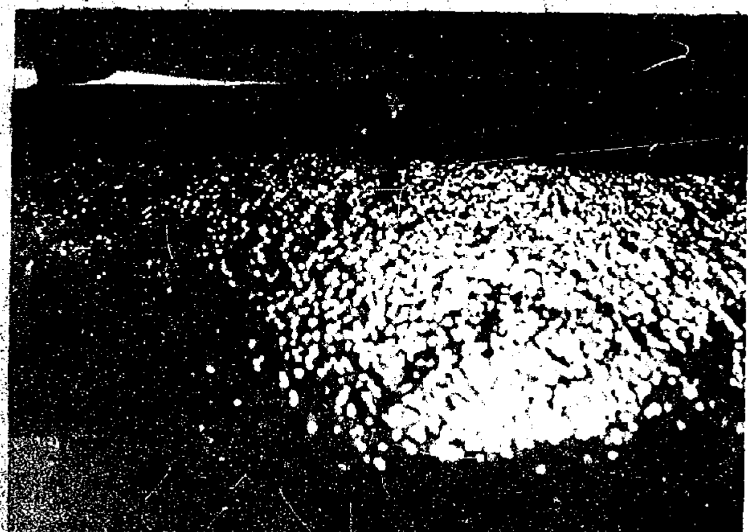
SLUICEWAY STRUCTURE - IMPROVED DESIGN

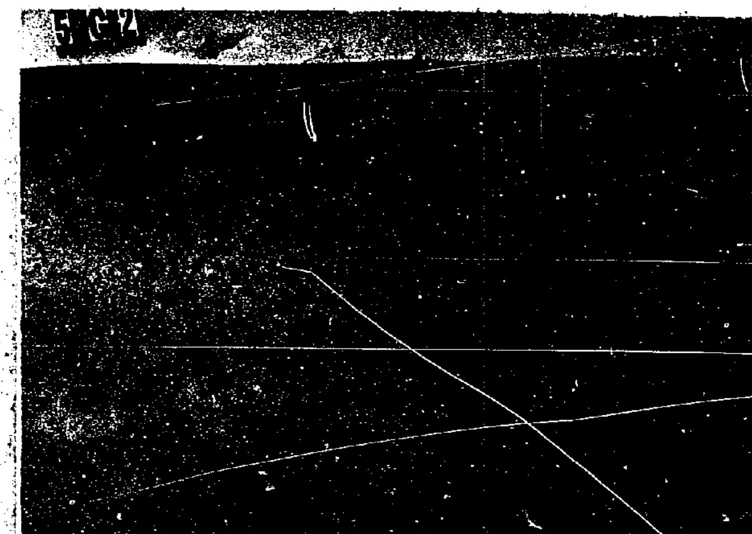
Figure 11



Original Design

Flow conditions - Original Design





Flow conditions - Plan 1

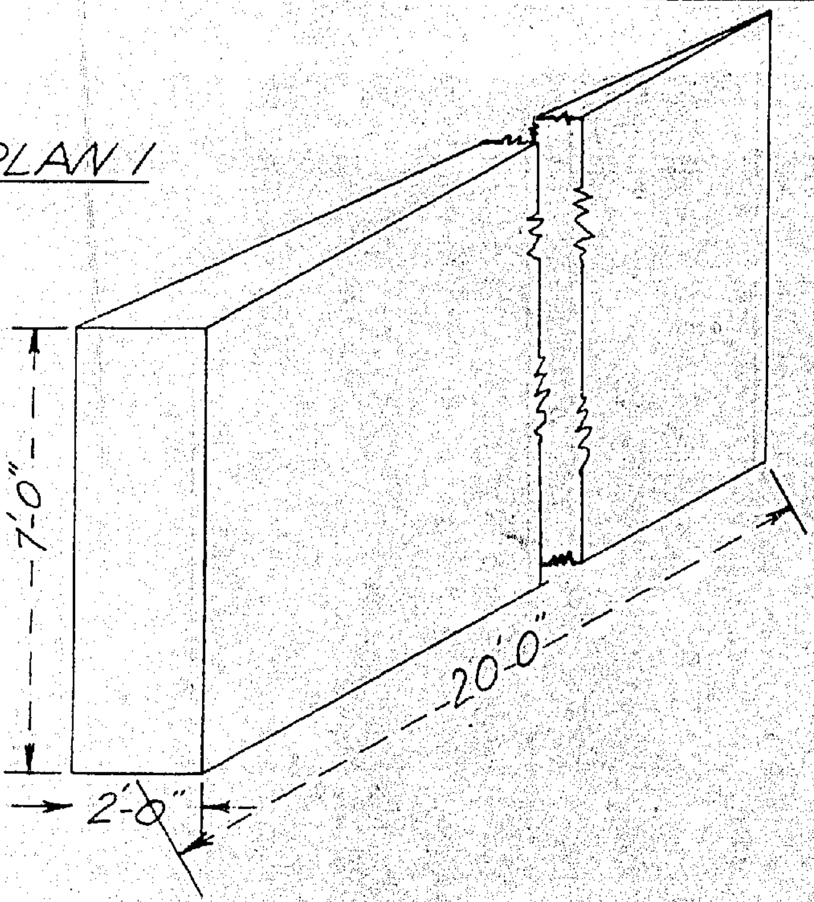
Flow conditions - Plan 2

UPSTREAM ... OF SLUICEWAY STRUCTURE

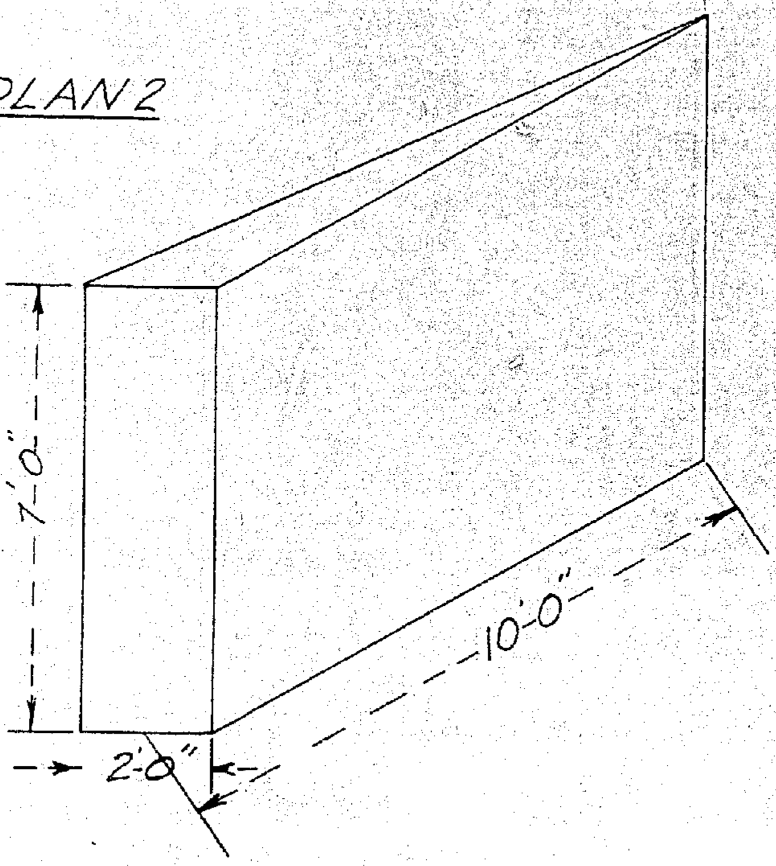
from right to left in the canal below the sluiceway but generally the flow conditions were not appreciably improved. All of the pier tails were removed and new ones of the shape shown on plan 3, figure 15, were installed. Flow conditions in the channel were improved, especially below the three right openings, figure 16. Flow distribution in the channel above the transition to the earth section of the canal was improved but there was still considerable drop in head between the two ends of the canal section. Observed conditions indicated that it would not be practical to make the pier tails straighter because the direction imparted to the water entering the channel would then be undesirable. With further changes on this point impractical, attention was directed to moving the canal wall farther downstream. This wall was moved until the opening between it and the right pier tail was practically equal to the width of the gate opening, plan 4, figure 15. This change made a very noticeable improvement in the conditions in the channel and the distribution in the transition upstream from the earth section. The drop-in head between the two ends of the canal section was also reduced. There was a slight surface roll below the three left gates. Throughout these tests it had been noticed that with flow over the gates the water surface in the canal was above the bottom of the beam across the top of the gate openings. Since the bottom of this beam was at elevation 179.0 and the water surface in the desilting basin was at elevation 179.5, the opening acted as an orifice. Improved conditions of flow were obtained by raising the bottom of this beam to elevation 180.0. Distribution before entrance into the earth section was very good and the drop in head between the two ends of the structure was reduced.

DRAWING NO. 12

PLAN 1



PLAN 2



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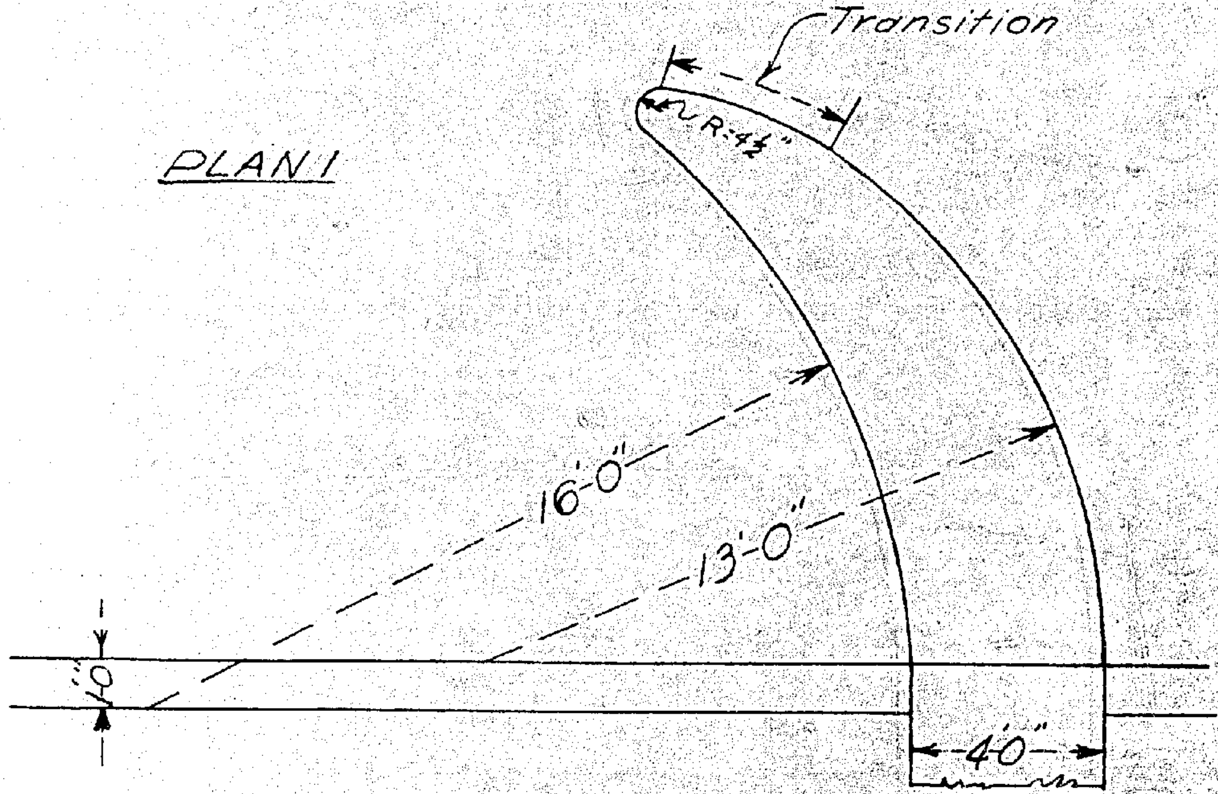
DRAWING NO. 13

PLAN 1



PLAN 2

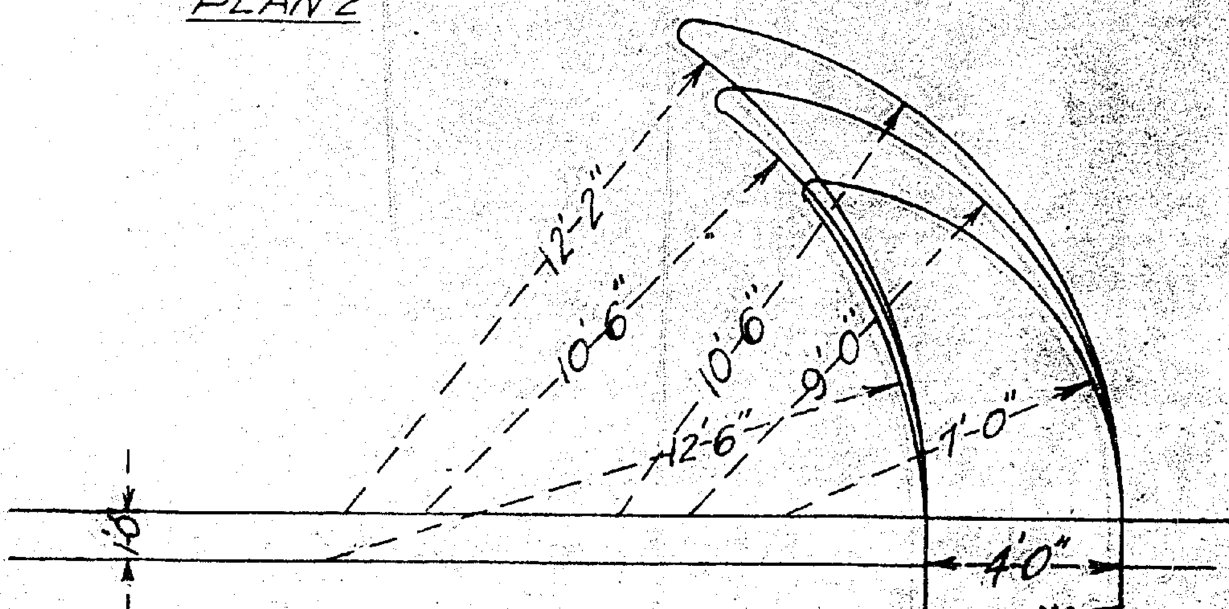


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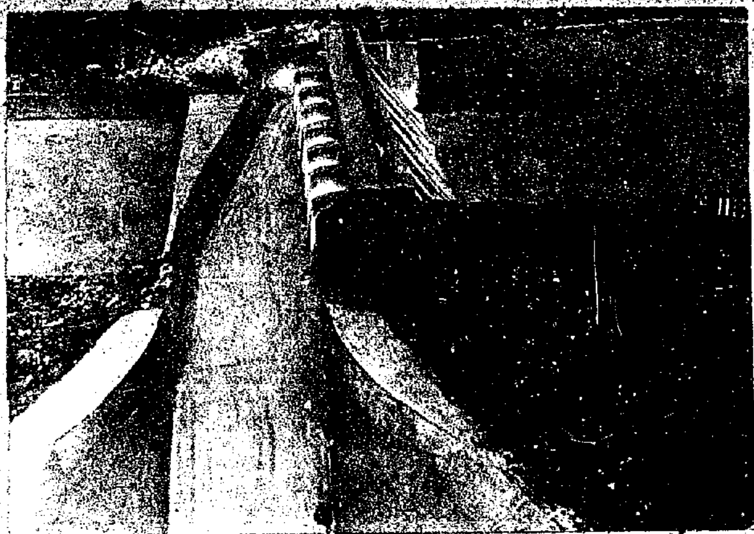
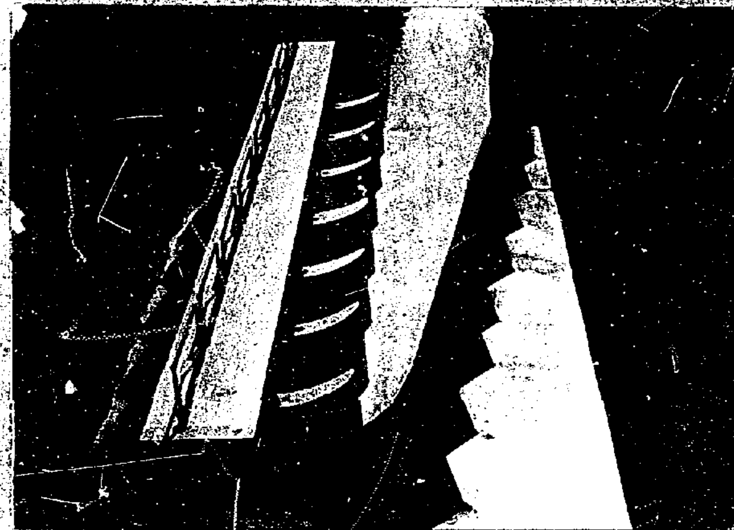
Figure 14

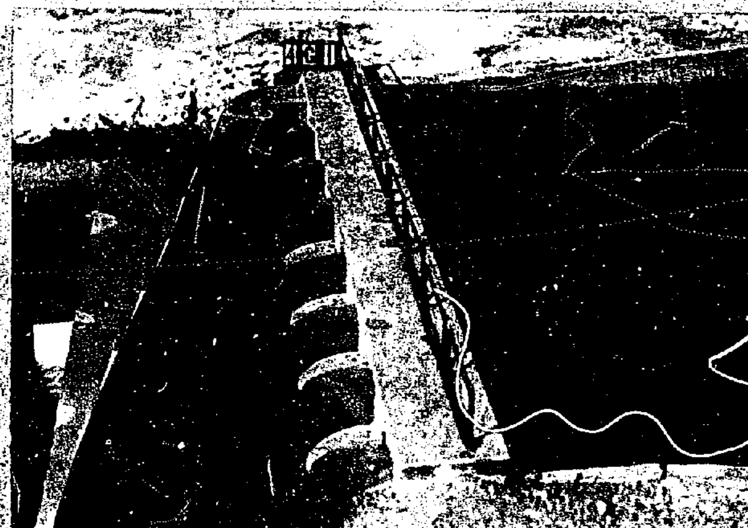


View from left



View from right

Flow Condition - Plan 1



Flow Condition - Plan 2

PIER TAILS ON SLUICEWAY STRUCTURE

DRAWING NO. 15

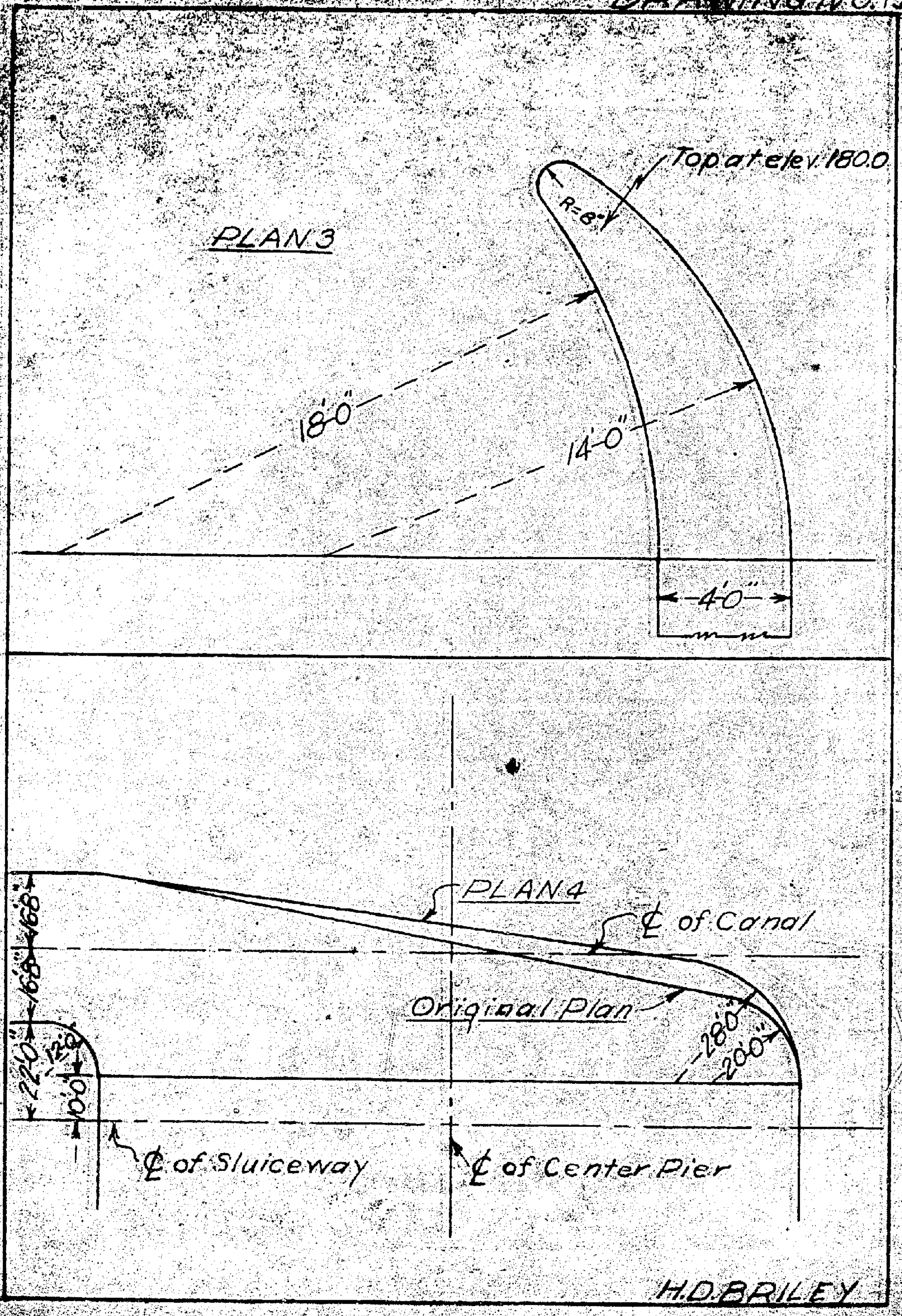
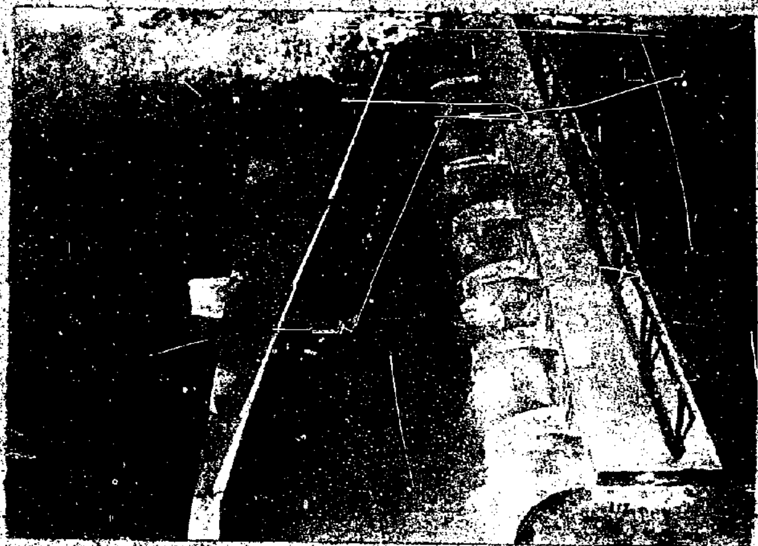
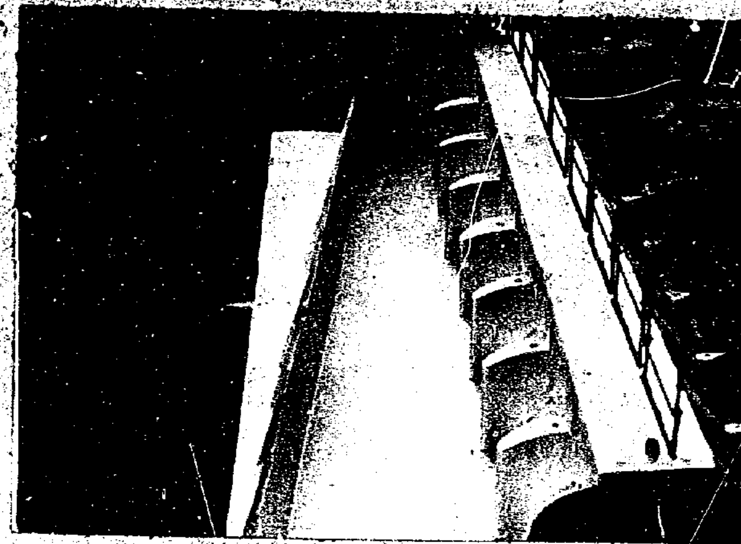


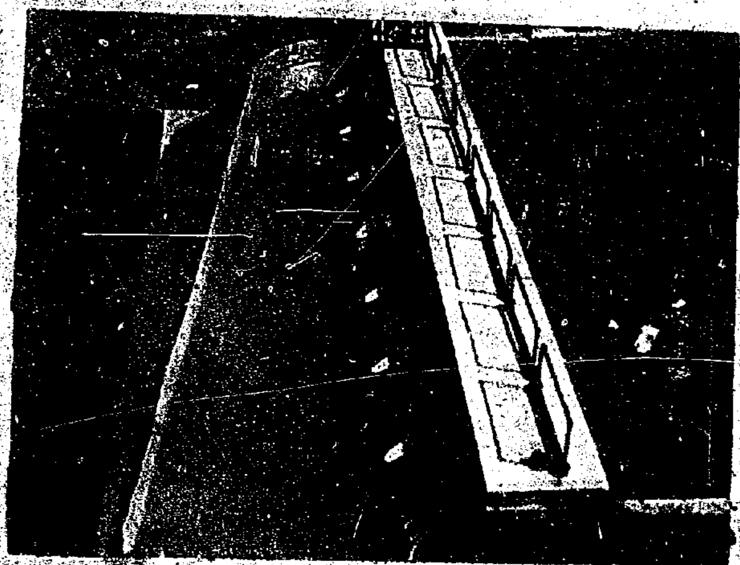
Figure 16



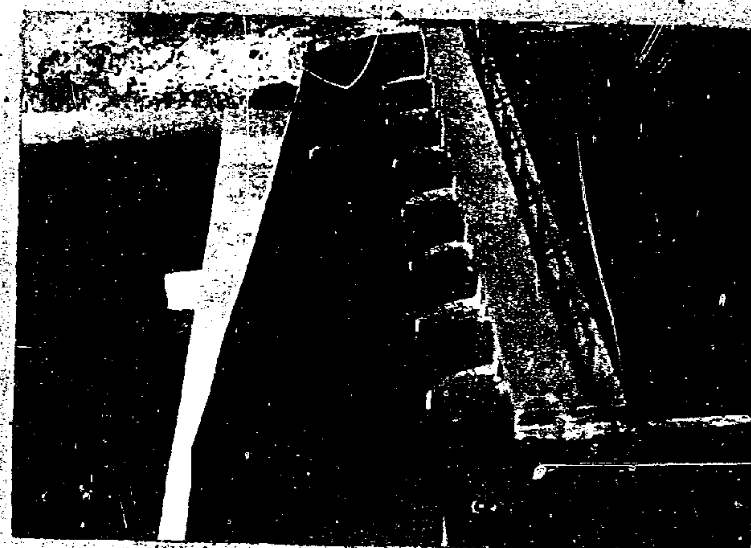
Flow Conditions - Plan 3



Structure - Plan 4



Flow Conditions - Plan 4



Flow Conditions - Bottom of Beam above Gates at Elevation 180.0

PIER TAILS ON SLUICEWAY STRUCTURE

The formation of a slight roll below each gate was noted. The jet from each of the gates was visible to the center of the channel and then became evenly distributed in the canal. These three changes, namely, change in shape of pier tails, plan 3, figure 15, new position of canal wall, plan 4, figure 15, and raising the bottom of the beam above the gates, have combined to improve the distribution of flow and entrance conditions in the canal.

6. Flow through Headgates to Canal. This study was made to determine, by visual observation, whether or not the best conditions existed with the flow over the diversion gates or with the flow under these gates. The water surface in the desilting basin was maintained at elevation 179.5, while the water surface in the canal section was held at elevation 178.0. This test was conducted after the changes described in section 5 had been made. Observations were made with the flow under the gates as called for in the original design. Flow in the canal was very rough, with an action at the gates resembling a surge or heavy roll which was not stable. The distribution in the canal section was not uniform, with some dead water along the left wall extending into the transition section. The gates were then lowered and the water allowed to flow over them. Flow in the canal was smooth and the only noticeable action below the gates consisted of a small roller immediately downstream from each gate. The distribution in both the canal and transition sections was very good. The water surface was not rough and there did not appear to be any area of dead water in the canal section. Entrance conditions were also improved. It is believed that the best conditions of flow are obtained by admitting the water over the diversion gates.

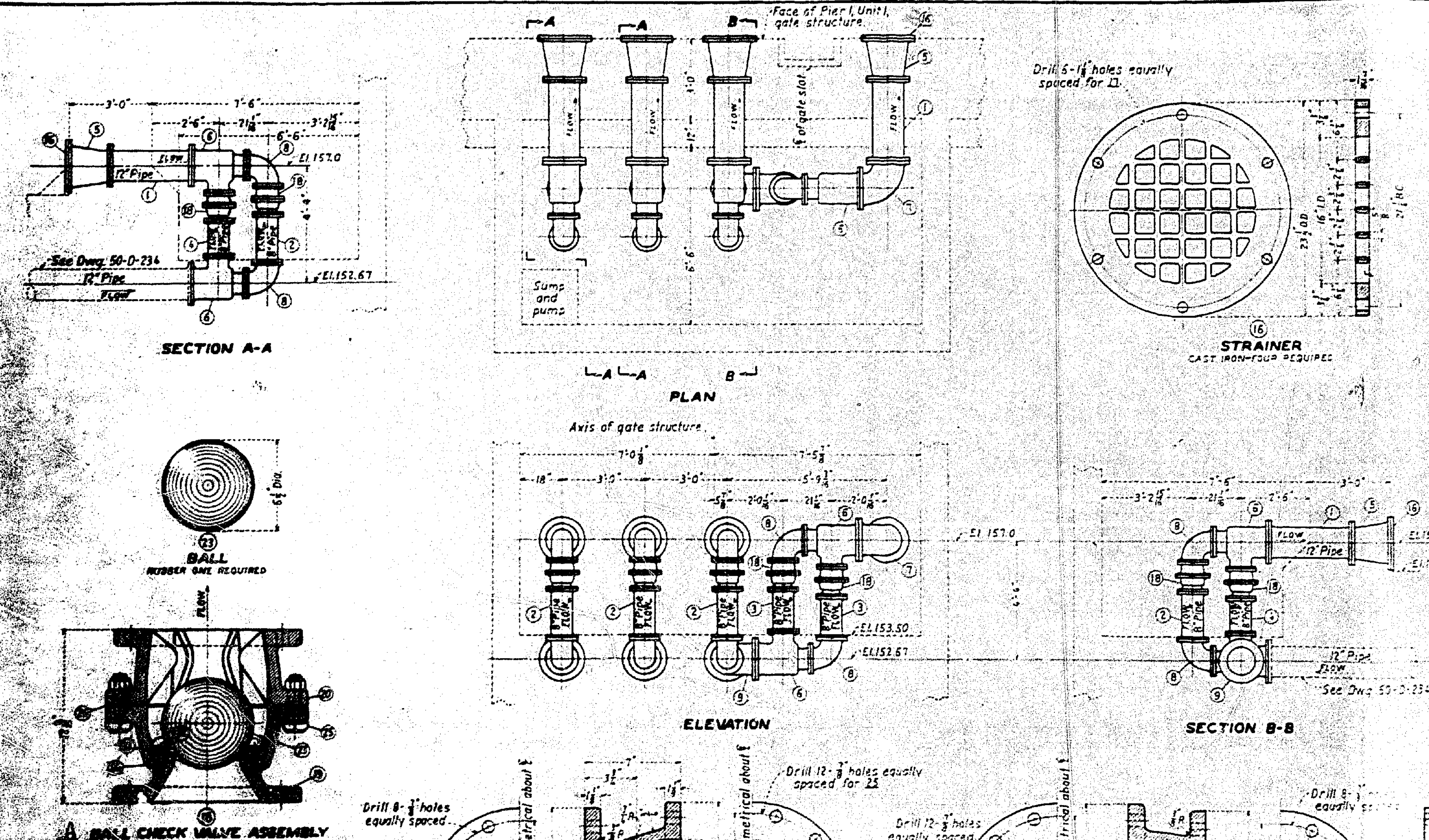
The Ball Check Valves for Gila Canal Desilting Basins

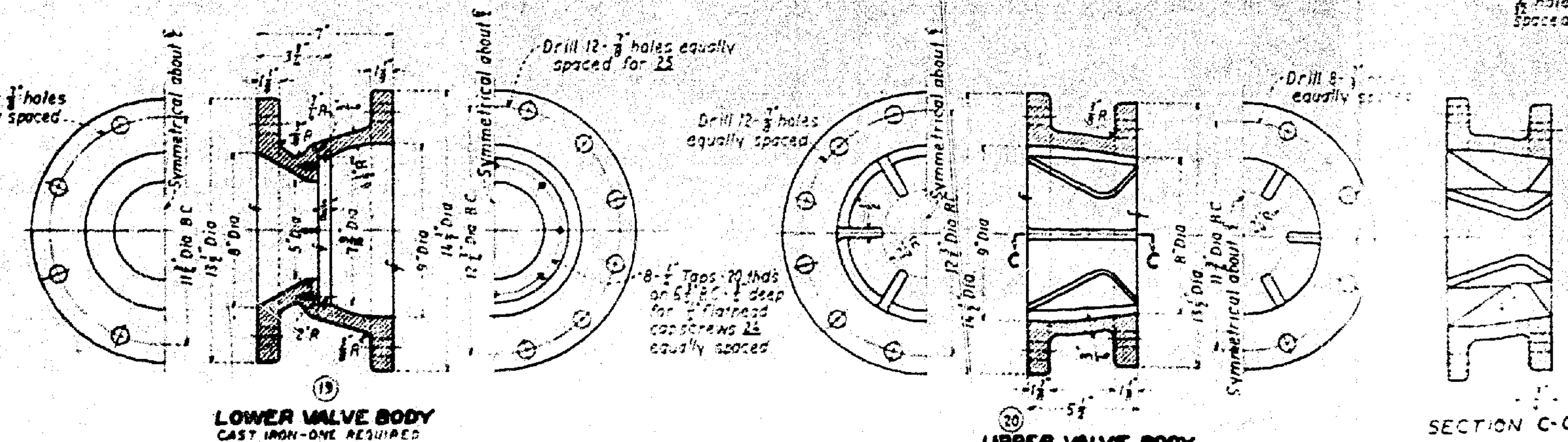
7. Purpose of the Check Valve. During the sluicing of the Gila settling basins, the water surface in the basin will be lowered rather rapidly. To prevent failure of these basins, some form of valve is necessary to permit seepage or ground water to drain quickly from the saturated soil behind the walls of the settling basins. To eliminate the care of an operator, an automatic check valve was adopted. The ball type of check valve was selected because of its simplicity. This is an automatic valve which opens during the sluicing process and closes when the water pressure in the structure becomes greater than the hydrostatic pressure due to ground water in the saturated soil.

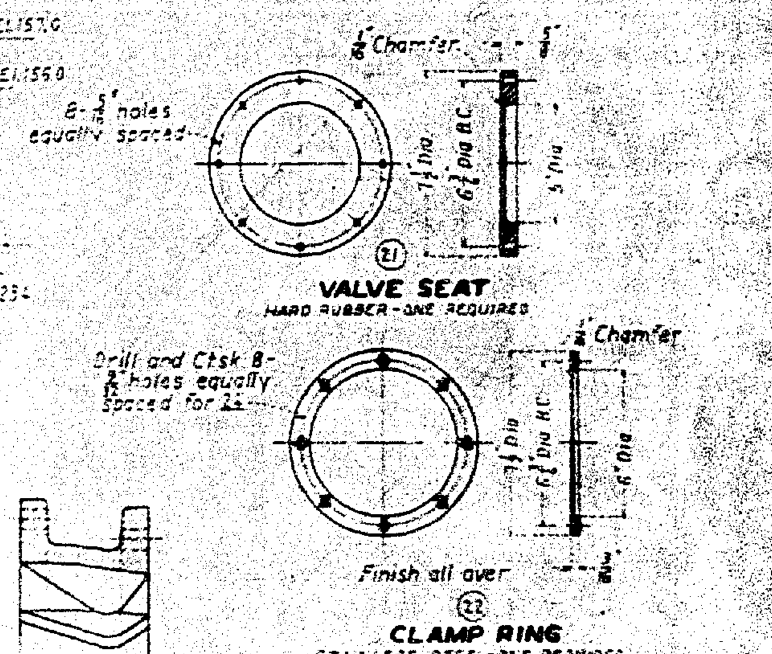
8. Original Valve Design. The original design of the valve and its field installation arrangement are shown on figure 17. Because of the importance of the valve, a 1 to 1 model was tested in the laboratery. A $6\frac{1}{2}$-inch hard rubber ball with a density of 1.14 had been specified for the valve. This ball was first tested in the laboratory to determine whether it would retain any permanent set after having stood under a high head for some period of time. After standing under a head of 60 feet for a week, a permanent indented ring was formed at the point of contact of the ball with the hard rubber seat. Obviously, the ball could not be expected to seat in the same position each time, with the result that considerable leakage might have been expected at lower heads. The use of the rubber ball was, therefore, abandoned.

A chromium-plated hollow brass ball of 1.25 density was next tested. No impression was made on this ball when tested under high heads.

FIG. 17







LIST OF PARTS

PART NO.	DESCRIPTION	MATERIAL	NO. REQ'D
•1	12" Pipe, both ends flanged, 2'-11$\frac{7}{8}$" face to face	Cast iron	4
•2	8" Pipe, both ends flanged, 1'-9$\frac{1}{2}$" face to face	Cast iron	3
•3	8" Pipe, both ends flanged, 1'-6$\frac{1}{2}$" face to face	Cast iron	2
•4	8" Pipe, both ends flanged, 1'-3$\frac{1}{2}$" face to face	Cast iron	3
•5	16"x12" Flanged reducer. 16" flange to have six-1" taps, 8 thds, equally spaced and one straddling horiz. center line. 12" flange to have standard drilling	Cast iron	4
•6	12"x8"x8" Flanged reducing tee	Cast iron	7
•7	12"-90° Flanged elbow	Cast iron	[illegible]
•8	8"-90° Flanged elbow	Cast iron	8
•9	12" Reducing side outlet tee - see Dwg. 50-D-205	Cast iron	4
•10	$\frac{3}{4}$"x3$\frac{1}{4}$" Sq. hd. bolt with one hex nut	Steel	168
•11	$\frac{5}{8}$"x3$\frac{1}{4}$" Sq. hd. bolt with one hex nut	Steel	210
•12	$\frac{1}{8}$"x12"x16$\frac{1}{2}$" Ring gasket	Soft Copper annealed	8
•13	$\frac{1}{8}$"x12"x15$\frac{1}{4}$" Ring gasket	Cloth-insert Rubber	5
•14	$\frac{1}{8}$"x8"x11" Ring gasket	Cloth-insert Rubber	24
•15	$\frac{1}{8}$"x8"x11" Ring gasket	Soft Copper annealed	8
16	Strainer	Cast iron	4
17	1"x2$\frac{1}{2}$" Hex. head cap screw, 8 threads	Bronze	24
18	Ball check valve complete (see assembly)	Cast iron	SEE SPECIF.

• Part No's. 1 to 15 inclusive, furnished by the Government. Purchased on Invitation No. 24,559-A. May 25, 1937.
Install copper gaskets where flanges are buried in concrete.
For Reference Drawings see Dwg. 50-D-234

LIST OF PARTS FOR ONE CHECK VALVE ONLY

PART NO.	DESCRIPTION	MATERIAL	NO. REQ'D
19	Lower valve body	Cast iron	1
20	Upper valve body	Cast iron	1
•21	Valve seat furn. by Gov.	Hard Rubber	1
22	Clamp ring	Stainless Steel	1
•23	Ball	Rubber	1
24	Flat head capscrews furn. by Gov.	Stainless Steel	8
25	$\frac{3}{4}$"x3$\frac{1}{4}$" Sq. hd. bolts with one hex. nut each	Steel	12
26	$\frac{1}{8}$"x9"x11$\frac{1}{2}$" Ring gasket	Cloth-insert Rubber	1

• Parts 21 and 23 furnished by the Government.

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
GILA PROJECT-ARIZONA
GILA VALLEY CANAL-DESILTING WORKS
BASIN 3-DIVERSION WORKS
DRAINAGE SYSTEM
PIPE - CHECK VALVE - STRAINER

DRAWN M.C.L. SUBMITTED
TRACED E.E.B. RECOMMENDED
CHECKED APPROVED

50-D-235

Operation of the original valve with the brass ball resulted in intensive "hammering" of the ball against the guide vanes accompanied by severe vibration of the valve for discharges up to 0.75 second-foot. For higher discharges, the ball remained stationary in position up against the guide vanes. Inspection of the ball after several minutes of operation under the "hammering" conditions showed many scars on the surface of the ball and exposed brass in many places.

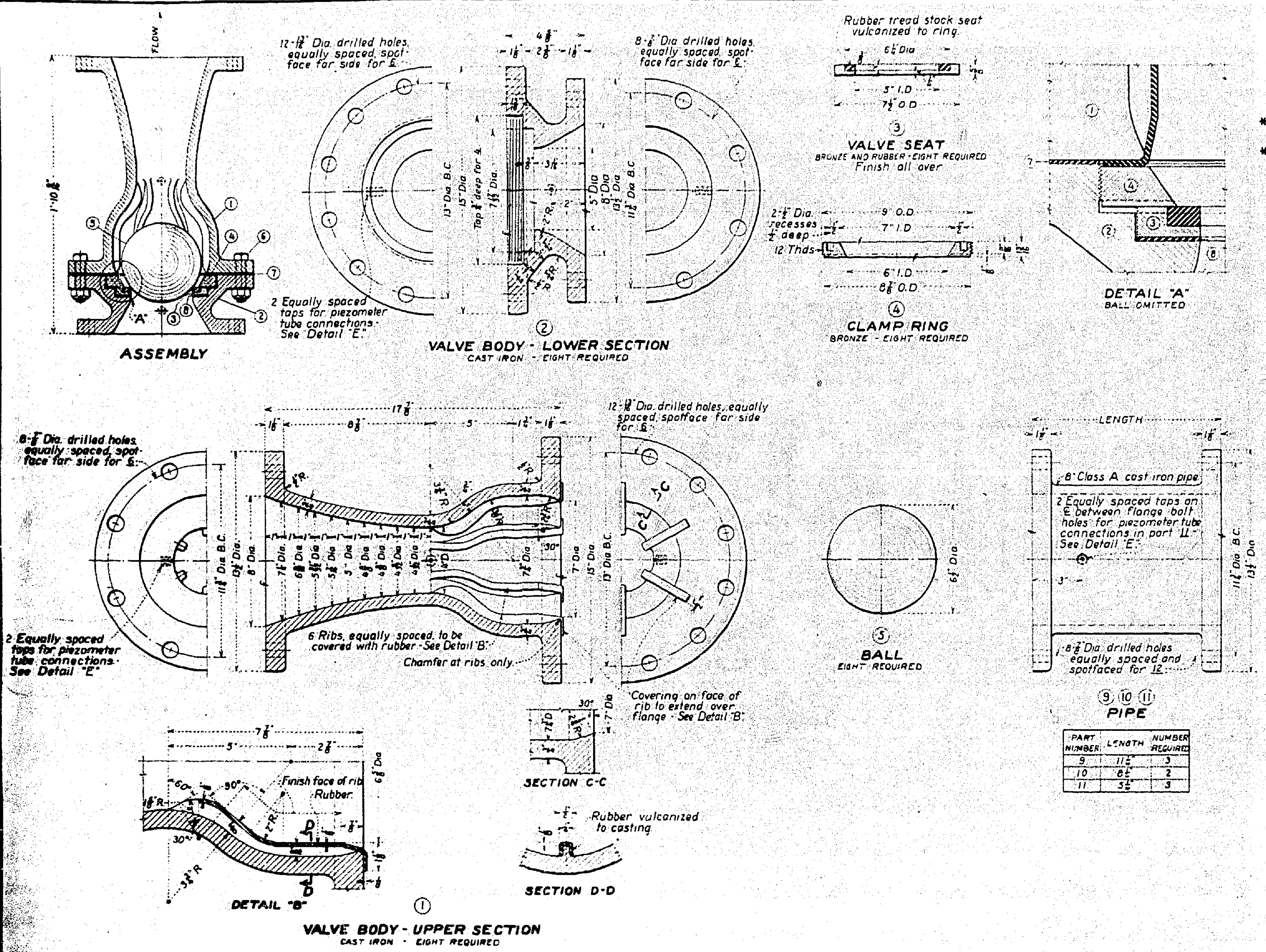
To eliminate the "hammering" action of the ball, further testing was conducted. The noise of "hammering" was reduced to a minimum by covering the guide vanes with 1/8-inch hard rubber strips, but the severe vibration of the valve was undiminished. The vibrations can be explained from a consideration of pressures developed in the valve during operation. For the original valve with the ball in any open position, the cross-sectional area of flow was greater above the ball than below it. It therefore follows from the laws of continuity and Bernoulli that the velocity was greatest below the ball and the pressure greatest above the ball. Consequently, for low heads resulting in discharges below 0.75 second-foot, the greater pressure on top of the ball tended to move it to its closed position. The pressure then increased under the ball moving it toward its open position. It was this unbalanced pressure system that caused the ball to hunt and consequently "hammer" on the guide vanes and cause the valve to vibrate. For the greater heads, where flow was above 0.75 second-foot, the pressure developed under the ball remained greater than that above and hence the ball was held motionless against the guide vanes.

9. Final Ball Check Valve. Theoretically, the ball will no longer hunt when the velocity above the ball is greater at all times than that below it. This requires that the cross-sectional area above

the ball be smaller than that below it for all open positions. The final design of the valve, figure 18, is such that, with the ball in the open position, there is a progressive decrease in cross-sectional area from inlet to outlet, with the resulting increase in velocity and decrease in pressure head.

Operation of the final valve at discharges below 0.46 second-foot resulted in no vibration of the valve and such a slight motion of the ball that its presence could be detected only by the fluctuation of the mercury columns of piezometer connections. During small flows, the ball is lifted only a small distance above the seat so that the cross-sectional area of flow between the ball and the seat is smaller than that above the ball, which results in an unbalanced pressure system similar to that developed in the original valve. Obviously, this condition can never be completely eliminated. The range of discharge over which the ball has motion can be reduced by further reducing the cross-sectional area through the valve, but, since this increases the loss and consequently reduces the dischaRge through the valve, and because the motion of the ball in the revised design was not considered excessive, this design was adopted.

10. Calibration of the Final Design of Valve. Figure 19 shows the characteristics of the ball check valve for discharges up to about 2.5 second-feet. The head loss through the valve in the 1 to 1 scale model was measured by 1/8-inch inside diameter piezometer openings located at quarter points in planes A and D, figure 18. A large differential pressure for rating purposes was obtained from diametrically opposite openings at location B and C. A slightly greater differential was obtained by using piezometers at point A in the 8-inch pipe instead of at

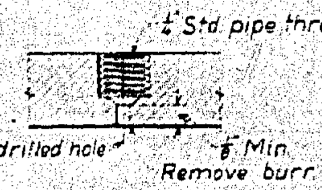


PART NUMBER	LENGTH	NUMBER REQUIRED
9	11½"	3
10	8½"	2
11	3½"	3

LIST OF PARTS

	PART NUMBER	DESCRIPTION	MATERIAL	NUMBER REQUIRED
	1	Valve body - upper section (see detail)	Cast iron	8
	2	Valve body - lower section (see detail)	Cast iron	8
*	3	Valve seat (see detail)	Bronze and rubber	8
	4	Clamp ring (see detail)	Bronze	8
*	5	Ball (see detail)	See specification	8
	6	¾"x3¼" Hex. head machine bolt with hex nut, semi-finish	Steel	96
	7	12" O.D. x 9" I.D. x 1/16" cloth inserted ring gasket	Rubber	8
	8	7½" O.D. x 5" I.D. x 1/16" cloth inserted ring gasket	Rubber	8
	9	6" Pipe (see detail)	Cast iron	3
	10	8" Pipe (see detail)	Cast iron	2
	11	8" Pipe (see detail)	Cast iron	3
	12	¾"x4" Studs threaded 1" each end	Steel	128
	13	Hex nuts for 12, semi-finish	Steel	256

* To be furnished by the Government



DETAIL "E"

NOTE

Taps for piezometer tube connections to be made in field.
For installation of piezometer piping, see Dwg. 50-D-676.

DEPARTMENT OF THE INTERIOR
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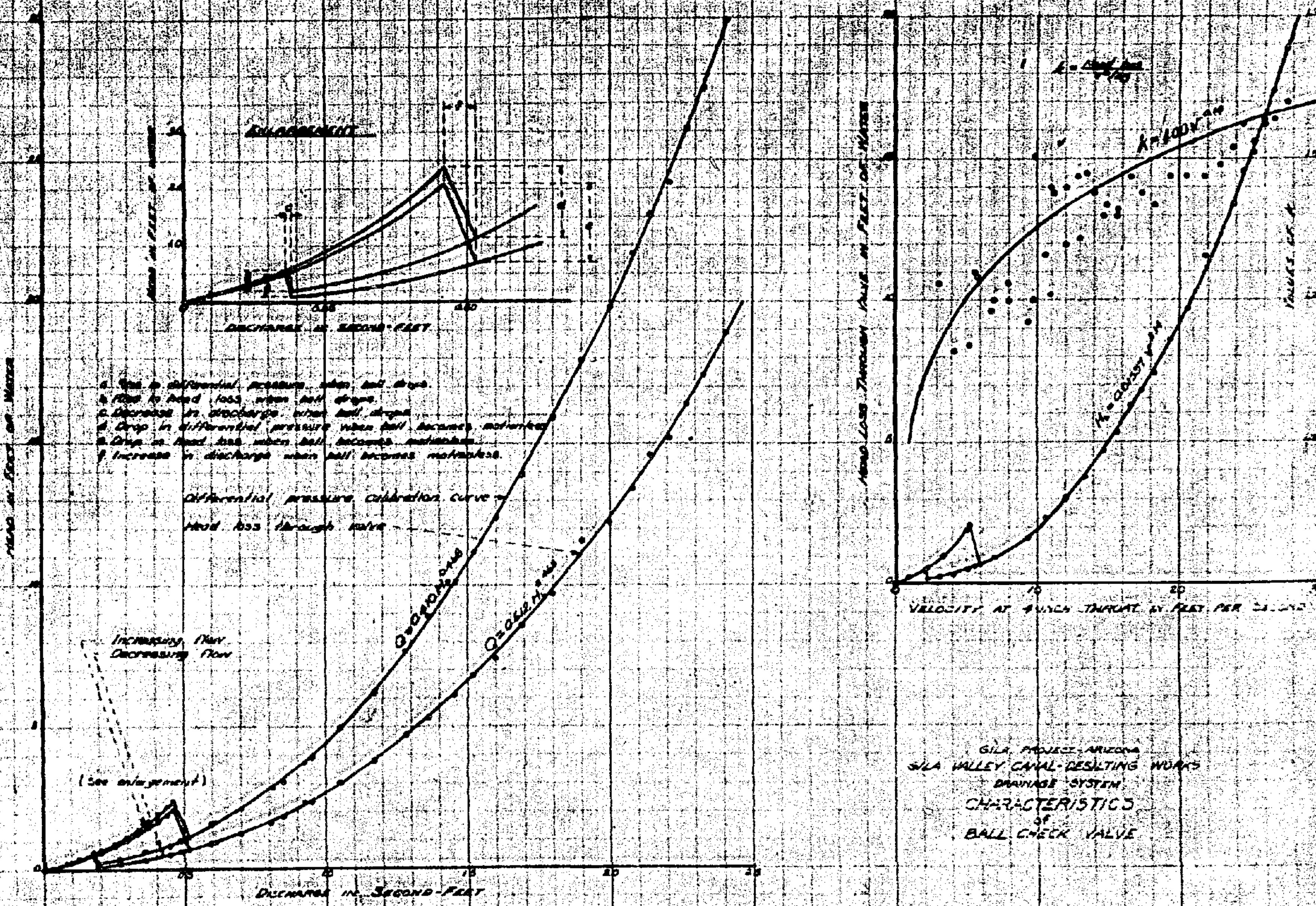
GILA PROJECT - ARIZONA

GILA VALLEY CANAL - DESILTING WORKS
BASIN 3 - DIVERSION WORKS
DRAINAGE SYSTEM
BALL CHECK VALVE

DRAWN V.F.W. SUBMITTED [illegible]
TRACED N.P.C. RECOMMENDED [illegible]
CHECKED [illegible] APPROVED [illegible]

DENVER, COLORADO, JUNE [illegible] 50-D-6[illegible]



GILA PROJECT-ARIZONA
GILA VALLEY CANAL-DESILTING WORKS
DRAINAGE SYSTEM
CHARACTERISTICS
OF
BALL CHECK VALVE

FIGURE 19

B, but, for dependability for field measuring purposes, location B is recommended. Manometer readings were practically the same when any one or all of the piezometers were connected. Piezometer openings at B and C were located on a line midway between adjacent ball guides and in a plane through the longitudinal axis of the valve. It is important that piezometer openings in the field installation be located in the same relative position to the guide vanes so that the laboratory-developed calibration can be used without question.

The increased resistance to flow when the ball is in motion is clearly shown by the lower portion of the curves of figure 19. As the flow increases, the ball is in motion up to a discharge of 0.46 second-foot and a loss of head of 2.05 feet, at which point the ball is held motionless against the guide vanes, with an accompanying decrease in head loss and corresponding increase in discharge. The head loss plotted against discharge then follows a smooth curve whose equation is

$$Q = 0.612\, H_L^{0.458} \qquad (1)$$

where Q is the discharge through the valve and H_L is the head loss between A and D. As the flow decreases from the maximum, the discharge-head loss relationship is the same for increasing flow and is given by equation (1) until a discharge of 0.19 second-foot and a head loss of 0.10 foot are reached, at which point the ball drops from its stationary position and assumes a very slow motion. The head loss immediately increases to that value found with the ball in motion during increasing discharge. During increasing flow, the ball remains in motion over a greater range of discharge than during decreasing flow because a greater difference in pressure between the top and bottom of the ball is required to stop its motion than is required to start it again.

The characteristics of the rating curve are the same as for the head-loss curve. The equation for discharge in terms of the measured differential pressure between B and C is

$$Q = 0.410 H_D^{0.468} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where Q is the discharge and H_D is the measured pressure difference between B and C. The use of this curve will be explained in detail in section 11.

The curve for velocity at the 4-inch throat against head loss necessarily has the same characteristics as the discharge-head loss curve. The equation for head loss in terms of throat velocity is

$$H_L = 0.01557 V^{2.14} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Note that the exponent of the velocity is higher than the usual value of 2.00.

The head loss through the valve is greater than the theoretical velocity head, $V^2/2g$. Expressing the head loss in terms of theoretical velocity head,

$$H_L = K (V^2/2g) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Substituting (3) in (4),

$$K = 1.00 V^{0.14} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The plotted points are somewhat scattered but they follow equation (5) fairly well. For a discharge of 2.00 second-feet, the value of K is 1.60.

11. <u>Operation of Valve</u>. The necessary theoretical head required to lift the ball and start operation is computed as follows: Diameter = $6\frac{1}{2}$ inches, volume = 143.8 cubic inches; weight of ball under water = 1.30 pounds; required unit pressure to lift the ball = 0.0662 pounds per square inch, and the corresponding head of water = 1.835 inches.

Careful tests showed that the ball lifted from the seat and flow started when the head was slightly under 2 inches. After standing under a 60-foot head for a week, the seal was broken by a back pressure of approximately 2 inches. There is a little leakage up to an 8-inch head.

Special emphasis should be given to the rate of lowering the water surface in the settling basin. If the water surface is lowered so rapidly that the ground water exerts more pressure on the walls and floor than that for which they are designed, serious damage may result. In the field operation, therefore, the operator should acquaint himself with the operating program and lower the water surface accordingly. In the Gila check-valve installation, provision has been made for careful control of the pressures. Piezometer connections which communicate the manometer gages have been installed. The primary purpose of these gages is to insure that the allowable pressure difference between the back and the face of the walls and floor is not exceeded. This is accomplished by measuring the differential pressure between piezometers at B and C and consulting the differential pressure rating curve constructed from laboratory tests (equation 2). From this curve, the discharge is obtained, and, from computations of losses, the total head (or difference between water levels inside and outside the basin) necessary to produce this discharge is obtained. Thus, the total head is the friction loss in the piping plus the loss through the valve plus the loss through the elbows, tees, and strainer plus the velocity head. These losses may all be expressed in terms of the velocity head corresponding to the velocity in the 12-inch pipe. It is then found that the total allowable head (difference) between water levels inside and outside the walls is

$$H_A = f\frac{V^2}{2g} + k\frac{V^2}{2g} + b\frac{V^2}{2g} + \frac{V^2}{2g} \quad \text{.................(6)}$$

where

f = coefficient of velocity head expressing friction loss.

b = sum of bends, tees, etc., coefficient plus strainer less coefficient.

k = coefficient of check-valve loss.

V = velocity at the 12-inch section of the valve.

$$H_A = (f + k + b + 1)\frac{V^2}{2g} \quad \text{......................(7)}$$

By evaluating f and b and assigning to H_A the maximum allowable value of pressure on the walls, equation (7) may be solved for V. From the equation, $Q = AV$, and, using the value of the area at the 12-inch pipe for A, the maximum allowable discharge, Q, through the pipe is found. Assuming that the flow through each valve is half that through the 12-inch pipe, then the corresponding maximum value of differential pressure as found from piezometers at B and C is found from the curve on figure 19. The rate of lowering the water surface in the settling basin is thus defined by this maximum allowable difference between piezometers at B and C

The walls of the settling basin were designed for a pressure of 1.15 feet of water at the top and 2.6 feet at the bottom, and the wall thickness varies uniformly from top to bottom. Computations indicate that the check valves of line I will operate with the balls in motion (on the higher loss curve of figure 19) until the total head causing flow becomes 2.3 feet of water. At the heads above 2.3 feet, the valves will operate with the balls motionless, and the loss through the valves will be appreciably smaller. Because drain line I is longer and has as many or more fittings than the other two lines, the loss through it will be the greatest, and, consequently, the flow and the maximum allowable differential pressure as indicated by piezometers B and C will be the lowest. Obviously, then, values of differential pressure found for line I will control the rate of lowering the water surface in the basin. A summary of computed values for line I follows.

Summary for Line I

Allowable head on walls or floor, feet water	Computed valve discharge, second-feet	Allowable differential pressure, piezometers B and C, feet water	Remarks
1.15	0.30	1.18	Within range where ball of check valve is in motion
2.30	0.46	2.40	
2.30	0.78	2.73	Within range where ball of check valve is motionless
2.60	0.83	3.07	

It must be kept in mind that the values of "allowable differential pressure" as measured at the valve between piezometers B and C (taken from the curves of figure 19) are based on computed values of discharge through the valves. Should the actual values of losses be greater than those assumed for computation purposes, then the computed values of discharge and the corresponding allowable differential pressures are too high. For complete safety of operation, either field measurements of the losses in line I should be made, or provisions made for measuring the head, due to ground water, on the walls and floor in the area drained by line I.