UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

AIR AND HYDRAULIC MODEL STUDIES OF THE EFFECT OF MOVING THE SLOTS UPSTREAM IN A SLIDE GATE, AND OF REDUCING THE SLOT SIZE NEAR THE FLOOR

Hydraulic Laboratory Report No. Hyd.-432

DIVISION OF ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
DENVER, COLORADO

June 21, 1957

CONTENTS

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
Date

Laboratory Report No. Hyd-432
Compiled by: W. P. Simmons, Jr.
Checked by: W. E. Wagner
Reviewed by: J. W. Ball
Submitted by: H. M. Martin

Subject: Air and hydraulic model studies of the effect of moving the slots upstream in a slide gate, and of reducing the slot size near the floor.

PURPOSE

The purpose of the studies was to determine if relocating or narrowing the gate slots would permit a slide gate to be operated at any opening at high heads under free discharge or back pressure conditions without cavitation damage.

CONCLUSIONS

Gate Slots Moved Upstream from Downstream Face of Leaf

1. The low pressures that occurred immediately downstream of the slot close to the floor in the present Palisades-type gate during submerged operation with small openings and small back pressures were eliminated when the slots were moved upstream relative to the gate leaf. The pressure conditions improved as the slots, which were narrower than the leaf, were moved progressively farther upstream.

2. No severe negative pressures were indicated by the air model at gate openings of 2, 3, 4, and 5 percent when the slots were moved 12 inches (prototype) upstream. Similar results were obtained for gate openings of 1 through 10 percent on the hydraulic model. The air model tests represented submerged operating conditions, and the hydraulic tests represented free discharge conditions.

3. The free discharge flow with the slots moved upstream was smoother, quieter, and occurred with less spray than the flow from the present gate.

4. Most of the relatively small disturbances present in the discharge leaving the modified gate were caused by water flowing downward in the clearance spaces between the leaf sides and the gate body and escaping beneath the seals near the downstream face of the leaf. The disturbances decreased greatly when the clearance spaces were eliminated.

5. The prototype clearances can be reduced to small values by bosses or ridges that are raised relative to the general surfaces and are properly machined.

6. The appreciable hydraulic advantages of moving the gate slots upstream were partially offset by the need for a flexible seal along the sides and across the upper edge of the downstream face of the leaf. Efforts should be made to develop the necessary seal so that it is reasonable in cost and dependable in service.

Gate Slots Made Narrow Near Floor

1. When the portions of the slots near the floor of the present gate were narrowed from 6.75 inches to 1 and 2.875 inches, a region of low pressure occurred on each wall of the model 0.10 inch downstream from the slots and 0.10 inch above the floor at a 3 percent gate opening. The pressures at all other points at the 3 percent opening, and at all other openings from 0 to 10 percent, were satisfactory. No tests were made at openings greater than 10 percent because previous data indicated no trouble at these larger openings.

2. The flow conditions of the discharging water were not as good as the conditions with the slots moved upstream. The disturbances at the side walls were more pronounced and there was much more spray and noise.

3. The flow conditions at gate openings from 1 through 5 percent were somewhat better than the conditions with the slot at the downstream face of the leaf, and not as good at openings from 6 through 10 percent.

Gate Slots at Downstream Face of Leaf (downstream slots)

1. When the downstream slot (present design) was used under free flow conditions, no appreciably low pressures were found at any gate opening.

2. There were more disturbances and more spray at openings of 1 through 5 percent with the downstream slot than with the narrowed slots, or than with the slots moved upstream. At openings of 6 through 10 percent, the disturbances and spray with the downstream slots were less than with the narrowed ones and more than with the slots moved upstream.

3. Some of the spray at the walls tended to fill the space between the flat surface on the leaf bottom and the surface of the contracting jet beneath the leaf, thereby causing somewhat low model pressures. No seriously low pressures are expected in these areas in the prototype gate because air will find its way through the spray to relieve the low pressures.

4. The absence of any appreciable negative pressures at openings of 1 through 10 percent with free discharge conditions, and the better flow conditions at openings of 6 percent or more, made the present downstream slot a better design than either of the 2 narrowed slots.

RECOMMENDATIONS

1. Continue using the downstream slot design pending further developments. In cases where a gate regulates under high heads and small back pressures, avoid operation at openings between 0 and 5 percent.

2. Conduct studies to develop the necessary seal for the best design where the slot is moved upstream relative to the control point on the leaf.

ACKNOWLEDGEMENT

The development and testing program discussed in this report reflects the cooperative efforts of members of the Canals Branch, the Mechanical Branch, and the Hydraulic Laboratory Branch of the Commissioner's Office in Denver.

INTRODUCTION

The regulating slide gate developed for free discharge conditions and high heads, 1/ performs very well under these conditions. Recently, the use of the gate was extended to two tunnel installations where the gates will be subjected to various degrees of back pressures. Model tests showed that for most back pressure conditions, the gate performance was good. 2/ However, at gate openings between 0 and 5 percent, and with submergences or back pressures sufficient to prevent aeration at the gate, but insufficient to produce appreciable back pressure, serious negative pressures occurred on the gate body just downstream of the slots near the floor.

It was desirable that the general slide gate design be such that the gate can be used in any installation, at any opening, with either free discharge or under back pressure conditions. In an effort to achieve this design, proposals were made for altering the gates. One proposal was to use short followers on the leaf so that at the small gate openings the slots would be filled and would not create flow disturbances. A second proposal was to move the slots away from the control point in the gate by placing the slots an appreciable distance upstream from the downstream face of the leaf. A third proposal was to taper the present slots so that they were smaller near the bottom of the gate, and hence less likely to produce large flow disturbances.

At the time it was considered impracticable to use followers on the leaf, and no tests were made on this proposal. But extensive tests were made to determine the effect of moving the gate slots upstream, and

---

1/Hyd-387 "Hydraulic Model Studies of the 7 foot 6 inch by 9 foot 0 inch Palisades Regulating Slide Gate."

2/Hyd-429 "Hydraulic Model Studies of the Control Structure for Tooma-Tumut and Tooma-Eucumbene Tunnels, Australia."

of tapering the present slots to reduce their effect upon the flow. Relatively large-scale air and water models were used in these tests. A discussion of these models and the test results obtained is presented in this report.

THE MODELS

Air Model

Preliminary studies of the effect of moving the gate slots upstream relative to the gate leaf were conducted on a 1:4 scale, sectional model using air as the flow medium (Figure 1). The test section of the model included a 48-inch long wooden tunnel 7 inches wide and 6 inches deep. A gate slot 2 inches deep and 1.75 inches wide was located in the right sidewall 18 inches downstream from the model inlet. The downstream slot corner was offset outward 0.13 inch from the line of the upstream wall, and the passage width was returned gradually to 7 inches by a 13.25-inch long section of converging wall. The gate leaf was made of wood and was fastened with screws to the transparent cover of the model.

Gate openings of 2, 3, 4, and 5 percent were represented in that order by cutting off the top of the leaf. At each opening the gate leaf was placed in three positions relative to the slot. The first position represented the design with the downstream face of the slot flush with the downstream face of the leaf (present design). The other two positions represented modified designs with the slot moved 1 and 3 inches upstream from the downstream face of the leaf (4 and 12 inches prototype). In the two modified designs a wooden seal strip was fastened to the downstream face of the leaf to close the gap between the leaf and the sides of the body. A seal in these areas was necessary because in the present gate design, the seal occurs between the surfaces of the slots and the surface of the leaf guide at the downstream face of the leaf. In the modified design, the leaf guides are well ahead of the downstream face, and do not extend to the control point at the leaf bottom.

Piezometers in the walls of the air model that had been built for other slot studies were not ideally located for the present tests, but no additions or changes were made because the locations were adequate for preliminary tests. The pressures were measured with water-filled "U" tubes and the values were read in tenths of an inch and were estimated to hundredths of an inch.

Air was supplied to the test section by a 20 hp centrifugal blower which discharged into a 10-inch-diameter pipe followed by a 36-inch long transition that connected to the test section. The air discharged freely from the test section into the atmosphere. The rate of air flow was determined with thin, flat plate orifices placed on the entrance of the 12-inch-diameter inlet line, and a piezometer ring 5 inches downstream of the orifices. The velocity distribution 6 inches downstream from the inlet to the test section, without the gate leaf installed, is shown in Figure 2.

Hydraulic Model

Detailed tests under high heads and free discharge flow conditions were made on a 1:5 scale sectional hydraulic model accurately constructed of 1/2-inch thick brass plate (Figure 3). In a strict sense, this equipment was not a model of any actual structure, but was built to those dimensions which would allow the largest reasonable gate slot and gate leaf sections compatible with the pump capacities, and without interference of one side wall with the other. The model was made 10 inches high to insure a good contraction under the leaf at the maximum desired test opening of 10% (2.16 inches). The passage was made 8 inches wide to insure that the wall effect at one side could not reach and alter the conditions on the other side. The test section was 23 and 1/2 inches long. A gate slot was placed in each side wall of the model, and a 5.40-inch thick gate leaf was used during all tests. Adjustable, rubber-faced seal bars were installed in the leaf sides near the downstream face to represent the hydraulically-operated, expanding seal proposed for the prototype structure. The gate leaf opening was adjustable in 1 percent increments from 1 percent through 10 percent by shims that were placed between the leaf and the model top. The leaf and shims were held solidly in place by two 5/8-inch bolts that extended from the leaf up through the model top. Leakage between the edges of the shims and the model side walls was prevented by wooden wedges that were driven into place after the leaf was secured.

Piezometers 1/16 inch in diameter were provided in strategic locations in the gate leaf, the right-hand gate slot, the right-hand conduit wall, and on the floor (Figure 4). The pressures acting at the piezometers were measured by single leg water manometers, or by a mercury gage when the heads exceeded the 6-foot height of the manometer tubes. For convenience, all the leads from piezometers which required the use of the mercury gage were connected to a common manifold. Needle valves on each connection to the manifold assured complete closure of all the lines. The pressure in an individual line could be measured by opening only the valve in that line. A single line connected the manifold to the mercury gage, and the gage was provided with a bleed line so that all air could be flushed from the system.

Water was supplied to the model through the central laboratory supply system (Figure 5). An uninterrupted 42 and 1/2-foot run of 12-inch-diameter pipe led to a 15-inch long transition and to the gate assembly. The head acting on the model was obtained at the reference station located in the 12-inch-diameter supply line 12 inches upstream from this transition. Two 12-inch-diameter centrifugal pumps, connected in series by piping and valves provided in the central laboratory supply system, furnished water in sufficient quantity and pressure so that a total head of 120 feet of water could be maintained on the model at all gate openings. The rate of flow was measured by calibrated venturi meters. The high velocity water discharged freely from the model and was intercepted and turned down into the laboratory reservoir by a heavily constructed and well anchored deflector located about 2 feet from the gate.

INVESTIGATION

Gate Slots Moved 12 Inches Prototype Upstream from Back of Leaf - Air Model

Pressure measurements were made in the air model with the downstream face of the leaf in contact with the downstream surface of the slot, as in the present gate design, and with the model leaf moved 1 and 3 inches downstream. Openings of 2, 3, 4, and 5 percent were represented, and readings were also taken with the gate leaf removed. The air from the model was discharged into the atmosphere and therefor represented submerged discharge conditions, or flow with back pressure.

Relatively low pressures occurred 1 inch downstream from the model gate slot at all gate openings tested when the downstream leaf face was in contact with the downstream surface of the slot (Figure 6). This paralleled the pressure distribution previously found in a 1:19 scale model of the gate when it was operated at small back pressures and an opening of 3 percent (Figure 7). Closer agreement of the data from the 2 models would not be expected because the piezometers were not in the same position relative to the floor. The region of low pressure was followed by a gradually increasing pressure. Upstream from the slot the pressure was high, and then dropped rapidly at the slot.

The pressures 1 inch downstream from the slot increased when the gate slot was moved upstream relative to the leaf. Actually, in the model, the leaf was moved downstream because the slot was a fixed part of the side wall, but the effect was similar to moving the slot upstream. The pressures just upstream from the slot also increased, particularly when the slot was moved upstream 3 inches (12 inches prototype) Figure 6. These results were directly in line with the pressure improvement being sought, and it was decided that the design with the slots moved 12 inches upstream should be further studied by free discharge tests conducted on a hydraulic model at relatively high head.

Gate Slots Moved 12 Inches Prototype Upstream from Back of Leaf - Hydraulic Model

The first hydraulic tests with the slots moved 12 inches prototype upstream were made with a prototype clearance of 3/8 inch (0.075-inch model) between the sides of the leaf and the gate body. Most of the runs were made at a total head of 120 feet with free discharge conditions downstream of the gate.

The pressure conditions were excellent at all gate openings from 1 through 10 percent (Figure 8A). The pressures on the sloping portion of the leaf and on the leaf sides in the clearance spaces were strongly positive. The pressures on the horizontal section of the leaf bottom were approximately atmospheric. It is interesting to note that even at the 1 percent opening, where the ratio of opening to the length of the flat surface on the leaf bottom was $\frac{0.216}{0.450} = 0.47$, the flow jumped free of the flat bottom on

the leaf so that aeration occurred, and no "short tube" action took place. The pressures in and near the gate slot 4 and 8 inches prototype above the floor were strongly positive. The pressures 0.8 inches prototype above the floor and directly beneath the slot were strongly positive, and decreased as the gate opening increased. At the 10 percent opening, the pressures were still about 50 percent of the total head on the gate. The wall and floor pressures at and downstream from the leaf were strongly positive near the leaf and decreased to about atmospheric pressure farther downstream (Figure 8A). No appreciable negative pressures were found at any point.

The relative position of the gate leaf to the bottom of the slot at the different gate openings is shown in Figure 9.

The flow conditions at openings from 5 to 10 percent were good, and there was relatively little disturbance at the walls (Figure 10). At openings from 1 through 4 percent there was appreciable disturbance at the side walls, and the disturbance was believed due to high pressure water that flowed downward between the leaf and the body and then escaped beneath the leaf seal. These high velocity streams tended to deflect the portions of the main flow near the walls inward toward the center of the passage. The disturbance was most noticeable at small openings where the pressures in the clearance spaces were highest and the quantity of flow beneath the leaf smallest.

Tests that were made with no clearance between the leaf and the body showed much less disturbance. In these tests the clearance spaces were filled by attaching plates of the proper thickness to each side of the leaf (Figure 11A). The flow characteristics were much better and the pressure conditions in the slot, on the side walls, and on the floor remained practically unchanged and therefor satisfactory (Figure 8B).

It is, of course, impracticable to build a large gate without some clearance between the leaf and the gate body. This is particularly true in the case of the Palisades-type gate because the leaf is made as a steel casting. The minimum practicable clearance for the major portion of the gate was therefore believed to be 3/8 of an inch. It seemed reasonable, however, that certain areas on the sides of the gate leaf could be raised relative to the general surface, and that these ridges or bosses could be machined to attain a minimum clearance of 1/8 inch on each side. The effectiveness of such control sections was investigated by placing appropriate strips of metal on the side of the model leaf. Two designs were used. In the first a strip 1/4-inch wide by 0.050-inch thick was placed on the curved section and along the 45° sloping section on one side of the model leaf to reduce the clearance to represent 1/8 inch (Figure 11B). In the second design a plate 0.050-inch thick, that extended from the leaf guide to the seal bar, was placed on the lower portion of the leaf (Figure 11C). With both designs, the flow conditions near the walls were better than with full side clearance, and not as good as without clearance. The plate produced slightly better conditions than the strip design (Figure 11).

The air and hydraulic model tests showed that the proposed design with the slot moved 12 inches prototype upstream from the downstream

face of the leaf would be free of areas of low pressure at all gate openings of 10 percent or less for free flow or back pressure conditions and high heads. It was reasonable to expect equally satisfactory pressure at larger gate openings. Thus, from the hydraulic point of view, the design was excellent. But, from the construction point of view, the design introduced a seal problem. To be effective, a retracting-type seal must be carried up the right and left sides of the leaf, around the top corners, and across the top on the downstream face to simultaneously seal against the gate body and the inside face of the bonnet. At the points where the seals pass from the leaf sides to the downstream face there are unusual problems of design and construction. At the present time there is no precedent to assist in the preparation of such a design, but it seems that a satisfactory design could ~~not~~ be developed. And, it appears that the hydraulic merits of the gate justify the time and effort that might be required to made the gate seal practical.

In the meantime, hydraulic model studies were continued to determine the effect upon the pressures and flow conditions within the gate when the present gate was modified by narrowing the slots near the floor.

Gate Slots Made Narrow Near Floor

It seemed reasonable that if the slots in the present gate, which are the same width and depth for their full height, caused appreciable flow disturbances at small gate openings, smaller slots near the floor would cause less disturbance. These smaller slots could be obtained rather simply and inexpensively in the prototype gate by placing filler blocks within the standard slots and by making appropriate reductions in the size of the gate leaf guides near the leaf bottom (Figure 12). At first a straight taper starting at a point well above the floor was suggested. But such a taper on the slots and on the gate guides would produce a wide passage between the guides and the slots as soon as the gate leaf moved open from the closed position, and high pressure water would flow downward through this passage. This downflow was undesirable. An alternate design was proposed that abruptly narrowed and reduced the depth of the slots about 1 foot above the floor, and provided a constant width and constant depth slot on down to the floor. In this design it was expected that the straight-sided guide on the leaf would act as a plug as soon as the guide entered the narrow portion of the gate slot. Thus there would be little tendency for high pressure flow to travel down the slot and disrupt the flow at the side walls.

To evaluate this proposed design, the hydraulic model was revised by moving the slot and leaf guide on one side of the gate to the downstream face of the leaf (Figure 13). The downstream corner of the model slot was set out 0.10 inch from the line of the upstream wall, and was followed by a 50:1 converging wall that returned the passage to the width upstream of the slot. Prototype clearances of 3/8 inch were represented between the main body of the leaf and the walls.

Gate Slot 1 Inch Wide at Floor

The first tests were made with the slot width reduced to 1 inch prototype, and with 1/4 inch clearance represented between the gate leaf guide and the slot. In general, the floor and wall pressures were highest close to the gate, and decreased as the flow moved downstream. The floor pressures were higher toward the center of the passage than near the wall. All the pressures measured on the walls and floor downstream from the slot were positive or only slightly negative, at all gate openings except 3 percent.

At the 3 percent opening the model pressure at the piezometer 0.10 inch downstream of the slot and 0.10 inch above the floor became negative to the extent of 12.6 feet of water (Figure 14A). This low pressure was inconsistent with the trend of other nearby pressures and the piezometer was examined to see if it was damaged. It proved to be in excellent condition and the presence of the negative pressure at the 3 percent opening was confirmed by a check run.

No flow occurred along the floor or along the wall near the passage corner at the 1 percent opening. Instead, the water separated from the side wall at the downstream corner of the slot and moved toward the center of the passage while rising in a pronounced fin (Figure 15A). This fin was much heavier and rose higher than the fin produced with the slot moved 12 inches upstream and with 3/8-inch clearance between the leaf and the body (Figure 10A). Much spray was present. At a 2 percent opening the fin was a little less pronounced and a thin sheet of water moved along the wall (Figure 15B). As the gate was opened farther, the main stream first tended to follow the wall, and then to clumb it, while the fin subsided and became a hump in the jet surface. This hump was topped by considerable spray, which fanned inwardly across the passage. Some of the spray moved almost laterally across the passage and along the leaf face, and tended to fill the space between the leaf bottom and the contracting jet. At the 10 percent opening, a sheet of water with considerable spray climbed the downstream wall at about a 30° angle.

In general, the pressure conditions with the slots narrow to 1 inch were satisfactory at all but the 3 percent opening, and the flow conditions were not as good as anticipated because of large fins and spray. No unusual noises or crackling sounds were detected, but the operation was more noisy than with the slots moved upstream.

Gate Slot 2.875 Inches Wide at Floor

In an attempt to get better flow, the width of the leaf guide near the bottom of the gate was increased to 2.75 inches to correspond to the distance from the start of the horizontal surface of the leaf bottom to the downstream face of the leaf (Detail A, Figure 13). This placed the upstream corner of the slot in the same vertical plane with the control point on the leaf. The slot width in the filler block was increased to accommodate this thicker gate guide with the minimum practicable clearance of 1/8 inch.

The pressures on the floor and wall were about the same as with the 1-inch slot except that the pressure 0.10 inch downstream of the slot and 0.10 inch above the floor was even more strongly negative (Figure 14B). The flow was similar to the flow obtained with the 1-inch slot, and at a 1 percent opening the water was deflected well away from the side wall (Figure 16A). At the 2 percent opening the fin was strong, nearly vertical, and 1 and 3/4 inches from the side wall at the end of the model. A thin sheet of water flowed between this fin and the corner, and rose about an inch on the wall. At the 3 percent opening the fin was in about the same position but less pronounced. Strong flow with a depth about 1/2 that in the main stream occurred between the fin and the wall, and a thin sheet of water climbed on the wall. At progressively larger openings the fin became less prominent and moved closer to the wall, while the sheet of water climbed higher and higher on the wall. The spray was about the same as observed with the 1-inch slot.

It appeared that only slight flow improvement had been achieved by increasing the slot width to 2.875 inches, and that a more dangerous negative pressure condition had been produced. No unusual noises were detected above the steady sound of the flowing water, and the noise level was the same as observed with the 1-inch slot.

Present Gate Slot

The performance of the present slot was demonstrated by removing the filler block from the narrowed slot and by placing the present design leaf guide on the leaf (Figure 13). A prototype clearance of 1/8 inch was represented in the slot and the prototype slot width was 6.75 inches. The two piezometers in the gate leaf bottom 0.60 inch from the side were read during these runs.

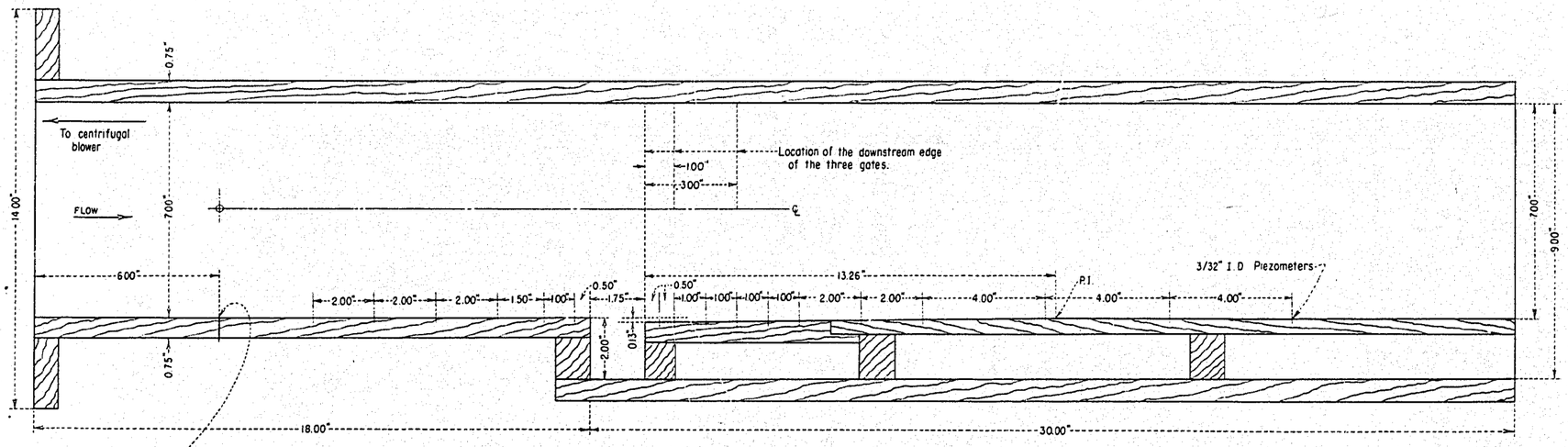
No negative pressures lower than 1 foot of water (model) were found on the floor or side wall at any opening from 1 through 8 percent (Figure 14C). At the 10 percent opening negative pressures of 1.19 and 1.45 feet of water were found on the sides just beyond the line of intersection of the converging and the parallel wall sections of the body. Somewhat lower pressures can always be expected in this region, but they may be controlled by using gradual rates of convergence downstream of the gate slots and by generously rounding the corner along the line of intersection. Slightly low pressures occurred at the piezometers on the horizontal portion of the leaf bottom near the wall where the spray swept across the surface. It is doubtful that seriously low negative pressures can exist in the full-size gate at this location because air will find its way through the spray and relieve the low pressures.

The flow pattern was similar to the patterns produced by the 1- and 2.875-inch slots except that there was more tendency for the flow to be deflected away from the walls (Figure 17). At 1 and 2 percent openings there was no flow on the wall nor on the floor between the fin and the wall. At a 3 percent opening a thin sheet of water spread on the floor from the fin to the side wall, and at a 4 percent opening the water rose slightly on the wall. The jet of water passing beneath the leaf was deflected inwardly

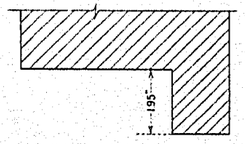
enough so that a small clear, aerated space about 1/8 inch wide occured at the downstream slot corner and extended from the water surface to the floor. This separation zone was present at larger openings but became progressively narrower. The flow at the wall changed considerably when the gate opening was increased from the 5% position to the 6% position. The quantity of spray decreased and the fin became less pronounced and moved closer to the wall. The separation zone was still present at the slot corner but no longer extended to the floor. At the 10 percent opening the separation zone extended about 1 inch below the water surface. Below this the flow was in full contact with the wall. No fin was present over the stream of water near the leaf at the 10 percent opening, and the water depth was essentially constant across the passage and up to the wall. Farther downstream the water rose on the wall in a thin sheet that was 5 and 1/2 inches high at the end of the model. Considerable spray was observed near the wall and some fanned across the model passage and swept inwardly along the leaf bottom for about 2 inches. Complete aeration was present along all other portions of the leaf bottom. No unusual noises or crackling sounds were present and the noise level was the same as the level observed with the narrowed slots.

These tests showed that the attempts to improve the present regulating slide gate design by reducing the dimensions of the slot near the floor produced only slightly better flow conditions and introduced some seriously low pressures. It is therefor advisable to continue the use of the present (Palisades-type) design in lieu of either of these designs and to avoid operation at openings below 5% in installations with small submergence. Later, when an opportunity permits, it may be worthwhile to construct a gate with the slots moved upstream so that experience and confidence can be obtained in designing the type of seal required for this gate.

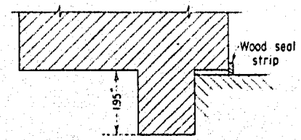
FIGURE 1
REPORT HYD. 432



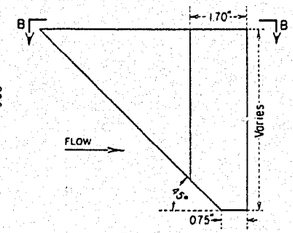
SECTION A—A



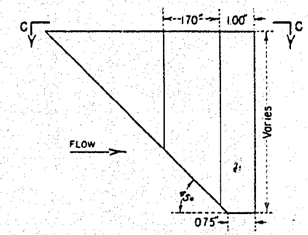
SECTION B—B



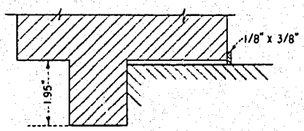
SECTION C—C



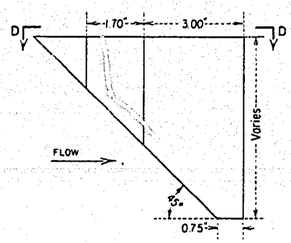
GUIDE @ REAR FACE
(Standard)



GUIDE 1.00" FROM REAR FACE

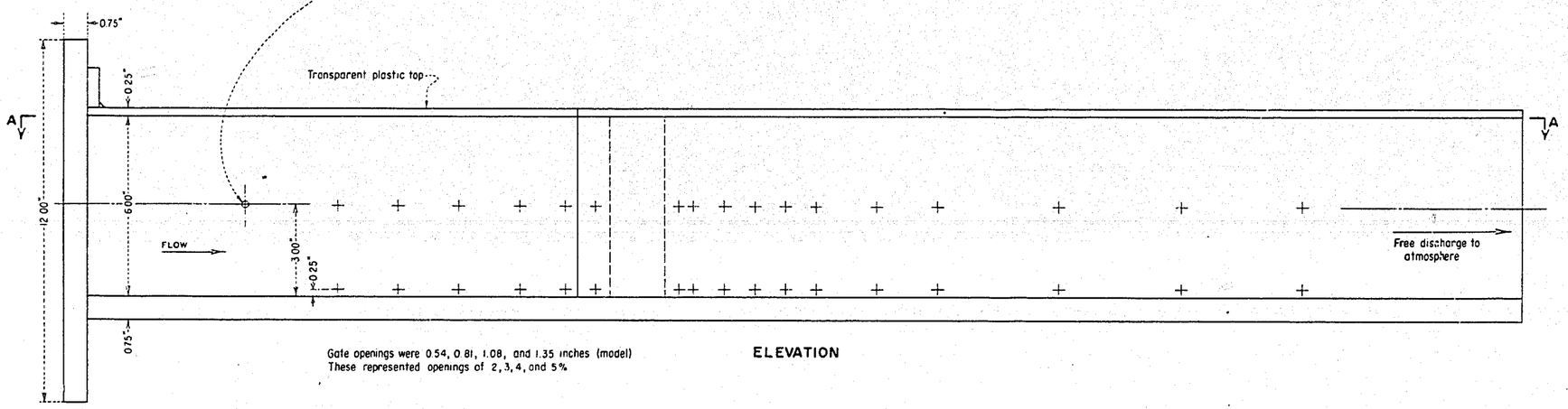


SECTION D—D



GUIDE 3.00" FROM REAR FACE

GATE LEAVES



Gate openings were 0.54, 0.81, 1.08, and 1.35 inches (model)
These represented openings of 2, 3, 4, and 5%

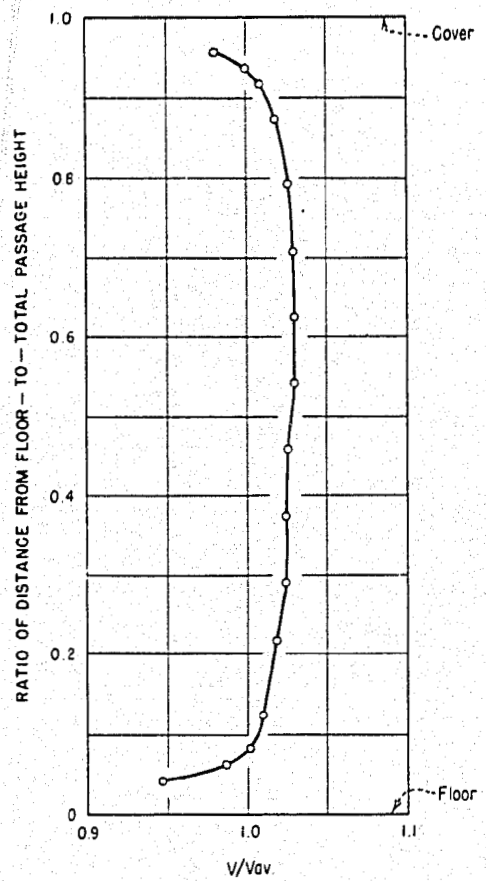
ELEVATION

GATE SLOT STUDIES

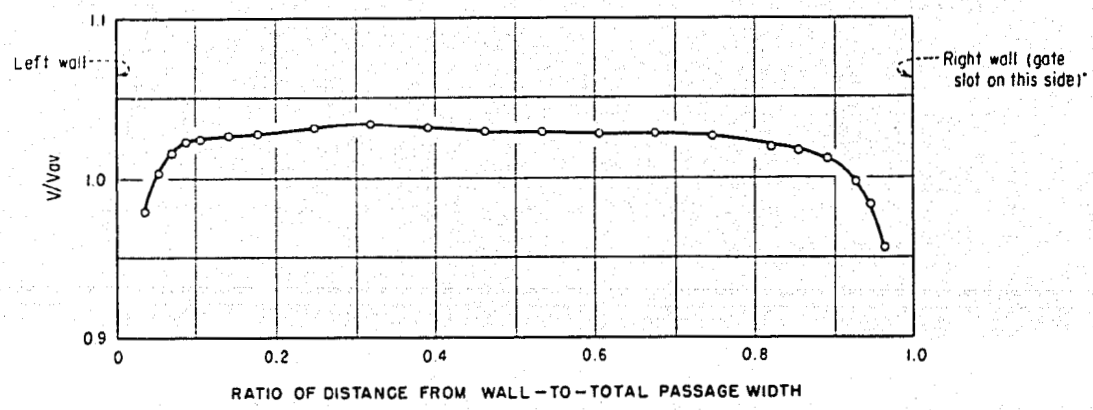
AIR MODEL TEST SECTION

1:4 SCALE SECTIONAL MODEL

557



A-VERTICAL PLANE AT CENTER OF PASSAGE



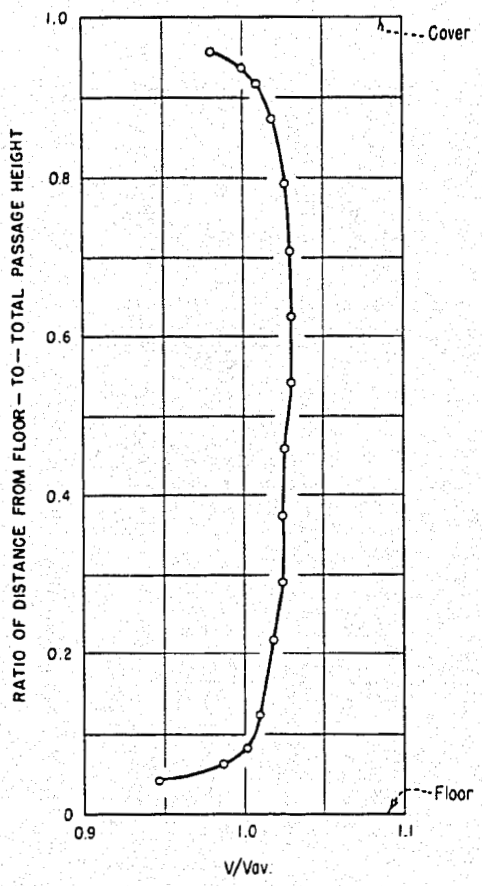
B-HORIZONTAL PLANE AT CENTER OF PASSAGE

GATE SLOT STUDIES

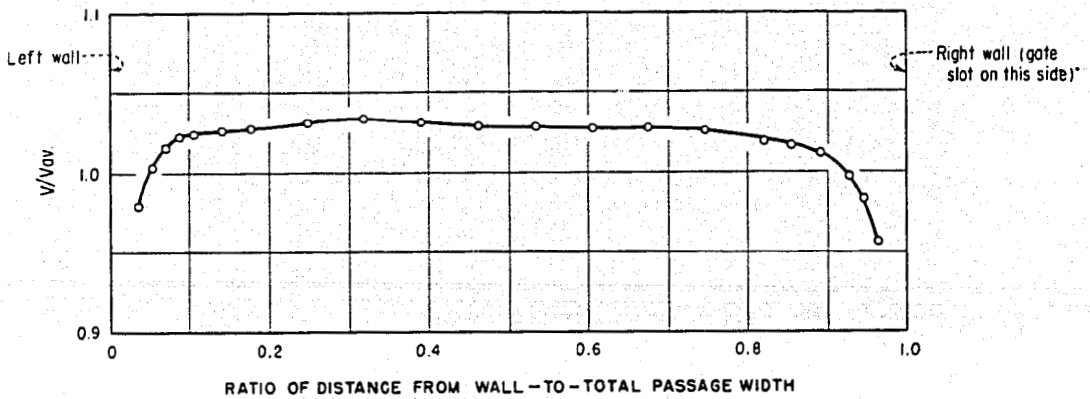
VELOCITY PROFILES OF FLOW ENTERING AIR MODEL TEST SECTION
NO GATE LEAF INSTALLED

1:4 SCALE SECTIONAL MODEL

557



A-VERTICAL PLANE AT CENTER OF PASSAGE



B-HORIZONTAL PLANE AT CENTER OF PASSAGE

GATE SLOT STUDIES

VELOCITY PROFILES OF FLOW ENTERING AIR MODEL TEST SECTION NO GATE LEAF INSTALLED

1:4 SCALE SECTIONAL MODEL

557

FIGURE 3
REPORT HYD 432

HALF PLAN-ASSEMBLY

HALF HORIZONTAL SECTION-ASSEMBLY

QUARTER ELEV.-FLANGE A

QUARTER ELEV.-FLANGE B

HALF ELEVATION FLANGE C

Note- Finish contact faces of all flanges after segment assembly.

PLAN-GATE SLOT

INTERIOR ELEVATION
GATE SLOT

HALF PLAN
GATE OPENING SHIMS

2 REQ'D.- 0.216" THICK
1 REQ'D.- 0.432" THICK *
1 REQ'D.- 1.080" THICK *

*Or equivalent multiples of the lesser thicknesses

SIDE ELEVATION

DETAIL D

DETAIL E

SECTION F-F

SECTION

SECTION

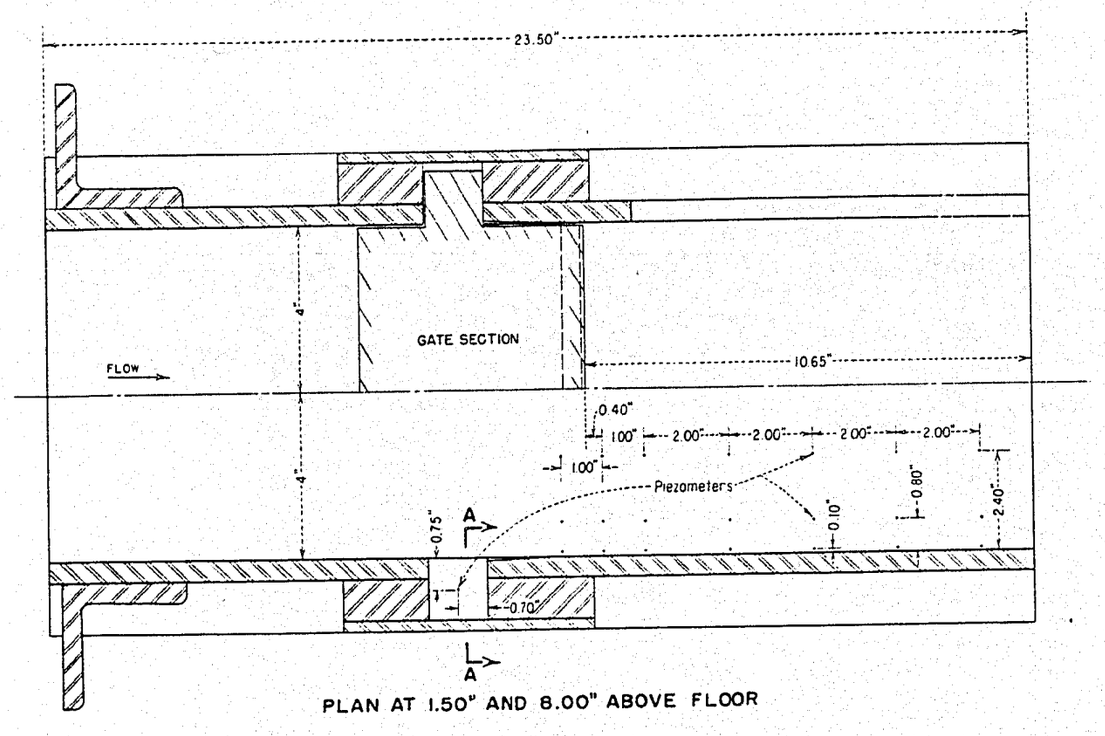
GATE DETAILS

GATE SLOT STUDIES

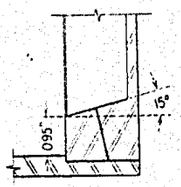
TEST ASSEMBLY - REGULATING SLIDE GATE WITH SLOTS MOVED 12" PROTOTYPE UPSTREAM FROM DOWNSTREAM FACE OF LEAF

1:5 SCALE SECTIONAL MODEL

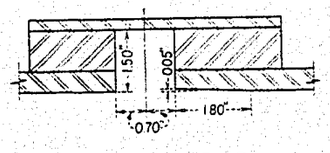
557
552



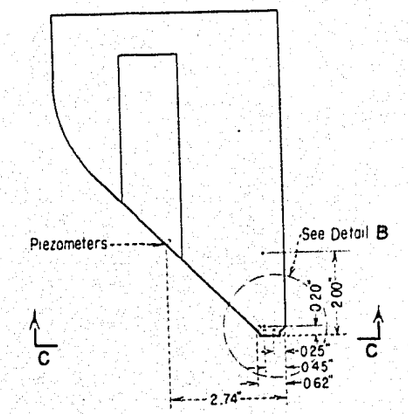
PLAN AT 1.50" AND 8.00" ABOVE FLOOR



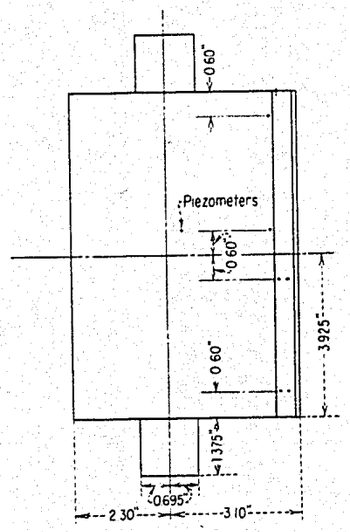
SECTION A-A



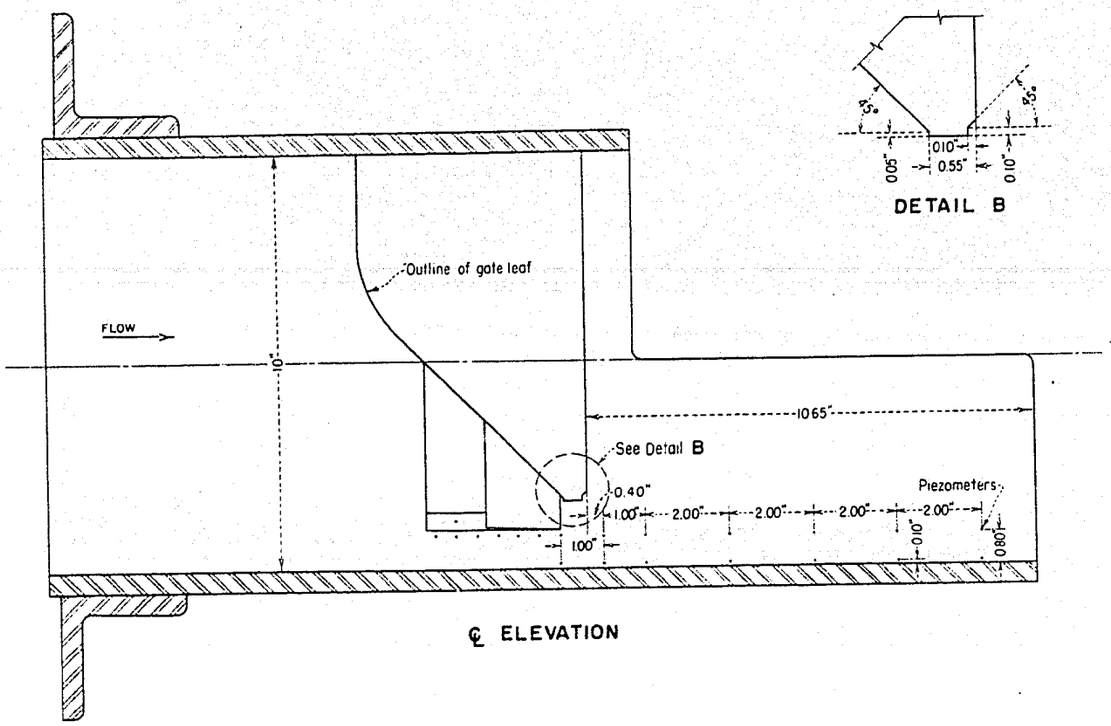
SECTION B-B



GATE LEAF ELEVATION

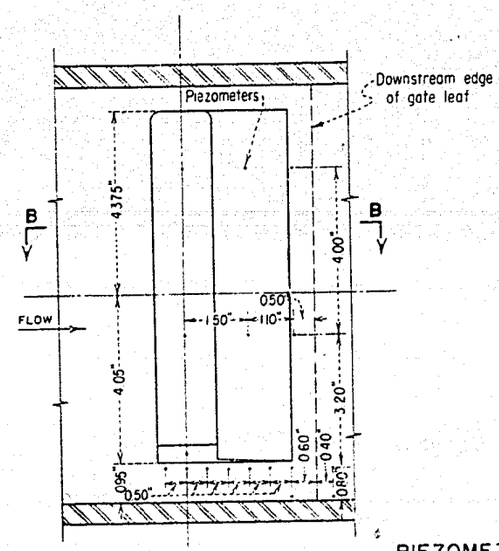


SECTION C-C



℄ ELEVATION

DETAIL B



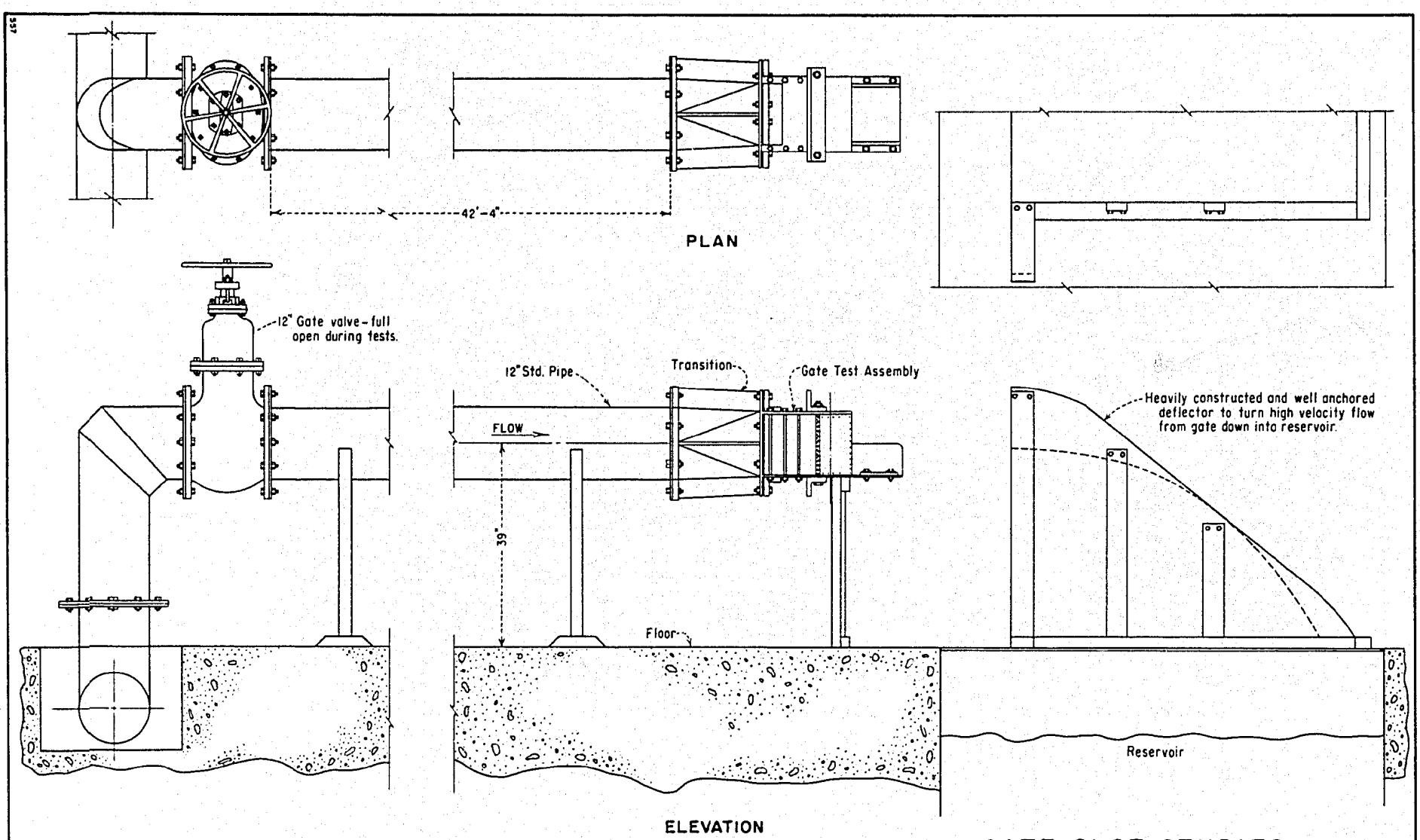
DETAIL GATE SLOT

GATE SLOT STUDIES

PIEZOMETER LOCATIONS - GATE SLOT 12" PROTOTYPE
UPSTREAM FROM DOWNSTREAM FACE OF LEAF

1:5 SCALE SECTIONAL MODEL

557



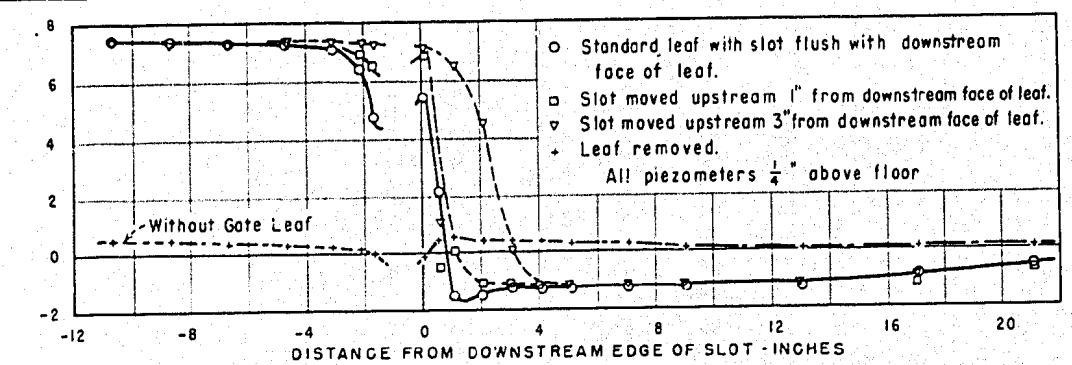
GATE SLOT STUDIES

ARRANGEMENT OF EQUIPMENT FOR HYDRAULIC TEST

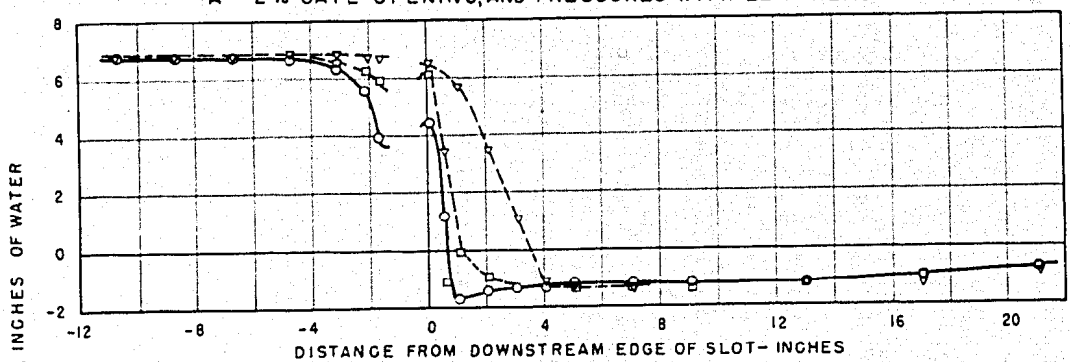
1:5 SCALE SECTIONAL MODEL

FIGURE 5
REPORT HYD. 432

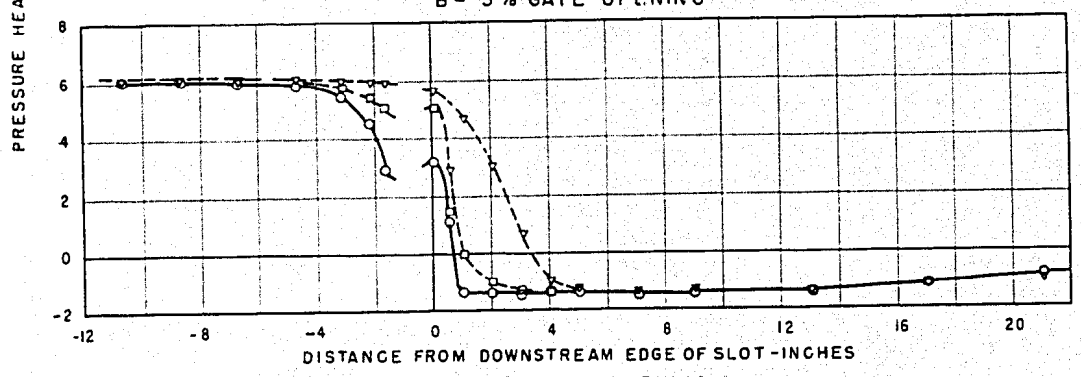
FIGURE 6
REPORT HYD.432



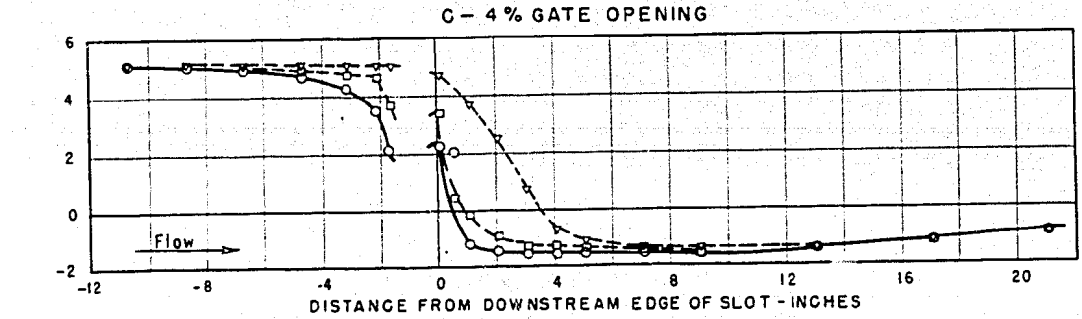
A – 2% GATE OPENING, AND PRESSURES WITH LEAF REMOVED



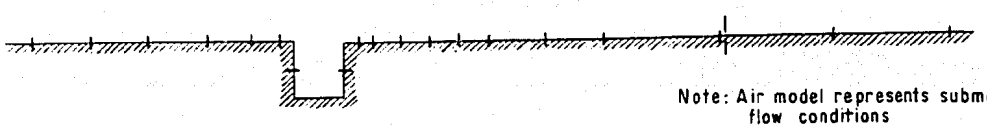
B – 3% GATE OPENING



C – 4% GATE OPENING



D – 5% GATE OPENING



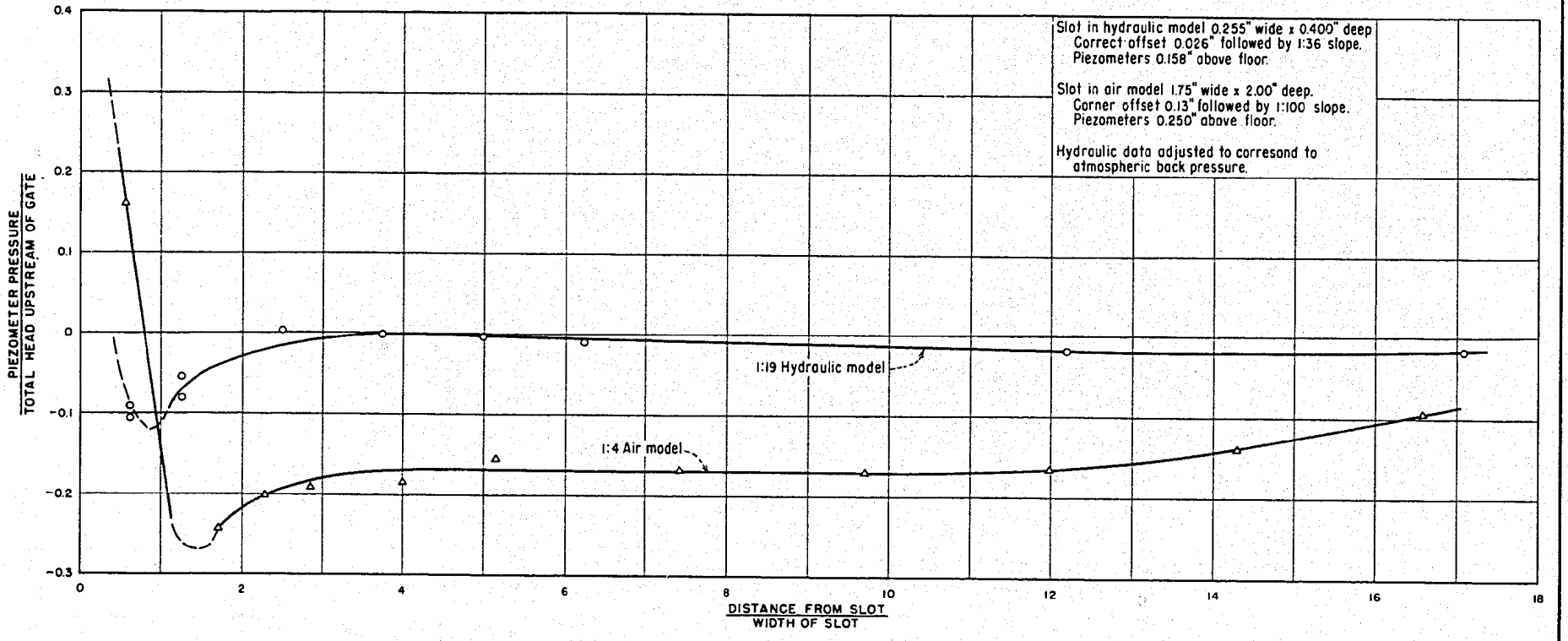
Note: Air model represents submerged flow conditions

GATE SLOT STUDIES

PRESSURES ON WALL OF AIR MODEL WITH SLOT AT DOWNSTREAM FACE OF LEAF, AND WITH SLOT MOVED UPSTREAM

1:5 SCALE SECTIONAL MODEL

557



GATE SLOT STUDIES

PRESSURES OBTAINED WITH AIR AND HYDRAULIC MODELS ON GATE WALL DOWNSTREAM FROM PRESENT SLOT

FIGURE 7
REPORT HYD. 432

PIEZ. LOC. / GATE OPENING MODEL	FLOOR 2.40" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF							FLOOR 0.80" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						
	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"
1% (0.216")	86.0	1.84	1.65	1.27	1.45	1.39	1.11	87.2	2.61	2.67	1.27	0.20	0.05	0.04
2% (0.432")	74.9	2.43	1.56	1.16	1.39	1.28	1.12	75.6	3.66	2.35	1.76	1.18	0.52	0.15
3% (0.648")	69.5	7.12	1.74	1.07	1.39	1.34	1.08	71.2	7.87	2.14	1.66	1.28	1.22	0.89
4% (0.864")	66.8	12.8	2.47	1.15	1.39	1.35	1.19	68.2	13.2	2.56	1.64	1.29	1.33	1.14
5% (1.080")	64.9	18.0	3.93	1.21	1.37	1.26	1.07	66.5	18.8	3.93	1.47	1.18	1.23	1.03
6% (1.296")	63.8	23.1	6.14	1.34	1.46	1.35	1.11	65.1	23.7	6.13	1.74	1.15	1.26	1.05
8% (1.728")	61.9	30.2	11.1	1.87	1.54	1.41	1.00	63.2	11.7(?)	11.5	2.23	1.16	0.81	0.87
10% (2.160")	59.4	34.6	16.5	3.39	1.85	1.48	1.18	60.5	35.5	17.2	3.95	1.52	1.03	0.95

PIEZ. LOC. / GATE OPENING MODEL	FLOOR 0.10" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF							WALL 0.10" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF						
	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"
1% (0.216")	97.6	2.89	0.79	0.16	0.05	0.04	0.03	99.8	0.18	0.39 TO 0.81	0.13	0.11	0.06	0.04
2% (0.432")	83.1	-1.18 TO +2.77	2.22	1.33	0.51	0.32	0.08	84.2	0.21 TO 1.45	1.96	0.69	0.50	0.27	0.16
3% (0.648")	75.6	6.92	2.57	1.73	1.22	0.73	0.16	76.6	6.54	2.96	1.51	1.28	0.77	0.37
4% (0.864")	72.9	13.0	2.68	1.90	1.62	1.40	0.40	71.8	12.8	3.37	1.89	1.77	1.40	0.87
5% (1.080")	67.8	18.3	6.82	1.96	1.72	1.63	0.75	68.0	18.1	4.24	1.76	1.79	1.66	1.28
6% (1.296")	65.8	23.3	6.18	2.05	1.62	1.75	0.83	65.8	23.7	6.66	1.99	1.91	1.82	2.33
8% (1.728")	63.2	30.7	11.8	2.53	1.38	1.20	0.13	64.2	32.2	14.6	2.53	1.58	1.75	1.30
10% (2.160")	60.7	35.3	17.6	4.00	1.61	1.25	0.27	61.3	39.3	24.8	3.77	1.64	1.68	1.23

PIEZ. LOC. / GATE OPENING MODEL	WALL 0.80" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF												
	-3.60"	-3.10"	-2.60"	-2.10"	-1.60"	-1.00"	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"
1% (0.216")	119.6	118.4	119.7	119.0	118.5	117.7	116.6	0.03	0.03	0.03	0.03	0.04	0.04
2% (0.432")	118.9	118.8	117.1	116.3	114.4	111.7	107.0	-0.02	-0.04	0.03	0.03	0.03	0.03
3% (0.648")	117.7	115.2	113.5	112.8	110.9	104.4	92.5	0.04	0.03	0.03	0.07	0.11	0.08
4% (0.864")	115.9	111.2	108.7	109.3	105.5	97.4	74.9	0.03	0.03	0.06	0.29	0.22	0.13
5% (1.080")	114.6	107.2	104.4	104.8	100.5	90.7	65.3	0.03	0.03	0.27	0.49	0.31	0.22
6% (1.296")	112.5	101.0	99.1	101.0	96.0	85.8	62.8	0.83 TO 0.71	0.71	0.76	1.28	0.75	0.56
8% (1.728")	109.4	91.4	90.0	92.4	89.0	78.9	61.9	20.4	6.70	1.48	1.61	0.97	1.06
10% (2.160")	105.1	87.2	76.1	81.4	80.4	72.4	60.5	30.7	12.8	2.27	1.43	0.88	0.86

PIEZ. LOC. / GATE OPENING MODEL	WALL AND SLOT 4.00" ABOVE FLOOR — DISTANCE UPSTREAM FROM REAR FACE OF LEAF			WALL AND SLOT 8.00" ABOVE FLOOR — DISTANCE UPSTREAM FROM REAR FACE OF LEAF			SIDE OF GATE LEAF — DISTANCE FROM BOTTOM OF LEAF		LEAF BOTTOM 0.60" FROM EDGE — DISTANCE UPSTREAM FROM REAR FACE OF LEAF				LEAF BOTTOM 0.60 FROM ℄ — DISTANCE UPSTREAM FROM REAR FACE OF LEAF				SLOT FLOOR CENTERED IN SLOT	TOTAL HEAD AT REF. PIEZ.
	0.50"	1.60"	3.10"	0.50"	1.60"	3.10"	0.20"	2.00"	0.25"	0.45"	0.62"	2.74"	0.25"	0.45"	0.62"	2.74"		
1% (0.216")	119.2	119.0	119.1	←	119.0	→	105.2	119.5	0.05	0.08	105.4	119.5	0.32	-0.14	104.8	119.4	119.6	120.0
2% (0.432")	119.4	117.7	118.1	118.1	118.2	—	94.2	117.8	0.03	0.07	96.4	119.0	0.03	-0.03	96.3	119.1	119.2	120.1
3% (0.648")	117.6	116.2	115.9	117.2	117.2	—	87.0	115.9	0.02	0.02	90.9	118.5	0.01	0.07	90.0	118.4	116.6	119.4
4% (0.864")	114.9	114.0	114.4	116.7	115.6	115.2	78.4	114.6	0.72	0.05	86.7	116.7	0.19	0.02	86.1	116.5	113.9	119.1
5% (1.080")	113.3	112.4	111.8	115.4	113.3	113.1	34.7(?)	112.9	0.04	0.45	82.2	115.4	0.64	0.06	83.0	114.8	111.2	120.0
6% (1.296")	109.0	112.2	111.8	113.6	112.0	112.2	73.3	111.8	0.02	0.02	81.1	113.6	0.09	0.02	80.2	113.3	108.3	119.7
8% (1.728")	107.9	109.8	109.4	110.3	109.5	110.2	69.9	109.8	0.03	0.03	77.6	110.9	0.11	0.35	76.9	110.9	104.0	119.5
10% (2.160")	99.8	105.9	105.1	104.8	105.2	108.6	64.5	104.9	0.03	0.03	71.2	105.3	0.62	0.03	72.1	102.9	99.0	118.4

A. 3/8 INCH PROTOTYPE CLEARANCE BETWEEN LEAF AND BODY

PIEZ. LOC. / GATE OPENING MODEL	FLOOR 2.40" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF							FLOOR 0.80" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF							FLOOR 0.10" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						
	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"
1% (0.216")	HIGH	1.16	0.98	0.71	0.95	0.84	0.75	HIGH	1.32	1.10	0.99	1.72	0.54	0.18	HIGH	1.50	1.13	0.57	1.30	0.16	0.06
3% (0.648")	HIGH	4.06	1.04	0.64	0.86	0.79	0.71	HIGH	4.40	1.10	0.89	0.65	0.58	0.16	HIGH	3.81	1.41	1.28	1.07	0.78	0.25
5% (1.080")	HIGH	6.40+	2.54	0.71	1.00	0.87	0.76	HIGH	6.40+	2.71	0.98	0.68	0.63	0.14	HIGH	6.40+	3.08	1.24	1.00	0.85	0.26

PIEZ. LOC. / GATE OPENING MODEL	WALL 0.10" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF							WALL 0.80" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF													TOTEL HEAD AT REF. PIEZ.
	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	-3.60"	-3.10"	-2.60"	-2.10"	-1.60"	-1.10"	-0.60"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	
1% (0.216")	HIGH	0.86	0.75	0.29	0.23	0.16	0.10	←		High	Pressures			→	←	Flow	not	on surface		→	78.1
3% (0.648")	HIGH	2.67	1.77	1.19	1.07	1.00	0.78	←		High	Pressures			→	0.03	0.04	0.17	0.40	0.24	0.20	70.8
5% (1.080")	HIGH	6.40+	3.38	1.18	1.02	1.10	0.87	←		High	Pressures			→	0.71	1.15	0.48	0.88	0.61	0.56	77.5

B. NO CLEARANCE BETWEEN LEAF AND BODY

NOTES

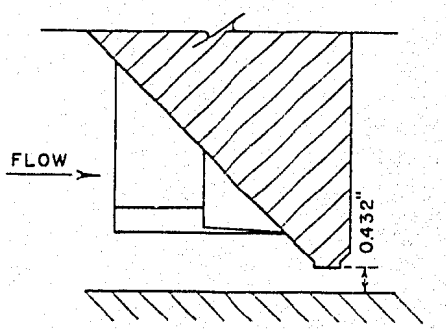
1. Free discharge flow conditions.
2. Pressures and dimensions refer to model.
3. Pressures in feet of water.
4. Piezometer locations are shown in figure 4

GATE SLOT STUDIES

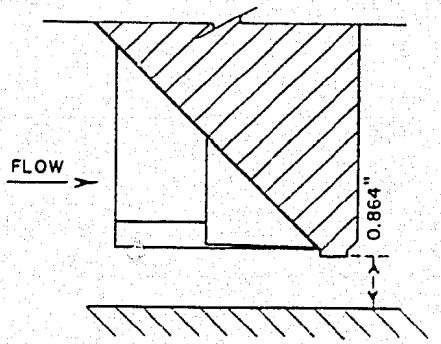
PIEZOMETRIC PRESSURES WITH GATE SLOT MOVED 12" INCHES PROTOTYPE UPSTREAM FROM DOWNSTREAM FACE OF LEAF

DATA FROM 1:5 SCALE SECTIONAL MODEL

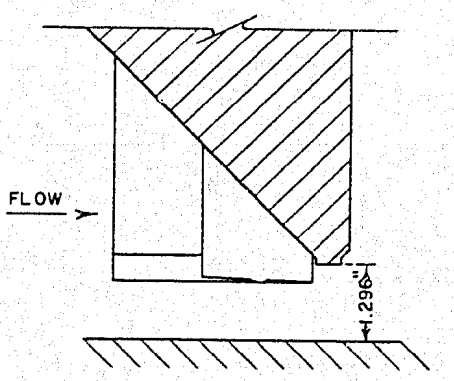
557



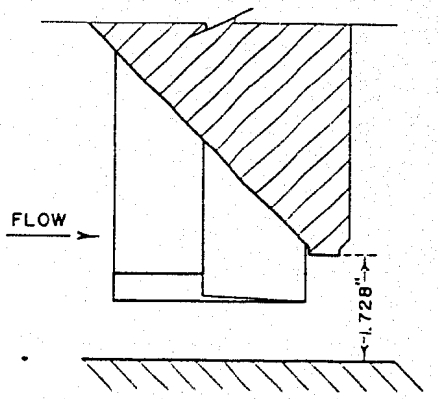
GATE 2% OPEN



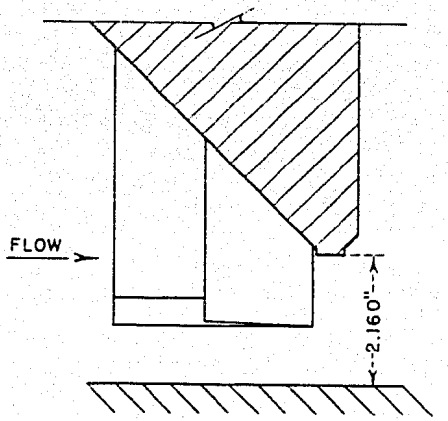
GATE 4% OPEN



GATE 6% OPEN



GATE 8% OPEN



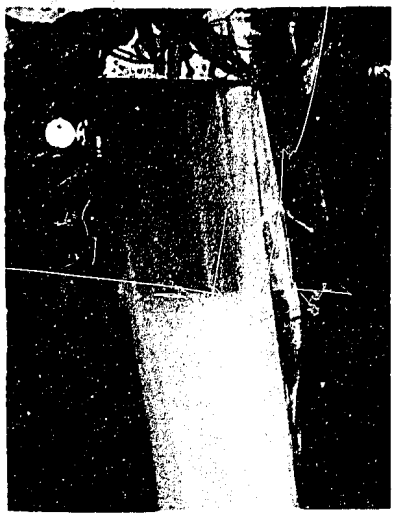
GATE 10% OPEN

Note: Dimensions refer to the model

GATE SLOT STUDIES

RELATIVE POSITION OF LEAF
• AND BOTTOM OF SLOT AT SMALL
GATE OPENINGS - SLOT MOVED
12 INCHES PROTOTYPE UPSTREAM
FROM DOWNSTREAM FACE OF GATE LEAF
1:5 SCALE SECTIONAL MODEL

FIGURE 9
REPORT HYD. 432



A-1% open

B-2% open

C-3% open

D-4% open

E-5% open

F-6% open

G-8% open

H-10% open

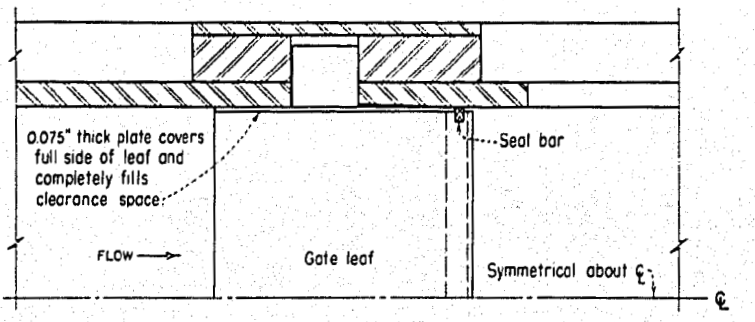
Slots are same on both sides of model. Head on model 120 feet Side Clearance between leaf and body 3/8 inch, prototype

GATE SLOT STUDIES

Flow Conditions with Gate Slots Moved 12 Inches Prototype Upstream From Downstream Face of Leaf

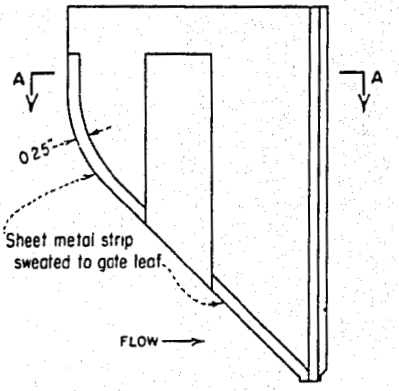
1:5 Sectional Model

Figure 10
Report Hyd 432

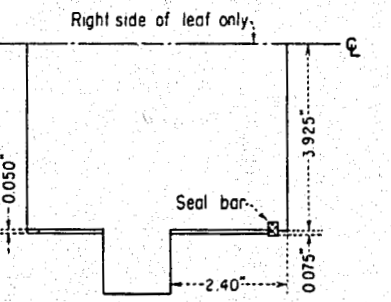


PLAN

A – PLATE ATTACHED TO LEAF TO COMPLETELY FILL CLEARANCE SPACE

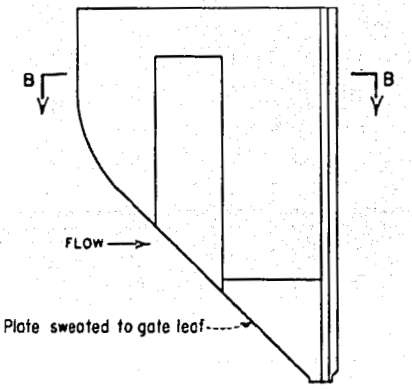


ELEVATION

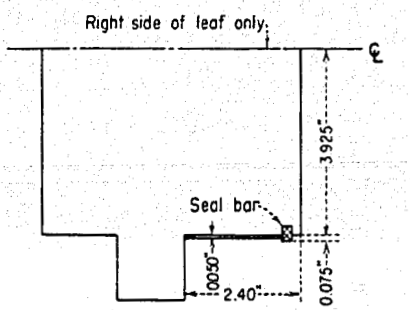


SECTION A–A

B – STRIP ATTACHED ALONG EDGE OF LEAF TO REDUCE CLEARANCE TO 1/8 INCH PROTOTYPE



ELEVATION



SECTION B–B

C – PLATE ATTACHED BETWEEN GUIDE AND SEAL AT LEAF BOTTOM TO REDUCE CLEARANCE TO 1/8 INCH PROTOTYPE

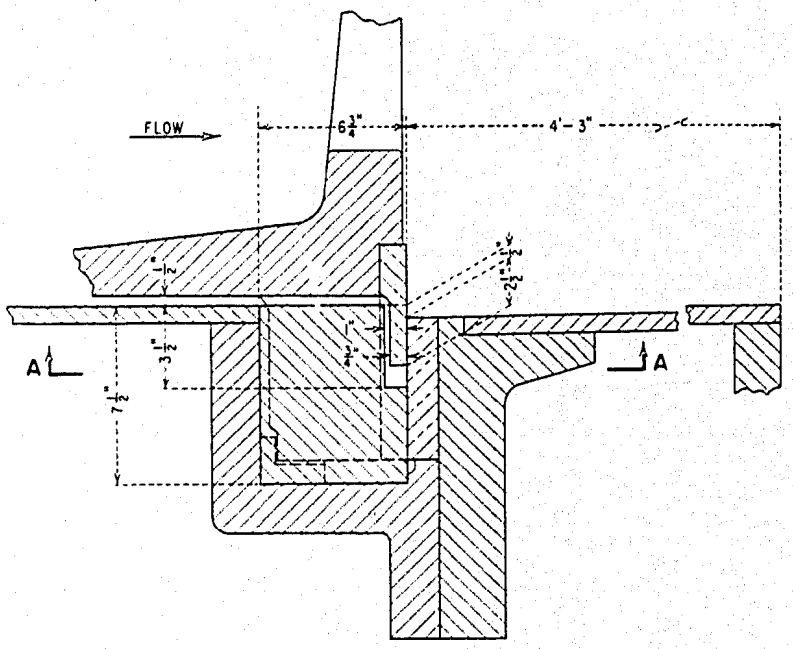
GATE SLOT STUDIES

METHODS USED ON MODEL FOR REDUCING CLEARANCE BETWEEN LEAF AND GATE BODY

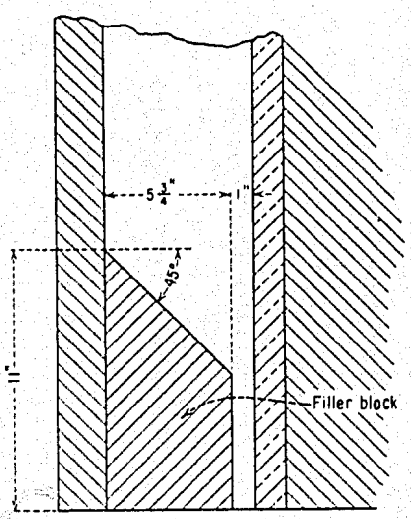
1:5 SCALE SECTIONAL MODEL

557

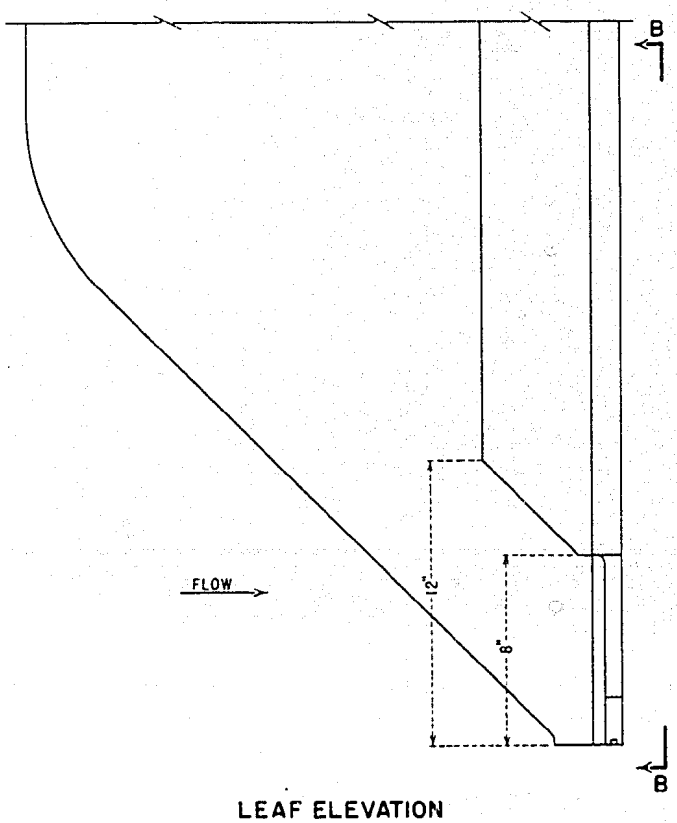
FIGURE 12
REPORT HYD 432



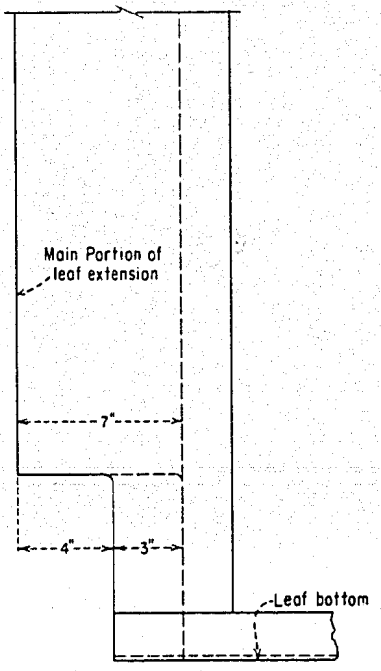
PLAN VIEW
(Near floor of gate)



GATE SLOT SECTION A-A



LEAF ELEVATION



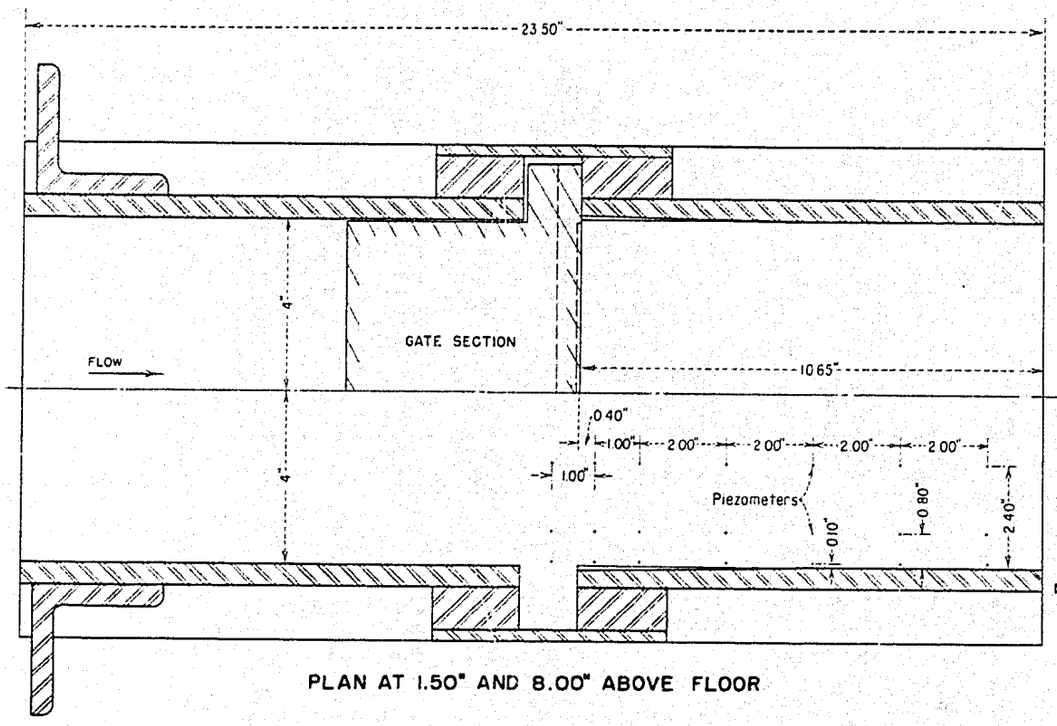
SECTION B-B

GATE SLOT STUDIES

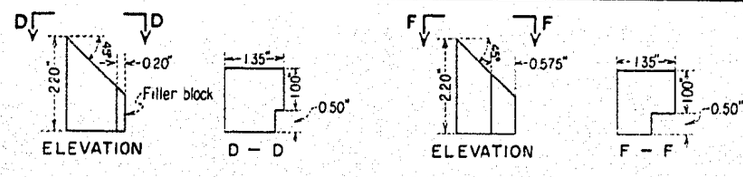
NARROW SLOTS NEAR FLOOR

557

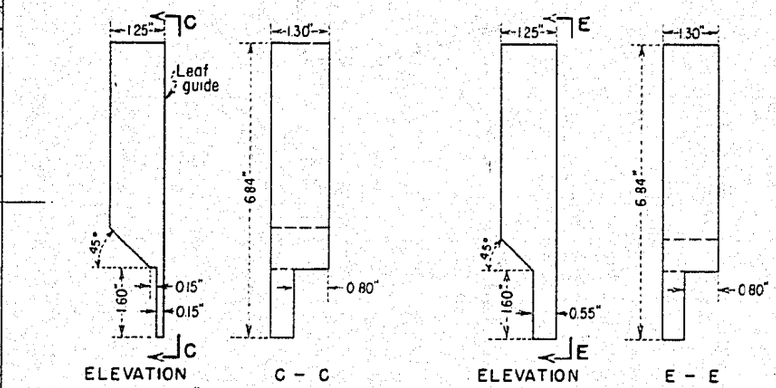
FIGURE 13
REPORT HYD. 432



PLAN AT 1.50" AND 8.00" ABOVE FLOOR

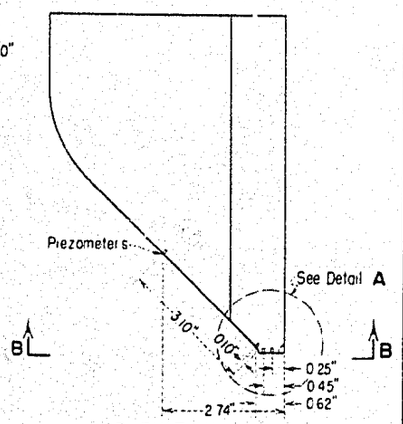


SLOT FILLER BLOCKS

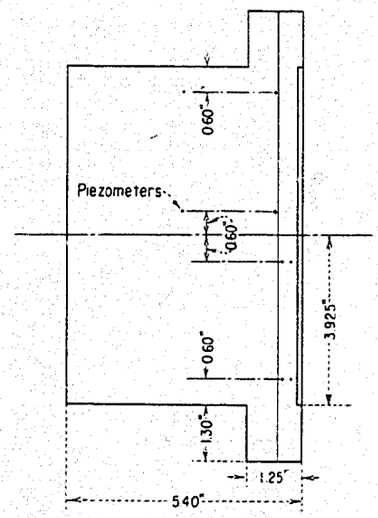


NARROWED SLOT 1.00" WIDE (PROTO.) NARROWED SLOT 2.875" WIDE (PROTO.)

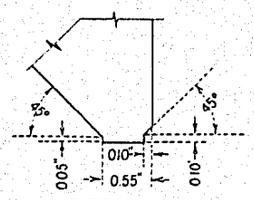
GATE LEAF GUIDES
(Shown on left side to conform with gate slot Detail)



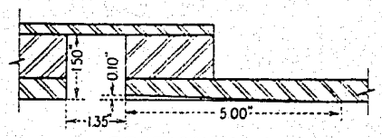
PRESENT GATE LEAF AND GUIDE



SECTION B–B

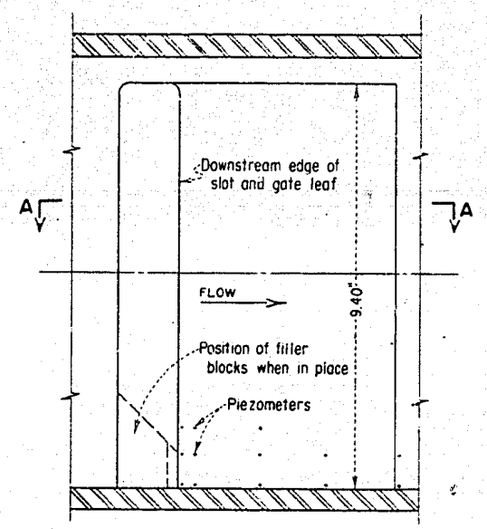


DETAIL A



SECTION A–A

℄ ELEVATION



GATE SLOT DETAIL
DETAIL, PRESENT SLOT–CONSTANT WIDTH AND DEPTH FOR FULL HEIGHT

NOTES
Model modified to represent present and narrowed slots on right side only, for clarity slots are shown the same on both sides.

GATE SLOT STUDIES

PIEZOMETER LOCATIONS AND GATE MODIFICATIONS FOR TESTS OF NARROWED AND PRESENT GATE SLOTS

1:5 SCALE SECTIONAL MODEL

557

GATE OPENING MODEL \ PIEZ. LOC.	FLOOR 0.10" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						FLOOR 0.80" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						FLOOR 2.40" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						WALL 0.10" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF							WALL 0.80" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF							WALL 1.40" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF			LEAF BOTTOM 0.60" FROM EDGE — DISTANCE UPSTREAM FROM REAR FACE OF LEAF		TOTAL HEAD AT REF. PIEZ.
	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	0.10"	0.40"	1.90"	3.40"	5.10"	7.40"	9.40"	0.10"	0.40"	1.90"	3.40"	5.10"	7.40"	9.40"	0.10"	0.40"	1.90"	0.45"	0.25"	
1%(0.216")	3.41	0.21	0.21	0.37			5.36	3.78	0.37				1.71	1.52	1.16	1.40	1.28	1.22	0.09	0.09																		120.0
2%(0.432")	1.09	1.05	0.52	0.11	0.02	0.07	8.11	4.18	0.78	0.31	0.18	0.14	2.75	1.52	1.16	1.44	1.38	1.23	2.61	0.20	-0.07	0.22	0.31	0.22	0.11	0.14	0.07	0.05	0.02	0.03	1.23	1.16	1.15					120.0
3%(0.648")	0.10 / -0.45	3.20	1.12	0.67	0.34	0.20	9.08	3.36	1.77	0.87	0.59	0.39	7.29	1.77	1.26	1.35	1.18	1.31	-12.64	3.50	-1.01	0.20	0.53	0.70	0.59	0.06	-0.08	0.11	—	0.11	0.11	0.11	-0.02					120.0
4%(0.864")	10.9+	3.13	1.57	0.90	0.49	0.26	10.9+	3.20	1.86	1.37	1.26	0.78	10.9+	2.55	1.26	1.38	1.16	1.24	10.9+	10.9+	-0.83	0.73	0.66	1.16	0.60	-0.05	0.02	0.44	0.37	0.41	0.32	0.29	0.03	0.07	—			120.0
5%(1.080")	6.42+	5.54	2.22	1.26	0.89	0.27	6.42+	4.46	1.75	1.36	1.02	0.59	6.42+	4.28	1.39	1.54	1.34	1.32	6.41+	6.41+	-0.06	1.32	0.52	1.34	0.90	-0.10	-0.02	1.22	0.60	0.24	0.31	0.17	-0.03	-0.01	-0.02			120.3
6%(1.296")	6.42+	6.42+	2.79	1.68	1.22	0.39	6.42+	6.42+	1.86	1.32	1.22	0.85	6.9	6.8	1.81	1.81	1.56	1.36	6.41+	6.41+	2.14	1.70	0.85	1.64	1.22	-0.12	0.22	2.61	1.08	0.54	0.55	0.33	-0.01	-0.01	-0.01			119.5
8%(1.728")	6.42+	6.42+	3.96	1.74	1.62	0.68	6.42+	6.42+	3.59	1.64	1.32	0.88	6.42+	6.42+	2.90	1.98	1.68	1.39	6.41+	6.41+	5.59	2.78	0.21	1.49	1.19	-0.03	0.46	3.27	1.71	1.23	1.72	1.53	-0.02	-0.01	-0.01			119.5
10%(2.160")	6.42+	6.42+	6.25	2.49	2.27	1.00	6.42+	6.42+	5.14	2.13	1.59	1.01	6.42+	6.42+	4.10	2.17	1.72	1.35	6.41+	6.41+	4.99	0.99	2.03	1.24	0	-0.06	0.62	4.35	4.34	1.63	2.21	1.73	-0.04	-0.02	0.63			119.4

A — SLOT NARROWED TO 1 INCH — $\frac{1}{4}$ INCH CLEARANCE (PROTOTYPE)

GATE OPENING MODEL \ PIEZ. LOC.	FLOOR 0.10" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						FLOOR 0.80" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						FLOOR 2.40" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						WALL 0.10" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF							WALL 0.80" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF							WALL 1.40" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF			LEAF BOTTOM 0.60" FROM EDGE — DISTANCE UPSTREAM FROM REAR FACE OF LEAF		TOTAL HEAD AT REF. PIEZ.
	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	0.10"	0.40"	1.90"	3.40"	5.10"	7.40"	9.40"	0.10"	0.40"	1.90"	3.40"	5.10"	7.40"	9.40"	0.10"	0.40"	1.90"	0.45"	0.25"	
1%(0.216")	0.12	0.10	0.12	←	0.10	→	4.71	4.09	0.12	←	0.10	→	1.91	1.58	1.24	1.46	1.39	1.27	←			0.07			→	←			0.05			→	←	0.05	→			120.0
2%(0.432")	0.24	-0.12	0.10	0.08	0.04	0.05	6.42+	3.29	0.01	0.03	0.03	0.03	2.97	1.55	1.15	1.39	1.20	1.02	-0.23	-0.12	0.03	0.05	0.04	0.03	0.06	←			0			→	←	-0.04	→	0.18	-0.02	120.1
3%(0.648")	5.67	2.96	2.17	1.48	1.18	0.36	6.42+	2.32	1.70	1.16	0.90	0.48	6.42+	1.68	1.19	1.39	1.33	1.21	-24.0	6.41+	0.69	1.08	0.68	1.12	0.24	-0.07	0.18	1.40	-0.03	0.43	0.42	0.24	←	0.02	→			119.7
4%(0.864")	6.42+	3.02	2.29	1.72	1.01	1.37	6.42+	3.17	1.64	1.09	1.03	0.63	6.42+	2.58	1.10	1.24	1.14	0.98	6.41+	6.41+	0.48	1.24	0.58	1.42	0.61	-0.19	0.23	1.94	0.92	0.37	0.46	0.41	-0.03	0.02	0.07	-1.10	-1.15	120.2
5%(1.080")	6.42+	4.89	2.52	1.80	1.77	0.60	6.42+	4.46	1.82	1.13	1.02	0.74	6.42+	4.25	1.30	1.47	1.39	1.21	6.41+	6.41+	1.03	1.40	0.45	1.52	0.59	-1.04	0.30	1.83	0.17	0.57	0.69	0.47	0	-0.05	0.08			120.3
6%(1.296")	6.42+	6.12	2.48	1.53	1.64	0.65	6.42+	6.34	1.98	1.19	1.10	0.82	6.42+	6.67	1.48	1.44	1.38	1.21	6.41+	6.41+	1.63	1.58	0.28	1.52	0.65	-1.03	-0.03	2.38	0.37	0.75	0.98	0.78	-0.06	-0.12	-0.02			119.8
8%(1.728")	6.42+	6.42+	4.02	2.19	2.07	0.85	6.42+	6.42+	2.97	1.39	1.23	0.93	6.42+	6.42+	2.43	1.69	1.52	1.27	6.41+	6.41+	5.38	3.20	0.76	1.79	0.86	-0.34	0.59	2.77	0.58	0.90	1.28	1.07	-0.14	-0.12	0.28			120.2
10%(2.160")	6.42+	6.42+	6.15	2.43	2.45	1.11	6.42+	6.42+	4.75	1.66	1.31	0.81	6.42+	6.42+	3.84	1.94	1.56	1.24	6.41+	6.41+	6.41+	5.21	0.83	2.04	1.01	-0.24	0.81	4.60	2.82	1.63	1.98	1.73	0	-0.02	0.42			120.6

B — SLOT NARROWED TO 2.875 INCHES — $\frac{1}{8}$ INCH CLEARANCE (PROTOTYPE)

GATE OPENING MODEL \ PIEZ. LOC.	FLOOR 0.10" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						FLOOR 0.80" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						FLOOR 2.40" FROM WALL — DISTANCE DOWNSTREAM FROM LEAF						WALL 0.10" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF							WALL 0.80" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF							WALL 1.40" ABOVE FLOOR — DISTANCE DOWNSTREAM FROM LEAF			LEAF BOTTOM 0.60" FROM EDGE — DISTANCE UPSTREAM FROM REAR FACE OF LEAF		TOTAL HEAD AT REF. PIEZ.
	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	0.04"	1.40"	3.40"	5.40"	7.40"	9.40"	0.40"	1.40"	3.40"	5.40"	7.40"	9.40"	0.10"	0.40"	1.90"	3.40"	5.10"	7.40"	9.40"	0.10"	0.40"	1.90"	3.40"	5.10"	7.40"	9.40"	0.10"	0.40"	1.90"	0.45"	0.25"	
1%(0.216")	0.24	0.02	0.04	0.04	0.04	0.05	6.42+	3.50	0.04	0.03	0.04	0.05	1.80	1.42	1.13	1.35	1.34	1.23	←			0.01			→	←			0.01			→	0	0	0.01	-0.20	0.09	120.0
2%(0.432")	0.57	0.01	0.04	0.27	0.04	0.04	6.42+	3.87	0.08	0.87	0.04	0.04	3.05	1.55	1.30	1.55	1.50	1.24	←			0.01			→	←			0.01			→	←	0	→	3.15	-0.52	120.1
3%(0.648")	1.96	0.10	0.04	0.04	0.04	0.53	6.42+	4.86	0.60	0.11	0.04	0.09	6.42+	1.85	1.48	1.70	1.57	1.29	0.24	0.02	0.01	0.03	0.09	0.03	0.24	←			0.01			→	←	0 01	→			119.6
4%(0.864")	3.34	0.44	0.21	0.10	0.08	0.04	6.42+	4.60	1.16	0.84	0.39	0.13	6.42+	2.72	1.43	1.55	1.54	1.36	-0.04	-0.09	0.21	0.21	0.07	0.08	0.05	-0.01	-0.01	0.04	0.03	0.03	0.03	0.02	0.02	-0.01	0.03	-0.60	-0.71	119.4
5%(1.080")	5.02	2.23	1.13	0.84	0.64	0.18	6.42+	4.31	1.52	1.12	1.17	0.79	6.42+	4.26	1.39	1.48	1.49	1.30	-0.12	-0.13	0.20	0.54	0.56	0.58	0.14	-0.07	-0.05	0.01	0.02	0.05	0.06	0.04	0.01	-0.01	0.01	-0.37 TO -0.47	-0.97 TO -1.02	119.2
6%(1.296")	6.27	4.55	3.06	1.75	1.52	0.56	6.42+	5.41	1.87	0.95	0.98	0.85	6.42+	6.49	1.48	1.43	1.42	1.22	-0.43	-0.37	2.74	2.26	0.91	1.65	0.38	-0.19	-0.19	0.03	0.08	0.12	0.18	0.17	0	-0.02	0.02	-0.49 TO -0.54	-0.32	119.7
8%(1.728")	6.42+	6.42+	3.57	1.05	1.95	0.92	6.42+	6.42+	2.68	0.72	1.03	0.63	6.42+	6.42+	2.18	1.44	1.39	1.16	-0.80 TO -0.90	6.41+	6.76	2.44	-0.90 TO -1.00	1.69	0.69	-0.64	0.35	6.09	2.45	-0.22	1.43	1.43	-0.05	0	0.10	-0.37 TO -0.41	0.09	118.9
10%(2.160")	6.42+	6.42+	4.45	0.44	1.67	0.67	6.42+	6.42+	4.07	0.77	1.05	0.60	6.42+	6.42+	3.68	1.65	1.43	1.14	6.41+	6.41+	6.41+	3.52	-1.19	1.62	0.59	0.55	6.35+	6.35+	3.50	-1.45	1.41	1.52	-0.24	0.07	0.84	-0.98	-0.09	119.4

C — PRESENT SLOT 6.75 INCHES WIDE FOR FULL HEIGHT — $\frac{1}{8}$ INCH CLEARANCE (PROTOTYPE)

Free discharge flow conditions
Pressures and dimensions refer to model
Pressures given in feet of water
Piezometer locations given in Figure 13

GATE SLOT STUDIES

PIEZOMETRIC PRESSURES WITH SLOTS NARROWED TO 1" AND 2.875" AT FLOOR, AND WITH PRESENT SLOT

DATA FROM 1:5 SCALE SECTIONAL MODEL

557

A-1% open

B-2% open

C-3% open

D-4% open

E-5% open (Not available)

F. 6% open

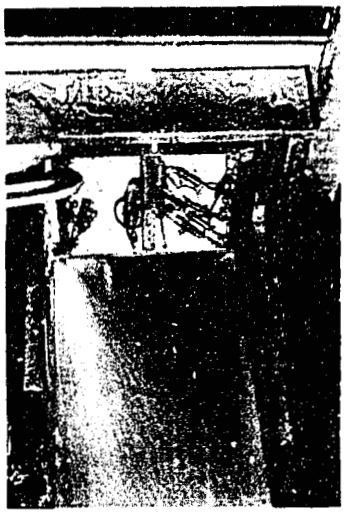
G. 8% open

H. 10% open

Narrowed slot is on left side in each photograph. At right side (left wall of gate) slot is represented 12" upstream and there is 3/8" clearance (proto)
Head on Model 50 feet
GATE SLOT STUDIES
Flow Conditions with Slot at Downstream of Leaf Narrowed to 1 Inch, Prototype
1:5 Seals Sectional Model

Figure 15
Report Hyd. 432

A. 1% open



B. 2% open

C. 3% open

D. 4% open

E-5% open

F-6% open

G-8% open

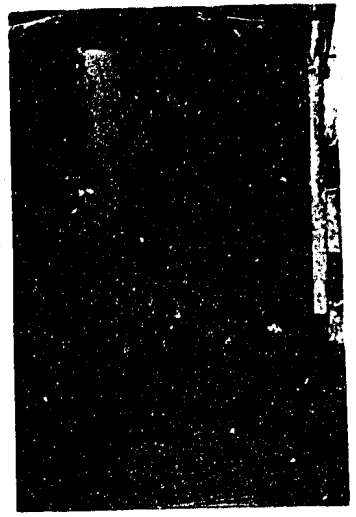
H-10% open

Narrowed slot is on left side in each photograph. At right side (left wall of gate) slot is represented 12" upstream and there is no side clearance.
Head on Model 80 feet
GATE SLOT STUDIES
Flow Conditions with Slot at Downstream of Leaf Narrowed to 2.875 Inches, Prototype
1:5 Scale Sectional Model

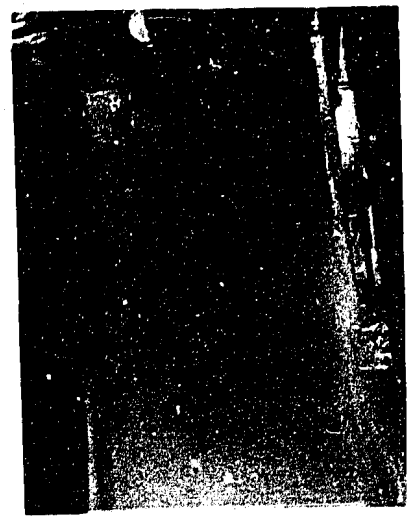
Figure 16
Report Hyd 432

A-1% open

B-2% open



C-3% open



D-4% open

E. 5% open

F-6% open

G-8% open

H-10% open

Present slot is on left side of each photograph. At right side (left wall of gate) slot is represented 12" upstream and there is 3/8" side clearance (Prototype)
Head on model 60 feet
GATE SLOT STUDIES
Flow Conditions with Slot at Downstream of Leaf Same Width Throughout Its Height-Present Slot
1:5 Scale Sectional Model

Figure 17
Report Hyd. 432