UNITED STATES

DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

MEMORANDUM TO CHIEF DESIGNING ENGINEER

SUBJECT: HYDRAULIC MODEL EXPERIMENTS FOR THE DESIGN

OF

THE SEMINOE STONEY GATE SPILLWAY

---

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HYD 3.4

TECHNICAL MEMORANDUM NO. 444

Denver, Colorado

March 15, 1935

(PRICE $2.80)

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Summary

Model tests of the original design showed the Seminoe spillway to have ample capacity for the maximum discharge. Flow in the chute, however, was rather rough, unsymmetrical, and noisy.

Tests indicated that flow conditions could be improved by making a few minor changes on the model. The design recommended by the hydraulic research department had incorporated in it the following revisions: (1) A revised gate section, rectangular in shape down to the end of the piers; (2) pier tailpieces toed in 0.94 feet from their designed positions toward the center line of the spillway; (3) the upper portion of the chute reshaped so as to correspond to the revised gate section; (4) wing walls having radii of 16 feet on each side above the gate section; and (5) the outlet channel rotated so as to be on line with the rest of the spillway. For the sake of economy, the floor of the approach channel was raised 12.5 feet to elevation 6294.5.

The positions of the piers in the gate section and the approach to the gate section are very important factors in a spillway of this type.

A comparison of the original and recommended designs are shown on figure 5.

The Project

Seminoe Dam will be located on the North Platte River 33 miles northeast of Rawlins, Wyoming and about 25 miles above the existing Pathfinder Dam. The Seminoe reservoir, which will have a storage capacity of about 910,000 acre feet, will provide additional storage for the North Platte Irrigation Project and enable irrigation expansion in that section of the state. The 260 foot high concrete arch dam (figure 1) situated in a narrow granite canyon will also enable power generation.

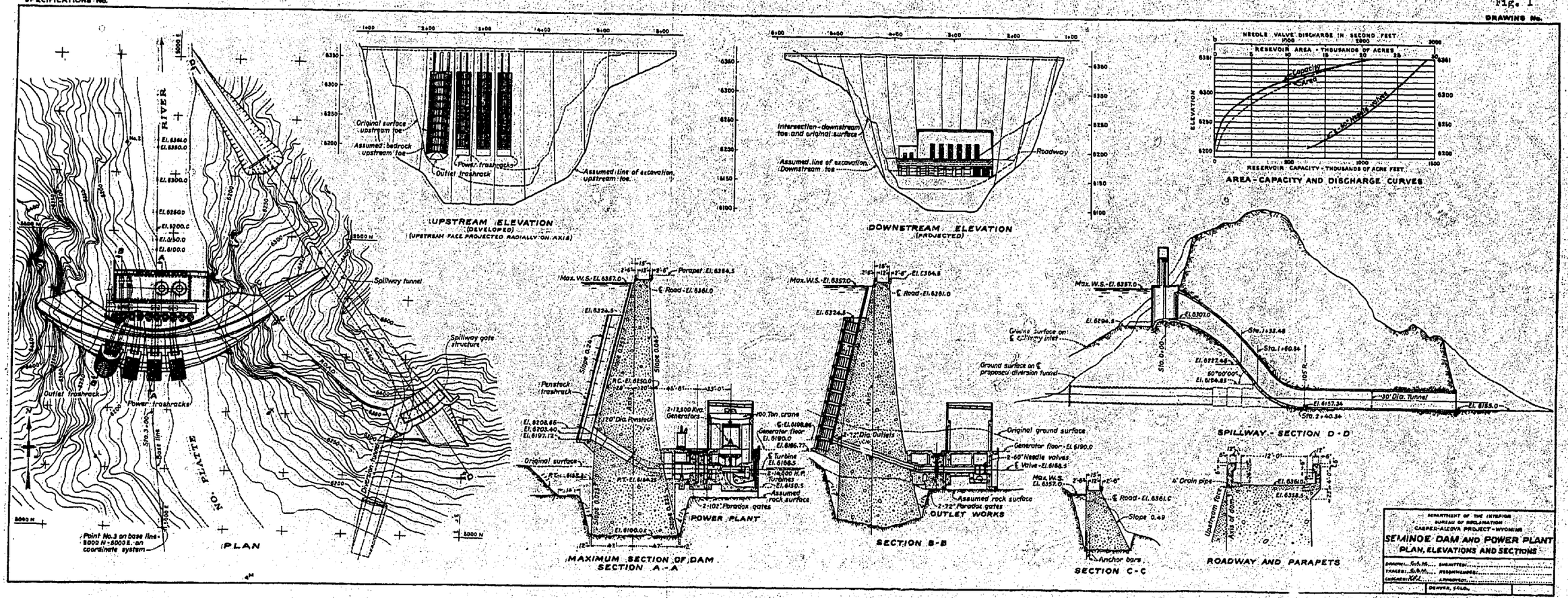
A ring-gate or morning-glory spillway similar to the one used on the Owyhee Dam was originally proposed, and because of the geology of the site would necessarily have been located in the left canyon wall. The original diversion tunnel was located in the right canyon wall, and in order to utilize this tunnel for the ultimate spillway, a Stoney-gate design for the right canyon wall was proposed.

A model of the ring-gate spillway was constructed and tested in the laboratory and a resume of this work will be written in the near future.

SPECIFICATIONS No.

Fig. 1

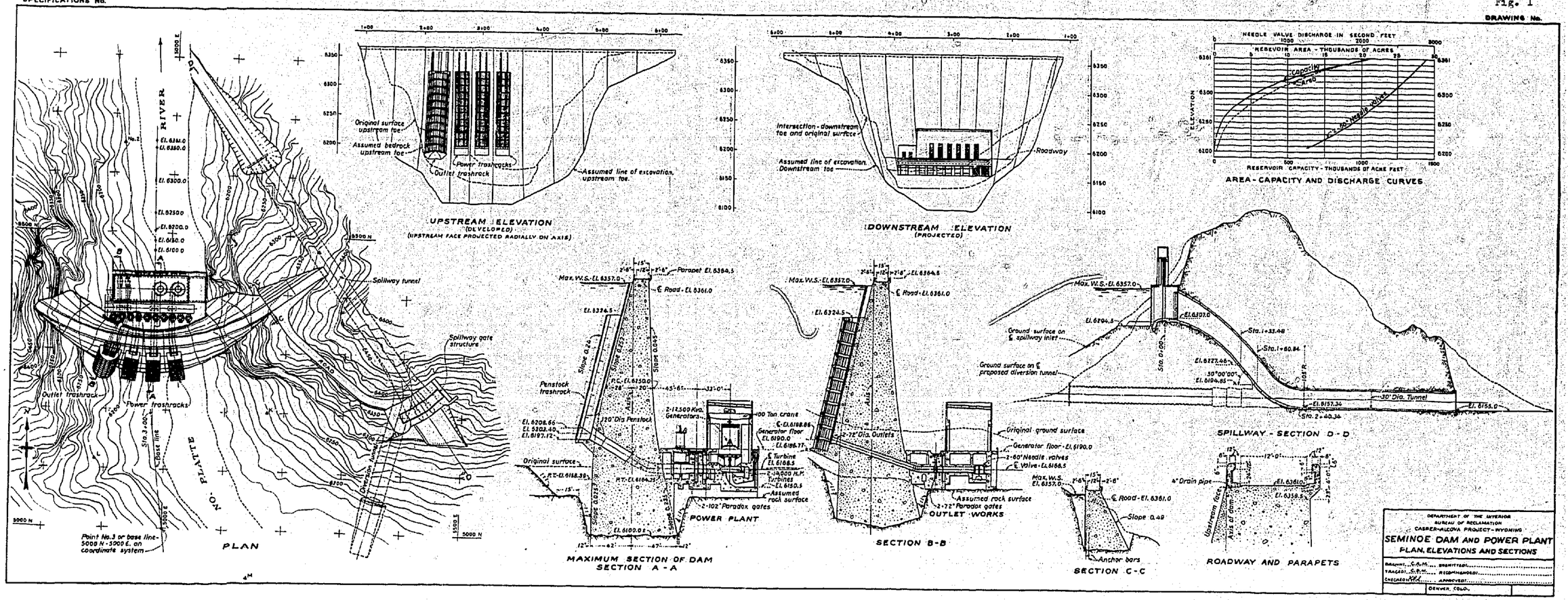
DRAWING No.



SPECIFICATIONS No.

Fig. 1

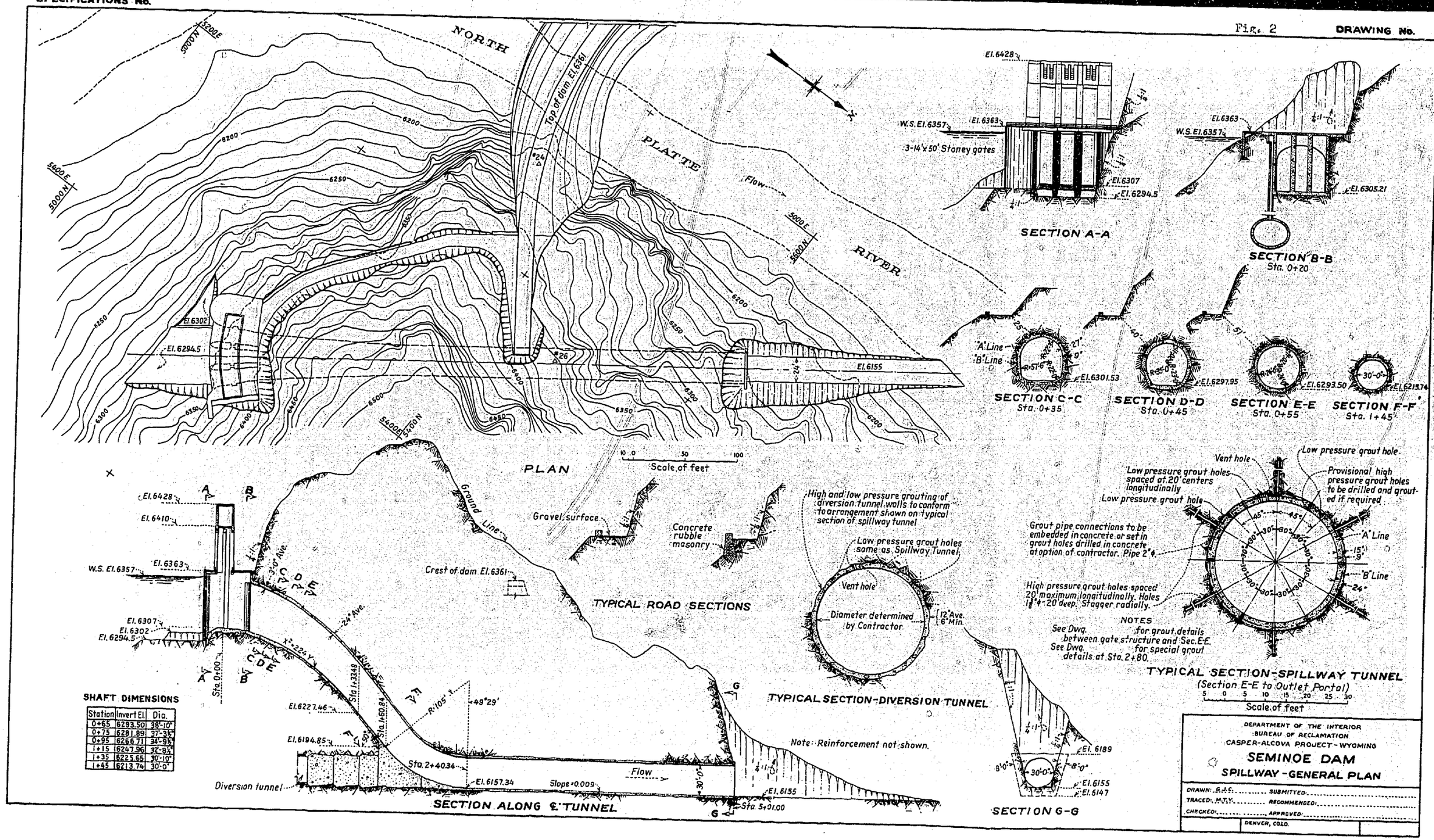
DRAWING No.



SPECIFICATIONS No.

Fig. 2

DRAWING No.



The Stoney-gate spillway, a drawing of which is shown in figure 2, will consist of a short trapezoidal approach channel leading from the reservoir to the gate section; a gate section, the floor of which resembles a flat crested weir with a curved upstream face; a transitional chute, the invert of which is a flat parabola; and a 30-foot diameter horizontal tunnel. The gate section is rectangular down to the end of the piers, and converges slightly in a downstream direction. Flow through the spillway will be controlled by three Stoney gates each measuring 14 feet between piers and located at the highest point on the crest. The spillway is designed for a maximum discharge of 50,000 c.f.s. which will require a head of about 50 feet on the crest. The chute which commences as a horseshoe tunnel at the downstream end of the piers will gradually be transformed into a circular section 30 feet in diameter at the lower end. The chute will drop the water 150 feet on a slope not greater than 50°, measured with the horizontal, into the original 30-foot diameter horizontal diversion tunnel. Upon completion of the dam, the upper portion of the diversion tunnel will be plugged, and the lower 260 feet together with 160 feet of open cut at the downstream end will be utilized to carry the spillway flow.

The Laboratory

The laboratory in which the model of the Seminoe spillway was constructed and tested is located in the basement of the Old Custom House in Denver where it is easily accessible to the designing staff of the Bureau of Reclamation. A plan of the laboratory is shown in figure 3.

Water for supplying the models is measured over a 90° V-notch weir located in the end of a weir tank 6 feet by 12 feet by 4 feet deep, which is partially below the laboratory floor. From here, a 6-inch centrifugal pump having a capacity of 3 c.f.s. raises the measured water up into a constant level tank located as high as the ceiling of the laboratory will permit. A stationary skimming weir makes it possible to maintain a constant head of water in this tank. The water flows from the constant level tank through two 8-inch calibrated gate valves, then through large expanding cones into two head tanks located directly below the constant level tank. Water is then supplied to the models directly from these head tanks. With this arrangement, two models can be operated simultaneously. After passing through the models, the water is collected in sheet metal flumes and returned to the weir tank. Thus, the same water is continuously circulated through the system. Two hook gages are used to observe the head on the V-notch weir and one hook gage is provided for measuring the elevation of the water surface in each of the head tanks.

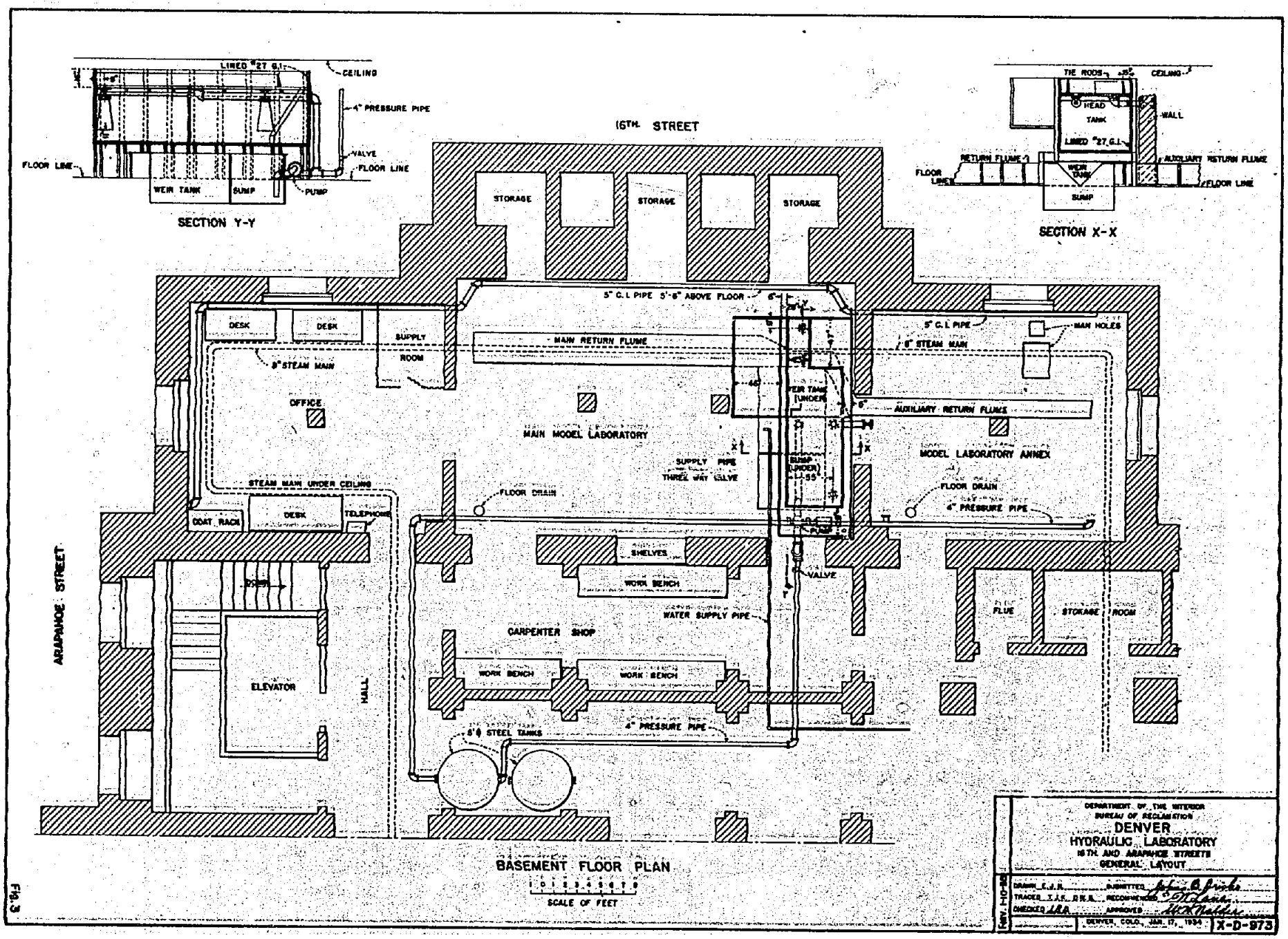

SECTION Y-Y
LINED #27 G.I.
CEILING
4" PRESSURE PIPE
FLOOR LINE
VALVE
FLOOR LINE
WEIR TANK
SUMP
PUMP
SECTION X-X
TIE RODS
CEILING
HEAD TANK
WALL
LINED #27 G.I.
RETURN FLUME
AUXILIARY RETURN FLUME
FLOOR LINE
WEIR TANK
FLOOR LINE
SUMP
16TH. STREET
STORAGE
STORAGE
STORAGE
5" C.I. PIPE 5'-6" ABOVE FLOOR
DESK
DESK
SUPPLY ROOM
MAIN RETURN FLUME
8" STEAM MAIN
5" C.I. PIPE
8" STEAM MAIN
MAN HOLES
OFFICE
WEIR TANK (UNDER)
AUXILIARY RETURN FLUME
MAIN MODEL LABORATORY
SUPPLY PIPE
THREE WAY VALVE
SUMP (UNDER)
MODEL LABORATORY ANNEX
STEAM MAIN UNDER CEILING
FLOOR DRAIN
FLOOR DRAIN
4" PRESSURE PIPE
COAT RACK
DESK
TELEPHONE
SHELVES
WORK BENCH
VALVE
ARAPAHOE STREET
ROOM
WATER SUPPLY PIPE
FLUE
STORAGE ROOM
CARPENTER SHOP
ELEVATOR
HALL
WORK BENCH
WORK BENCH
4" PRESSURE PIPE
8'ϕ STEEL TANKS
BASEMENT FLOOR PLAN
SCALE OF FEET
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DENVER
HYDRAULIC LABORATORY
16TH AND ARAPAHOE STREETS
GENERAL LAYOUT
DRAWN E.J.R.
SUBMITTED
TRACED T.J.K. D.W.R.
RECOMMENDED
CHECKED
APPROVED
DENVER, COLO., JAN. 17, 1934
X-D-973

Fig. 3

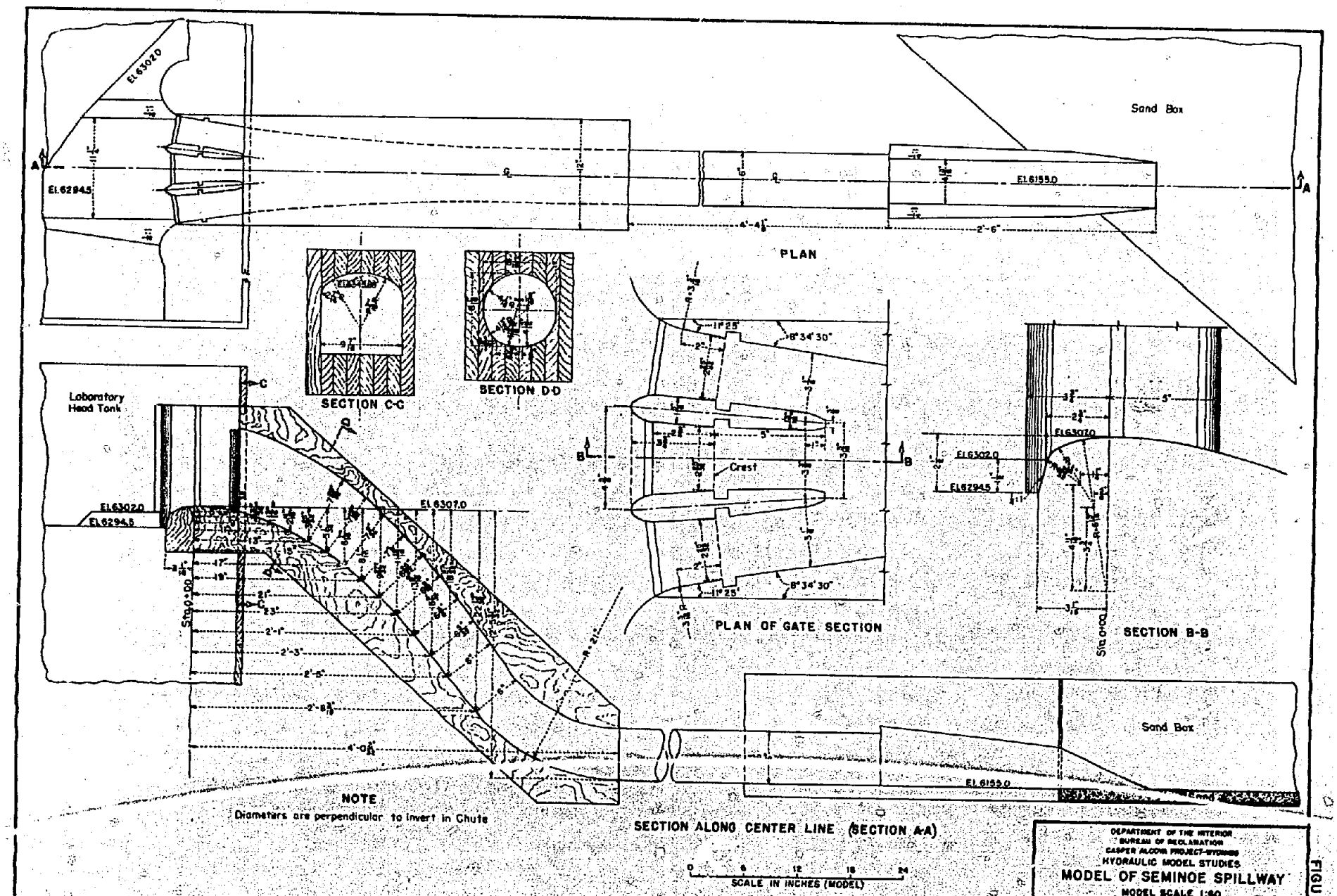
The Model

A model of the Seminoe spillway was constructed in the laboratory on a scale of 1:60. A drawing of the model as finally revised is shown in figure 4. The approach to the gate section was located in one of the laboratory head tanks and was constructed of sheet metal. The gate section and chute were carved in a laminated block of wood made up of 2- by 12-inch planks. The block was split on the vertical center line to facilitate the carving operation, and the two halves were later bolted together. A band saw cut was made just above the predicted maximum water surface line so that the top could be removed for observation purposes. The chute and cover can both be seen in photograph A, plate I. The piers were made of redwood and were held in place in the gate section by small dowels. Both piers and chute were thoroughly oiled and varnished before water was allowed to come in contact with them. The 260 feet of horizontal tunnel below the chute was rolled out of sheet metal, and the 160 feet of open cut was shaped from the same material. As the water entering the river from the spillway will have a supercritical velocity, a model of the river bed was constructed below the spillway outlet in order to observe and remedy any undesirable effects that might be produced therein. This portion of the model consisted of a watertight box with side slopes similar to those encountered in the canyon below the dam. An adjustable weir located at the downstream end of the box served to regulate the tailwater elevation below the spillway outlet.

Eight piezometers were located at various intervals down the invert of the chute in order to observe the pressures at these points. Twenty-two piezometers were installed in the right hand pier, as shown in the sketch on figure 11, in order to obtain the drop in pressure through the gate section. These were installed on both faces of the pier so the readings are representative of the entire gate section. Point gage measurements of the water surfaces were also taken above the piers, through the gate section, and at various points down the chute. The head on the crest was observed from a hook gage which was connected to the laboratory head tank. The tailwater elevation at the spillway outlet was registered directly by a piezometer connected to the tailwater box.

The Original Spillway Design

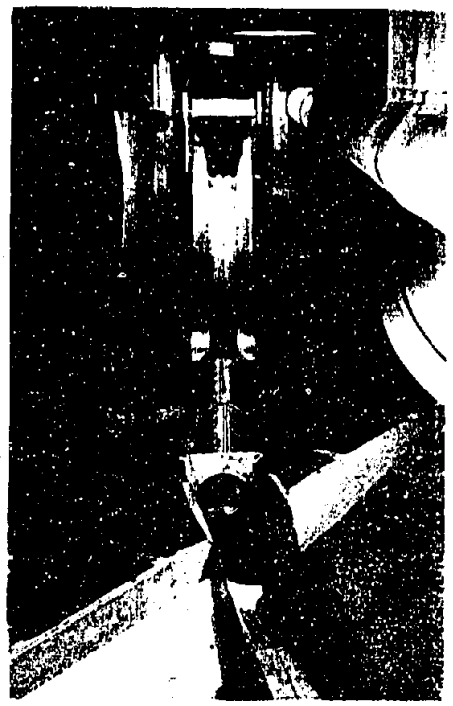
As originally designed, (see figure 5) the Seminoe spillway worked fairly well. It was quite certain, however, that a few improvements could be made. Flow through the gates was not exceptionally good, and this in turn caused the water surface in the chute to be irregular and unsymmetrical. In the original design, the beginning of the chute at the downstream end of the piers, was of horseshoe shape with a curved bottom, thus the center gate had a larger area than either of the other two and a greater discharge flowing through it. This condition caused the deeper jet issuing from the center gate to predominate in the chute.



DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CASPER-ALCOVA PROJECT-WYOMING
HYDRAULIC MODEL STUDIES
MODEL OF SEMINOE SPILLWAY
MODEL SCALE 1:60

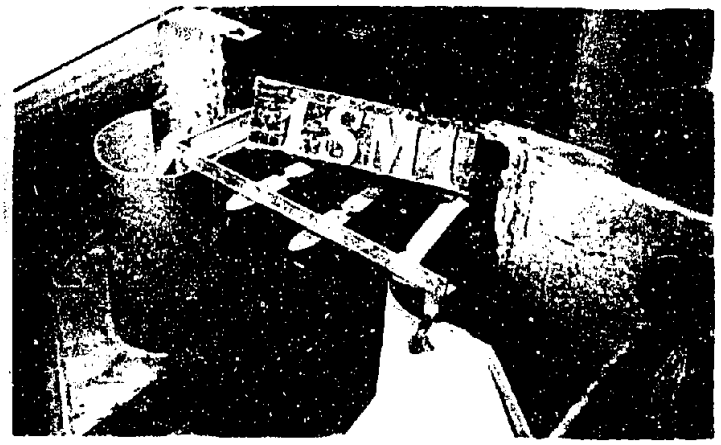
DRAWN E.C.P. SUBMITTED J. H. Bradley
TRACED R.F.W. D.R.B. RECOMMENDED
CHECKED R.F.M. APPROVED
DENVER, COLO., FEB. 18, 1958
144-D-301

FIGURE 4



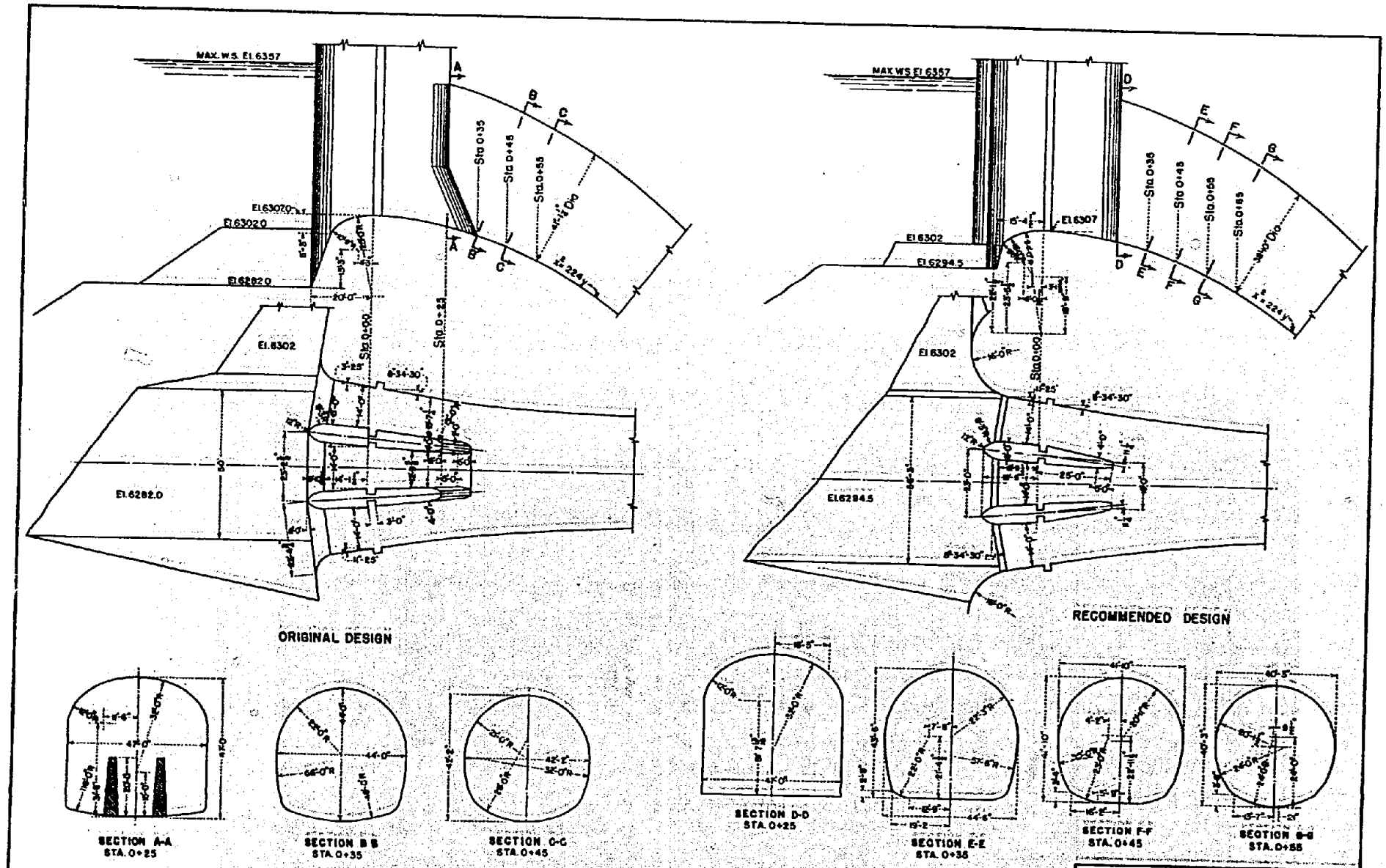
A. COMPLETE MODEL.
(CHUTE COVER ON LEFT)

B. LOOKING UP CHUTE
DISCHARGE 50,000 C.F.S.



C. ORIGINAL GATE SECTION (LOOKING DOWNSTREAM)
WITH REVISED WING WALLS.

ORIGINAL DESIGN



DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CASPER ALCOVA PROJECT—WYOMING

HYDRAULIC MODEL STUDIES

SEMINOE SPILLWAY
COMPARISON OF ORIGINAL AND RECOMMENDED DESIGNS

DRAWN A.H.R. SUBMITTED J. L. Bradley
TRACED F.P.C. & K.B. RECOMMENDED
CHECKED R.H.V. APPROVED

DENVER COLO. FEB. 13, 1958. 144-D-342

FIGURE 8

This, together with an abrupt transition section directly below the piers, caused a large part of the water from the outer two gates to converge toward the center and ride on top of the water issuing from the center gate. As a result, a large fin formed down the center of the chute. Flow through the outer gates was not symmetrical, which from all indications was due to the unsymmetrical approach to the gate section. Flow in the chute was noisy, and this condition would be objectionable in the prototype as vibration might result. After reaching the vertical curve at the lower end of the chute, the centrifugal force created in that vicinity smoothed out the surface of the water making possible a very satisfactory flow in the horizontal tunnel. The photographs on plate I show the model as originally designed. Photograph A is a view of the entire model with the chute cover removed, and B shows a discharge of 50,000 c.f.s. flowing down the chute. Photograph C, is a view of the original gate section looking downstream.

Preliminary Revisions on the Original Spillway

Extensive tests were made on the original model with numerous minor changes, in an effort to improve flow conditions through the gates and in the chute before any definite measurements were recorded. This being the case, a brief summary of the procedure and the results obtained follows:

Installation of Hinged Piers

As a first effort to improve the flow through the gates and eliminate the objectionable fin down the center of the chute, a set of piers was constructed identical with the original ones except that the tailpieces (downstream of the gates) were hinged to the fore part as shown in the sketch on figure 6. The stationary portions of the piers were mounted on the crest in the very same positions as were the originals. The hinged tailpieces however, could be set in any position desired while the model was in operation. It was found that spreading the tailpieces outward from their original settings, produced a larger and more irregular fin. By toeing the tailpieces in toward the center line of the spillway, the fin was somewhat reduced in size. If the tailpieces were toed in an extreme amount, the fin directly below the gate section was further reduced in size but objectionable side fins were created in the lower portion of the chute. An interesting but aggravating problem to the test crew, was the fact that flow conditions changed as the water progressed down the chute. In other words, when flow conditions were satisfactory at the upper end, they were usually unsatisfactory at the lower end and vice versa. From results obtained on chutes of various designs testedin the laboratory on previous occasions, it was generally found that flow down a chute occurs with various surface forms, and if the chute is long enough and other conditions favorable, these forms may tend to repeat at intervals.

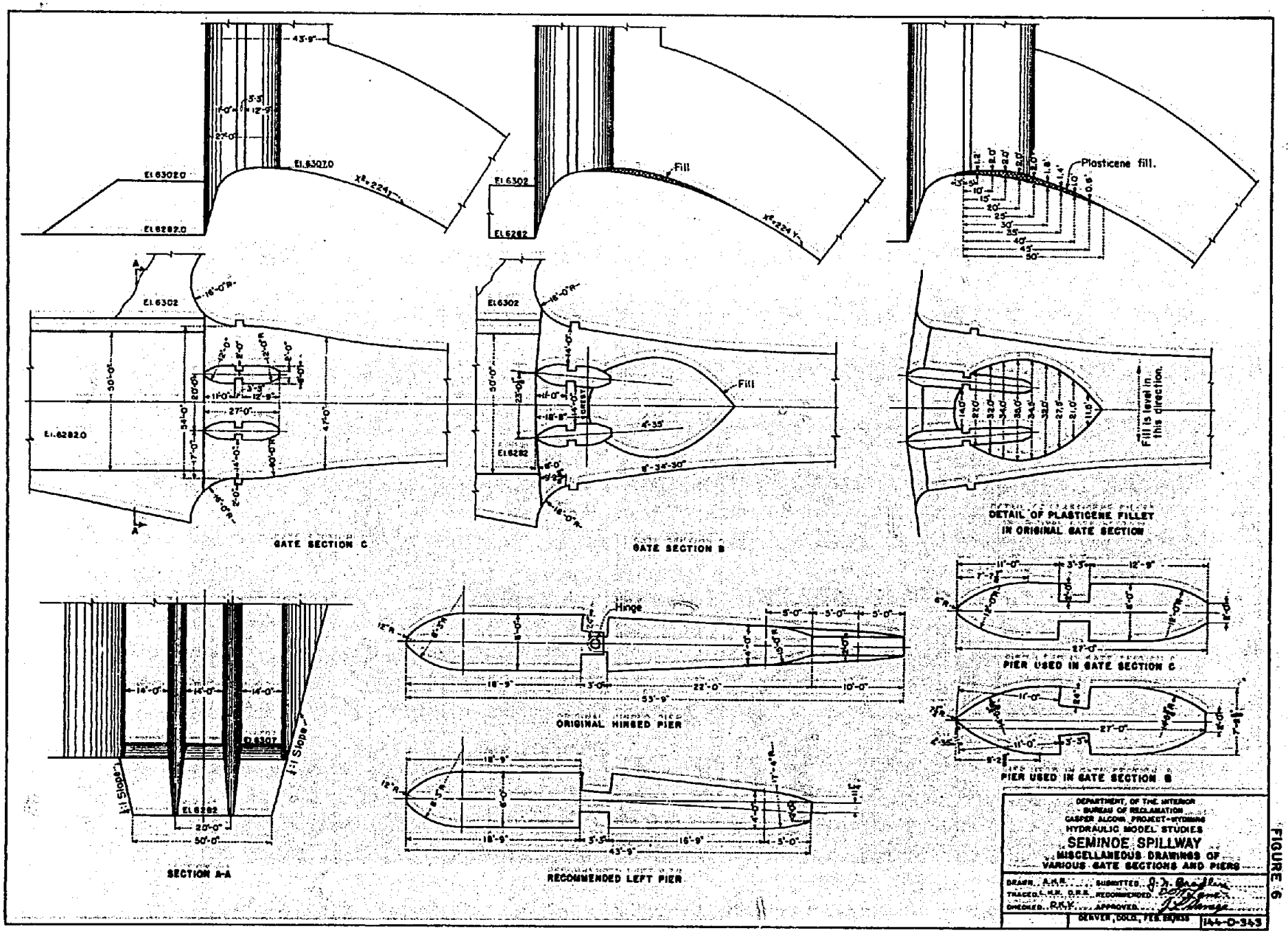

GATE SECTION C
GATE SECTION B
DETAIL OF PLASTICENE FILLET IN ORIGINAL GATE SECTION
Plasticene fill.
Fill is level in this direction.
PIER USED IN GATE SECTION C
PIER USED IN GATE SECTION B
ORIGINAL HINGED PIER
RECOMMENDED LEFT PIER
SECTION A-A
Hinge
Fill
1:1 Slope
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CASPER ALCOVE PROJECT-WYOMING
HYDRAULIC MODEL STUDIES
SEMINOE SPILLWAY
MISCELLANEOUS DRAWINGS OF VARIOUS GATE SECTIONS AND PIERS
DENVER, COLO., FEB. 1963
144-D-343

FIGURE 6

Floor Raised in Upper Portion of Chute

As there was a very sudden change in the slope of the chute floor just below the center gate which was not true of the slope below the outer two gates, an idea was conceived that filling in the invert in the upper part of the center of the chute with some material would decrease the depth of flow through the center gate and perhaps aid in correcting the difficulties encountered with surface fins. Plasticene (a commercial modeling clay) was pressed into place below the center gate forming the fill shown on figure 6. Trial runs were then made with the long hinged piers installed on the crest. The tailpieces were adjusted to give the best flow conditions, and it was found that the addition of the fill made a very noticeable improvement. Flow through the outer two gates however, was still unsymmetrical.

Revision of Wing Walls

An investigation showed that approach conditions to the right gate were superior to those to the left. A curved wall consisting of a flexible piece of sheet metal which could be bent to any desired radius was installed just above the left gate forming a continuation of the left wall of the gate section. Runs were then made to determine the curvature which would produce the best flow through the gates. It was found that the larger the radius used, the better were the resulting approach conditions. As a conservative limit, a wing wall having a radius of 16 feet was adopted. A similar wall having the same radius was installed on the right side of the gate section. The recommended design on figure 5 shows a plan of these walls, and photographs C, on plates I, II and IV show views of the same. With the fill in the upper portion of the chute invert and the reconstructed wing walls, flow through the gates and in the chute was much improved.

Gate Section B

Gate section B was similar to the original design with the exception that short piers were installed and the gates were moved upstream as shown in "Gate Section B" (figure 6). The plasticene fill was left in the invert in the upper part of the chute. Contrary to expectations, flow conditions were quite unsatisfactory and testing was discontinued on this setup.

The plasticene fill was removed, the gate section was dug out so as to make the floor much flatter in cross section without disturbing the center line elevations, and the long hinged piers were again installed. Flow was somewhat better but still not very satisfactory.

Gate Section C

In a further effort to improve the flow through the gates, the design department submitted another gate section designated as "Gate

Section C" (figure 6) which was rectangular in cross section throughout, and in which the sudden change in slope below the center gate was eliminated. The piers and side walls were all parallel to the center line of the spillway. The model was revised to conform with the new design. Photograph C (plate II) is a view of the gate section, looking downstream. With the short piers installed, nothing but mediocre results were obtained.

Long Hinged Piers Installed

The short piers were replaced by the original long hinged piers. In this case, the stationary portions of the piers were set parallel to the center line of the spillway. Trial runs were made while the tailpieces were adjusted to a position which gave the best flow conditions. The run in which the best flow was obtained for gate section C is shown plotted as test 11-1 on figure 7. The tailpiece on the right pier was toed in 3.12 feet toward the center line of the spillway and the tailpiece on the left pier was toed in 1.88 feet. It was found throughout these tests that in the majority of cases, the best results were obtained when the right tailpiece was toed in a greater amount than the left. This was necessary in order to compensate for the lack of symmetry in the approach structure. Approach conditions are very important in a spillway of this type, especially when large heads are involved. The profile of test 11-1 (figure 7) represents the water surface elevation on the center line of the spillway, and the sections shown were taken at the points indicated. An inspection of the sections show a considerable amount of irregularity in the water surfaces. Photographs A and B (plate II) show a discharge of 50,000 c.f.s. flowing down the chute with the long piers installed in gate section C. The pier tailpieces were set as shown in test 11-1.

Approach Channel Floor Raised

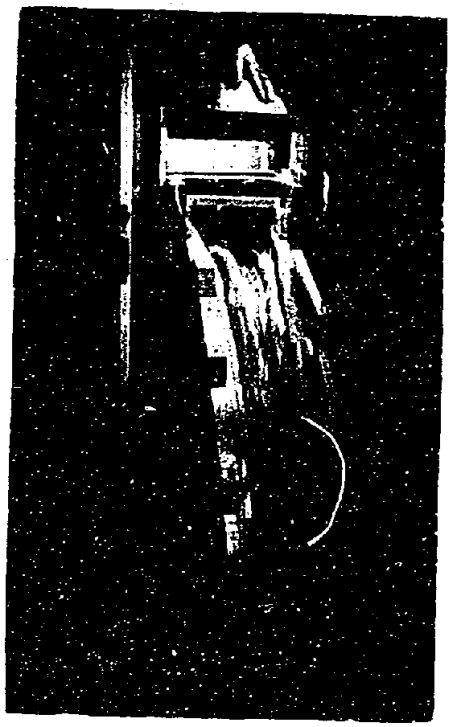
The approach channel to the gate section was presumably deeper than necessary and a series of runs were made as an investigation. The floor of the channel was raised by means of a succession of accurately fitted boards and the head at maximum discharge measured for each condition. The elevation of the raised channel floor is plotted against the observed head on the crest in each case in graph B, figure 13. The curve shows that for maximum discharge, the floor of the channel can be raised 12.5 feet (up to elevation 6294.5) without affecting the head on the crest. In all subsequent tests, the channel floor was at this elevation.

The Recommended Gate Section

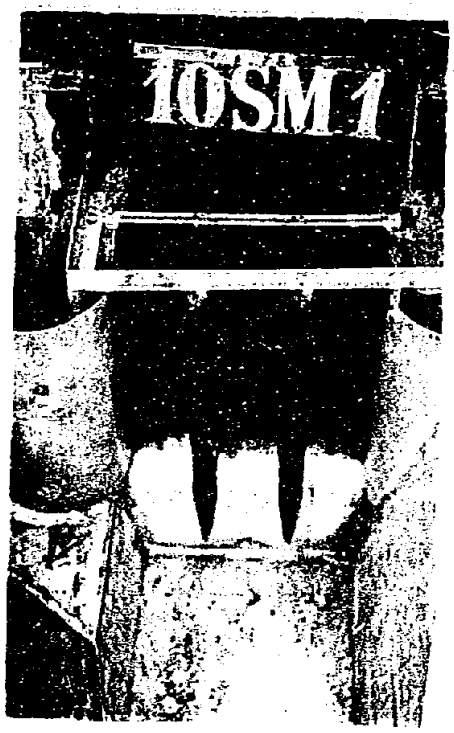
Resume of Pier Settings

The gate section was again revised to correspond to the drawing titled "The Recommended Design" shown on figure 5. Photograph C (plate IV)

A. LOOKING UP CHUTE
DISCHARGE 50,000 C.F.S.



B. ANOTHER VIEW OF SAME RUN
DISCHARGE 50,000 C.F.S.



C. VIEW OF REVISED GATE SECTION "C".

GATE SECTION "C".

FIGURE 7

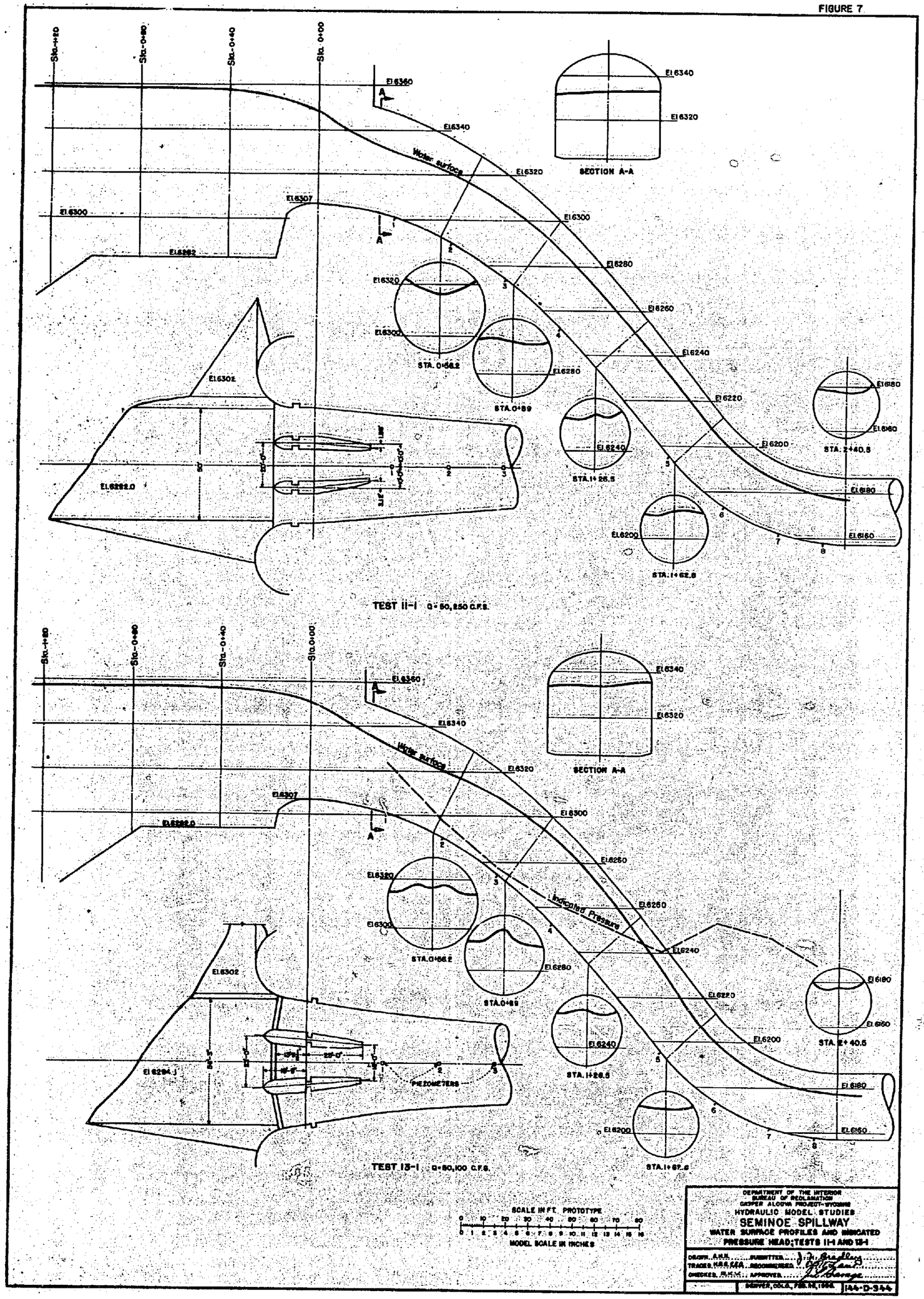


Fig. 7

shows a view of this gate section, looking downstream. The floor of the approach channel is at elevation 6294.5, the 16 foot radius wing walls are installed, and the long hinged piers are set symmetrically in the gate section. A plot of this layout for a run of 50,000 c.f.s. is shown as test 13-1 on figure 7. Notice the center fins in the sections taken at stations 0+56.2, 0+89.0, and 1+26.5 and the side fins at station 2+40.5. Photographs A and B (plate III) are two views of the water flowing down the chute at maximum discharge. Photograph C, is a view of the water approaching the gate section.

A number of runs were made on the recommended gate section with the pier tailpieces set in various positions in order to find a setting that would produce the best flow through the gates and down the chute. Profiles and sections of the water surfaces for a few of these settings are included in this report in order to impress upon the reader the importance of the pier positions in the proper operation of a spillway of this type. Tests 15-1 and 16-1, plotted on figure 8, show the water surfaces in the gate section and chute for the maximum discharge when the right tailpiece was toed in 0.47 foot and 0.94 foot respectively. The tailpiece on the left pier remained untouched during these two tests.

Test 14-1 (figure 9) shows a plot of the water surface when both tailpieces were toed in 0.47 feet toward the center line of the spillway. Test 17-1 (figure 9) shows the water surface for maximum discharge when the right tailpiece was toed in 0.94 feet and the left tailpiece was toed in 0.47 feet. In the latter case, flow conditions were quite satisfactory.

The Recommended Pier Setting

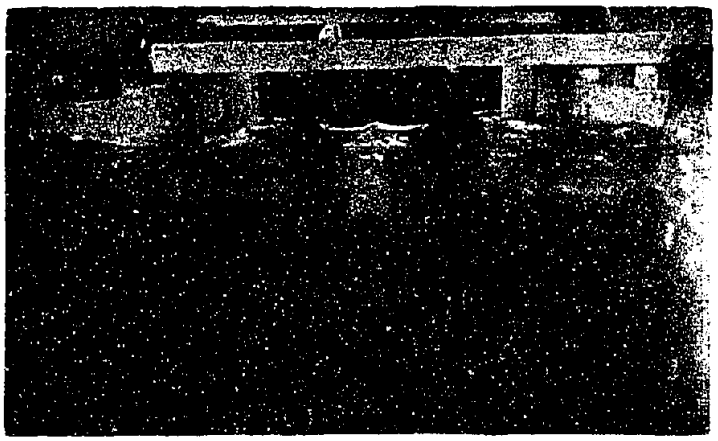
The best results using this gate section were obtained when both pier tailpieces were toed in 0.94 feet (figure 10). An advantage of this setting over the last one mentioned is that the piers are symmetrical in the gate section. Water surfaces are plotted on figure 10 for discharges of 50,000, 35,000, 20,000 and 10,000 c.f.s. These results actually are a decided improvement over those obtained in all previous tests. The water surfaces are quite irregular for the partial discharges, but for these, no serious consequences can result. To have excellent flow conditions for all discharges would require a spillway of different design. Photographs A and B (plate IV) show two views of the recommended spillway discharging at 50,000 c.f.s. Photograph C, shows the gate section, and D is a view of the complete spillway. A sketch of the left pier as recommended is shown in figure 6. The other pier is an exact opposite. It is expedient to construct them in this manner in order to preserve the symmetry of the upper portion of the gate section.

Piezometer Pressures in Chute

Pressures obtained from the eight piezometers which were located along the invert of the chute are plotted on figures 7 to 10 inclusive. An

A. PIERS SET AS DESIGNED
DISCHARGE 50,000 C.F.S.

B. ANOTHER VIEW OF SAME RUN
DISCHARGE 50,000 C.F.S.



C. FLOW APPROACHING GATE SECTION
DISCHARGE 50,000 C.F.S.
HEAD ON CREST 51 FEET.

FINAL GATE DESIGN.

FIGURE 8

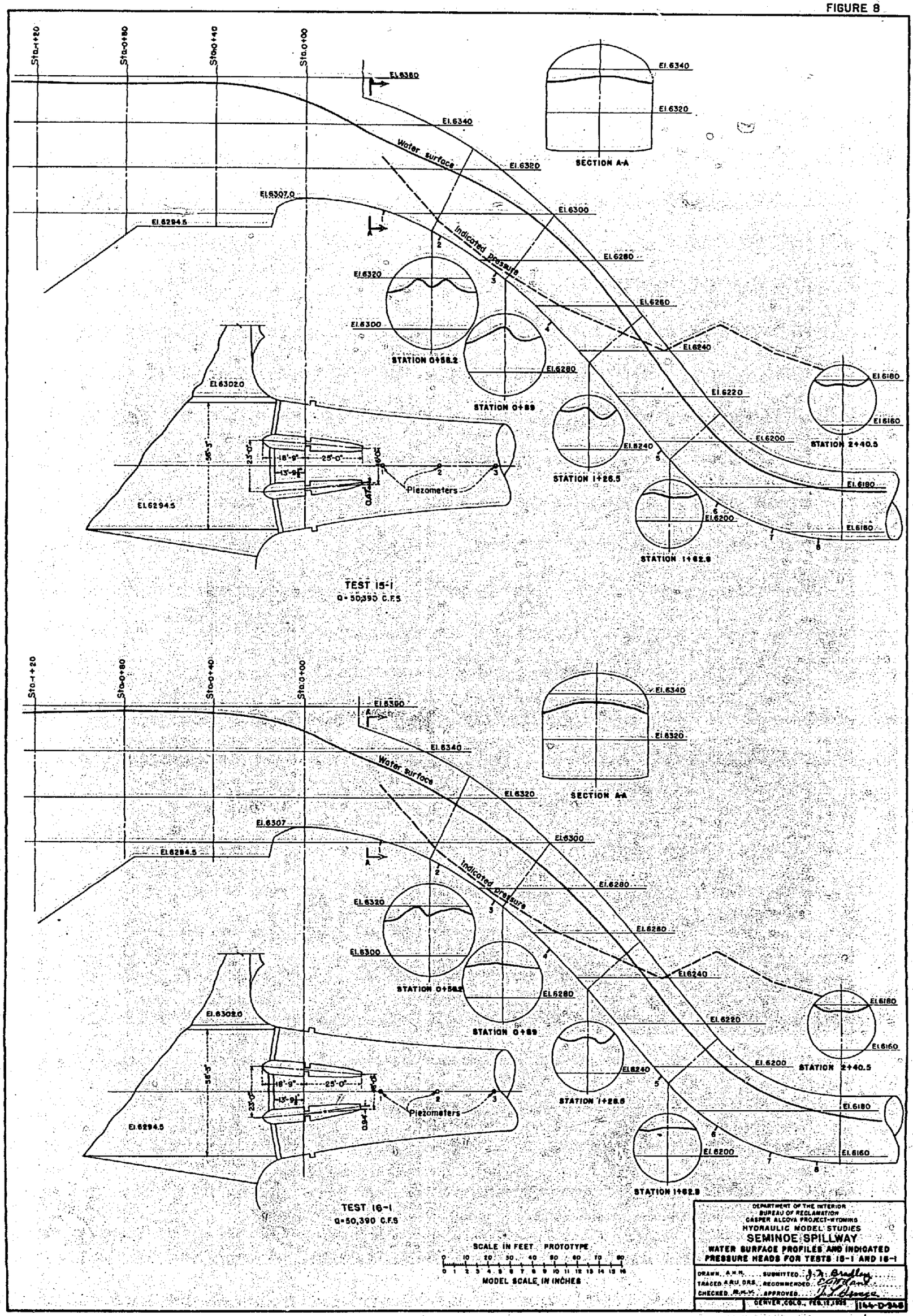


Fig. 8

FIGURE 9

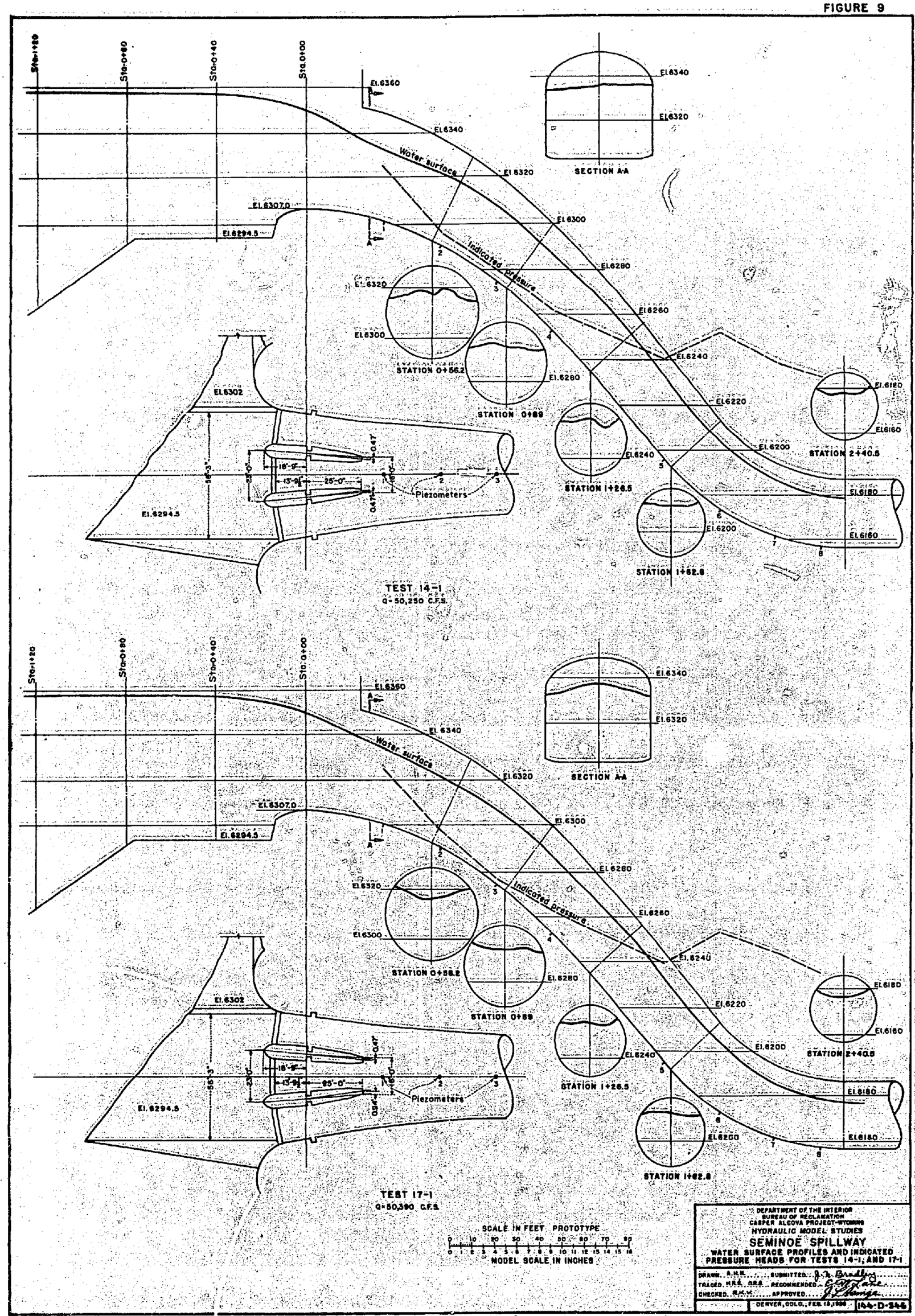


Fig. 9

FIGURE 10

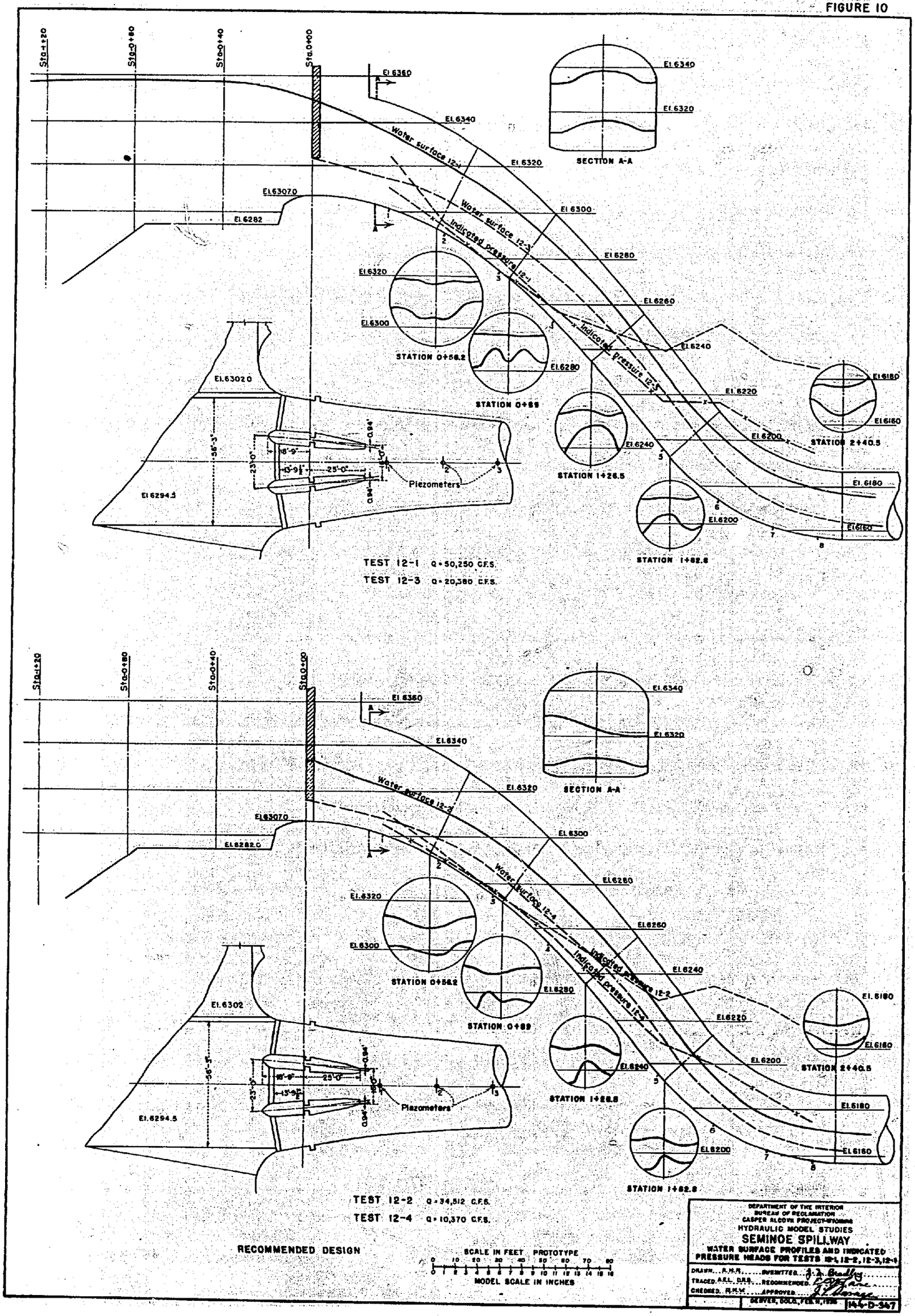
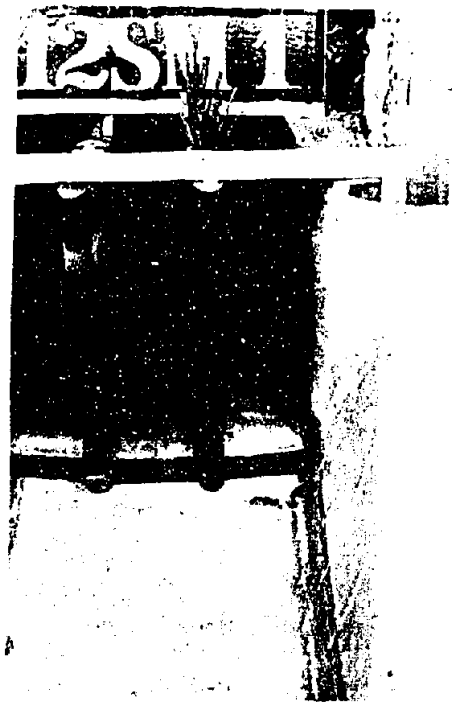


Fig. 10

A. PIERS TOED IN 0.94 FEET
DISCHARGE 50,000 C.F.S.

B. [illegible]
DISCHARGE 50,000 [illegible]



C. FINAL GATE SECTION WITH
APPROACH FLOOR RAISED

D. COMPLETE MODEL AS
RECOMMENDED

RECOMMENDED SPILLWAY DESIGN.

examination of these show that all pressures measured were above atmospheric.

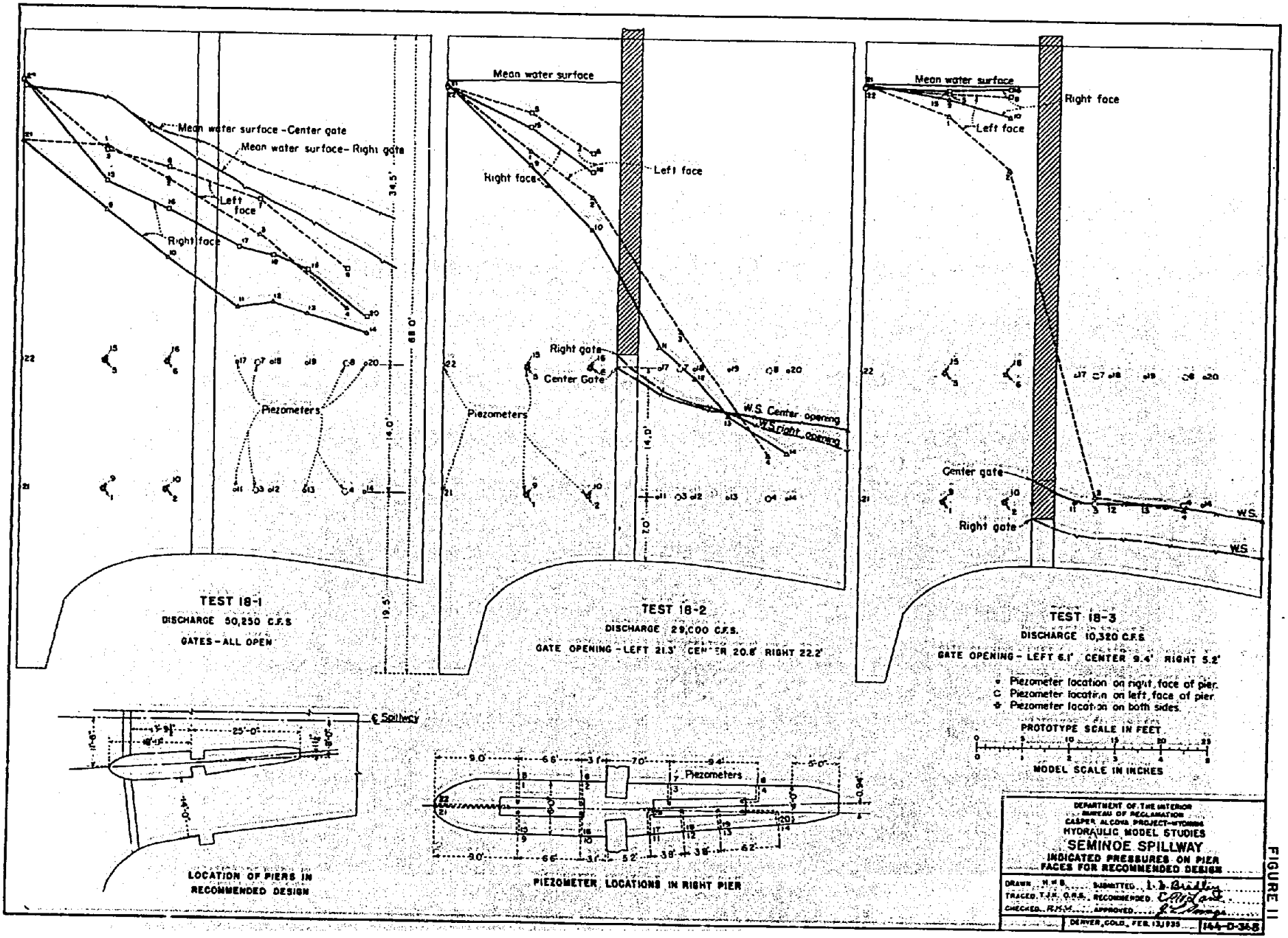
Piezometer Pressures on Right Pier

Pressures registered by the twenty-two piezometers which were installed in both faces of the right pier are plotted for three discharges on figure 11. The locations of these piezometers in the pier are shown in one of the sketches on figure 11. Notice that for a discharge of 50,250 c.f.s. the water surface in the center gate is higher than that in the right gate. Likewise, the piezometer readings in the center gate are greater than those in the right gate. It is necessary that the water surface be higher in the center gate than in the outer two if fin formation is to be reduced to a minimum. A second reason why the piezometers on the left side of the pier read higher than those on the right is that the general direction of flow is not parallel to the piers. This would cause the piezometers on the left face to register some velocity head, while those on the right face probably read less than the actual static head. The piezometers below the gates for discharges of 29,000 and 10,320 c.f.s. (figure 11) verify this statement as some of them show readings which are above the water surface. The plot for 29,000 c.f.s. illustrates this point in another way. Although the right gate is open a greater amount than the center gate and the water surface is higher below the right gate than the center, the piezometers below the center gate indicate pressures larger than those below the right gate. The indicated pressures are difficult to analyze, however, they should be representative of those that actually do exist at the points where measured.

Gate Operating Schedule

A gate operating schedule which proved very satisfactory on the model is shown on figure 12. It was obtained by setting the three gates so as to give the best flow conditions for various discharges. The three gate openings were then plotted for each discharge. In order to obtain satisfactory flow conditions in the chute, it is necessary that the center gate be open a greater amount than the side gates for all discharges less than 40,000 c.f.s. as can be observed from figure 12. It would seem that both side gates should be operated exactly alike, but due to the inequality of approach conditions, this is not true. The approach to the right gate is superior to that on the left, consequently it is necessary that the right gate be open a greater amount than the left for discharges of less than 40,000 c.f.s. This schedule was obtained using maximum head on the gate (reservoir elevation = 6357.0) as it was assumed that the Stoney gates would not be opened until the water surface in the reservoir approached this elevation.

Very poor flow results when all gates are opened an equal amount for discharges of less than 40,000 c.f.s. A side gate should not be


Mean water surface - Center gate
Mean water surface - Right gate
Left face
Right face
Piezometers
34.5'
68.0'
14.0'
19.5'
TEST 18-1
DISCHARGE 50,250 C.F.S.
GATES - ALL OPEN
Mean water surface
Left face
Right face
Right gate
Center Gate
W.S. Center opening
W.S. Right opening
TEST 18-2
DISCHARGE 29,000 C.F.S.
GATE OPENING - LEFT 21.3' CENTER 20.8' RIGHT 22.2'
Mean water surface
Right face
Left face
Center gate
Right gate
W.S.
TEST 18-3
DISCHARGE 10,320 C.F.S.
GATE OPENING - LEFT 6.1' CENTER 9.4' RIGHT 5.2'
• Piezometer location on right face of pier.
C Piezometer location on left face of pier
✱ Piezometer location on both sides.
PROTOTYPE SCALE IN FEET
MODEL SCALE IN INCHES
℄ Spillway
25'-0"
LOCATION OF PIERS IN RECOMMENDED DESIGN
Piezometers
PIEZOMETER LOCATIONS IN RIGHT PIER
DEPARTMENT OF THE INTERIOR
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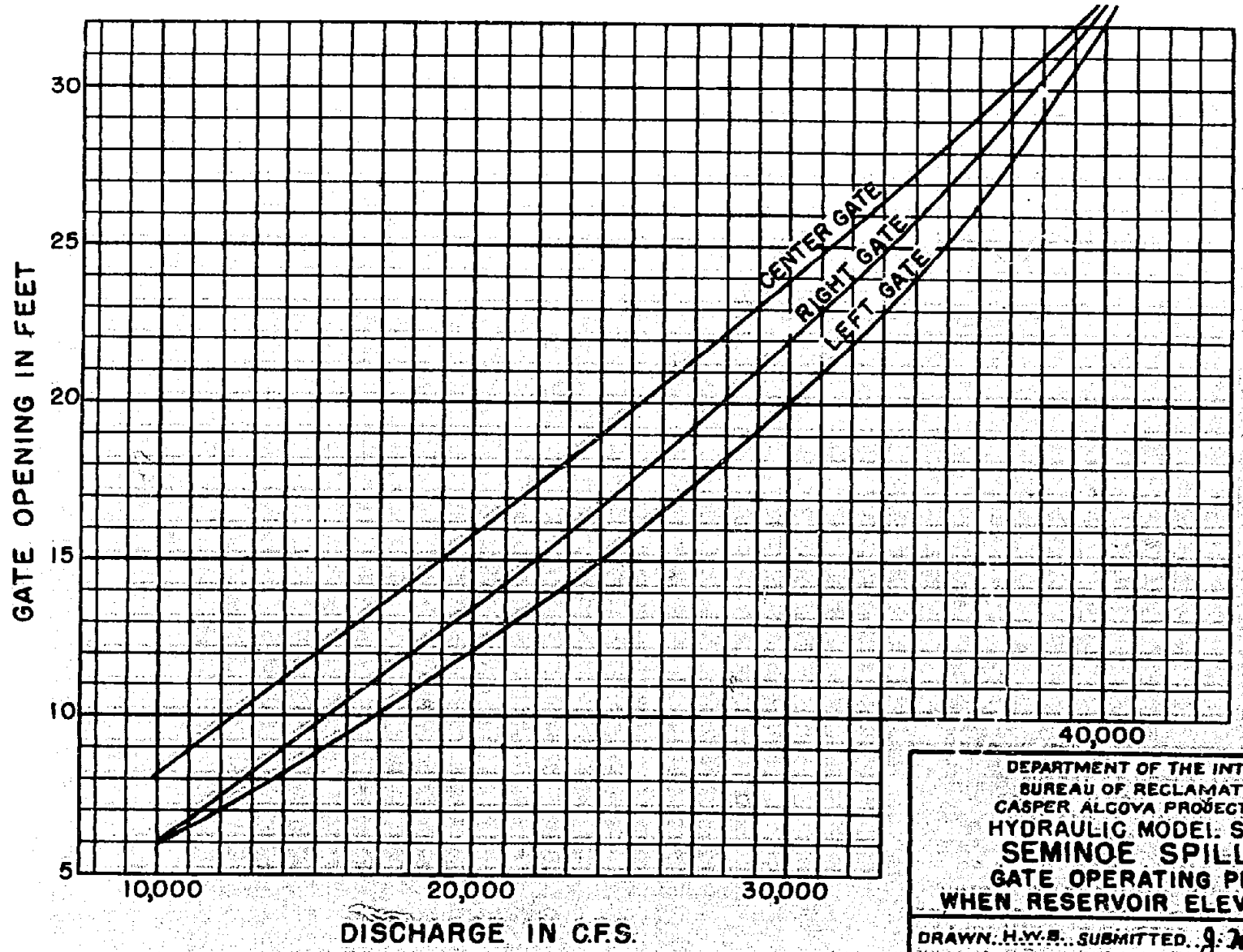
CASPER ALCOVA PROJECT-WYOMING
HYDRAULIC MODEL STUDIES
SEMINOE SPILLWAY
INDICATED PRESSURES ON PIER FACES FOR RECOMMENDED DESIGN
DRAWN N.W.B. SUBMITTED
TRACED T.J.K. O.R.S. RECOMMENDED
CHECKED R.H.M. APPROVED
DENVER, COLO., FEB. 13, 1935
144-D-365

FIGURE 11



NOTE: These curves were obtained with maximum head on the crest.

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HYDRAULIC MODEL STUDIES
SEMINOE SPILLWAY
GATE OPERATING PROGRAM
WHEN RESERVOIR ELEV. IS 6357

DRAWN H.W.B. SUBMITTED J. A. Bradley
TRACED O.R.S. RECOMMENDED G. H. Paste
CHECKED R.K.V. APPROVED H. E. Savage
DENVER, COLO., JAN. 28, 1935 144-D-349

FIGURE 12

operated separately or in conjunction with the center gate except in cases of necessity. Either the center gate alone or a combination of all gates should be used.

The Head Discharge Relation and the Coefficient of Discharge

The relation of head on the crest to discharge was obtained from the model of the recommended design with all gates fully open. A curve showing this relation is plotted on graph A (figure 13). For the maximum designed discharge of 50,000 c.f.s., a head of 51 feet on the crest is required. An explanation is necessary at this point as to why the head on the crest for the maximum discharge in graphs A and B (figure 13) do not agree. The reason for the difference is the curve on graph B was obtained from gate section C and the curves on graph A were taken from the tests made on the recommended gate section.

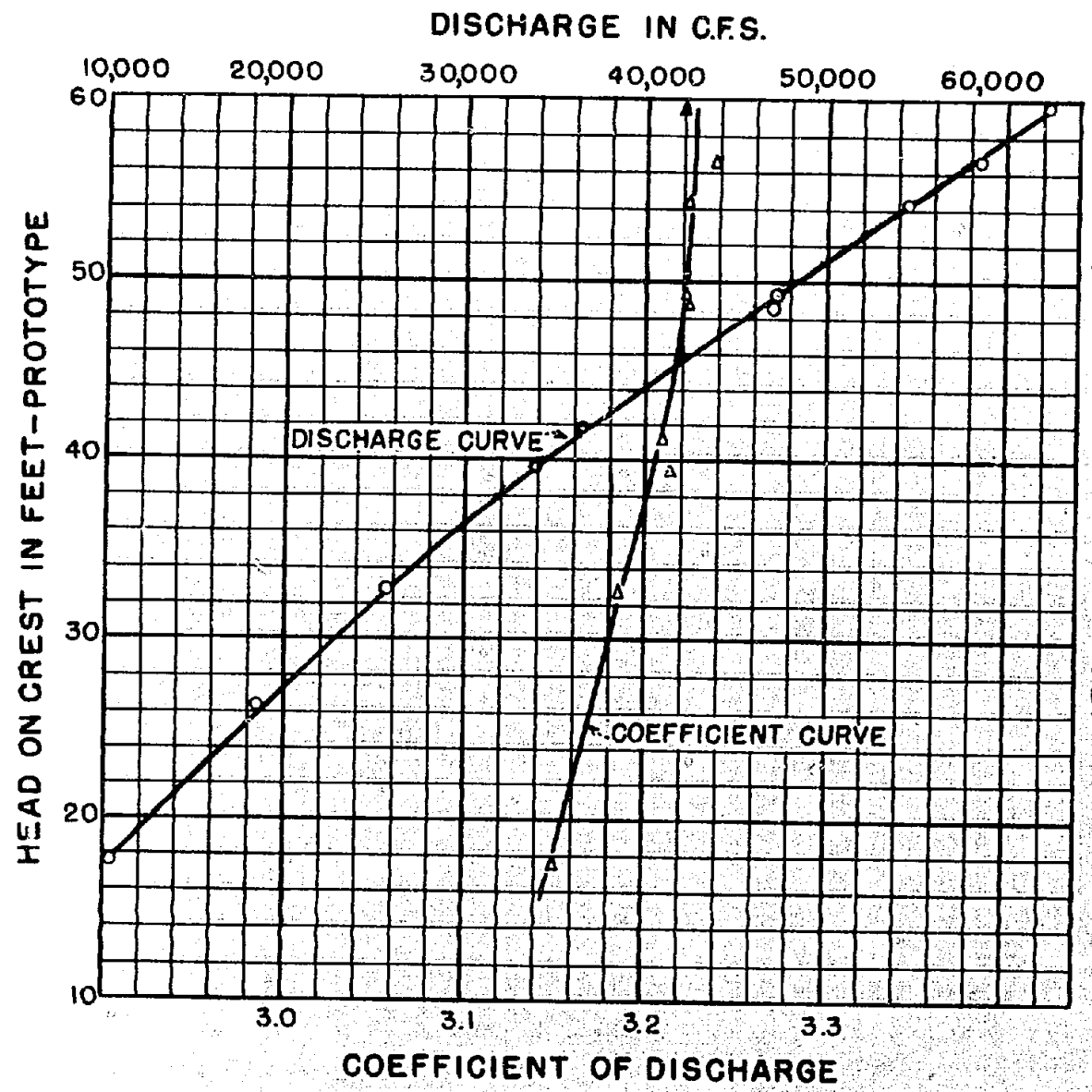
The maximum capacity of the spillway is 62,000 c.f.s., but this would require a head of 59 feet on the crest.

The coefficients of discharge for various heads on the crest were computed using the formula $Q = CLH^{3/2}$, where L is the width of the gate section exclusive of piers, and measured directly above the gate slots. A curve showing the relation of the coefficient of discharge to the head on the crest is plotted on graph A (figure 13). Coefficients were not obtained for partial gate openings.

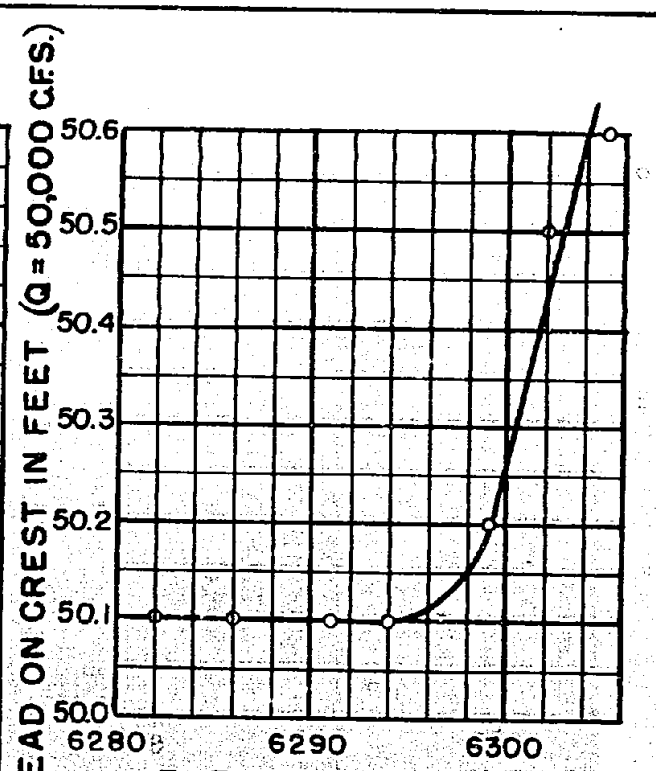
The Original Outlet Channel

Water leaving the trapezoidal outlet channel was at shooting flow and this created considerable disturbance in the river and a high splash on the opposite canyon wall. The canyon walls are composed of granite and any damage done to them or the river bed is unimportant. It is important however, that the disturbance does not extend upstream sufficiently to interfere with the proper operation of the power house. It is also essential that the jet shall not splash high enough on the far canyon wall to endanger a proposed road which will run along the river to the power house. As originally designed, the outlet channel made an angle of 10 degrees, in an upstream direction, with the center line of the spillway in order to minimize on the amount of excavation in this open cut.

The model showed that the curved channel was ineffective as far as steering the stream of water was concerned. The water climbed up the right wall, only intermittently contacting the left, and shot out into the river as a jet concentrated in a vertical plane. This incident again demonstrates the fact that it is impossible to successfully deflect water in a horizontal direction when it is flowing at a velocity above



GRAPH A



GRAPH B

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HYDRAULIC MODEL STUDIES

SEMINOE SPILLWAY

RELATION OF HEAD ON CREST TO DISCHARGE COEFFICIENT OF DISCHARGE AND ELEV. OF APPROACH CHANNEL

DRAWN H.V.B. SUBMITTED J. R. Bradley
TRACED O.R.S. RECOMMENDED C. H. Lane
CHECKED R.K.V. APPROVED J. L. Savage

DENVER, COLO., 1-29-35 | 144-D-350

FIGURE 13

critical in an open channel. The disturbance created in the river did not extend as far upstream as the power house, so aside from appearance, no harm can result. Photographs A and B (plate V) show the jet discharging into the river from the original outlet channel.

Flow in the 30 foot horizontal tunnel was very satisfactory for all discharges. For the maximum discharge of 50,000 c.f.s. the tunnel flowed slightly more than two thirds full.

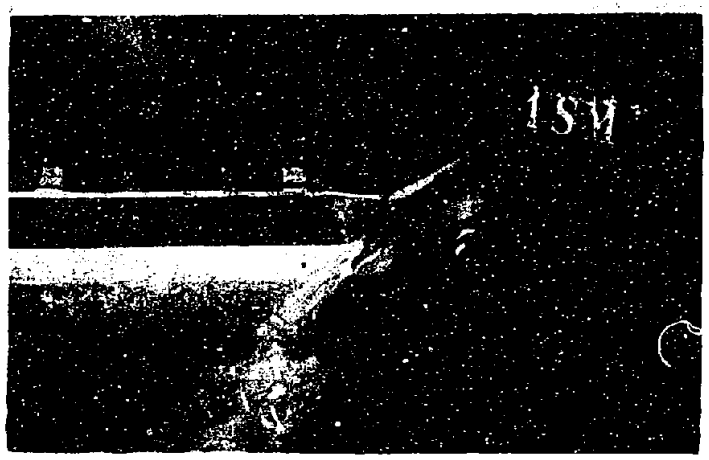
The Recommended Outlet Channel

The original trapezoidal channel was replaced by one which could be rotated in a horizontal plane. Runs were then made with the channel set at various angles, and the height of splash on the opposite canyon wall was measured. Figure 14 consists of a topographic plot of the west canyon wall with splash heights interposed on it for discharges of 50,000 and 30,000 c.f.s. These are plotted for three positions of the channel, namely; 10 degrees upstream, 0 degrees, and 5 degrees downstream with respect to the center line of the spillway. This plot should give some idea as to a safe elevation of the road on the west canyon wall. Notice that for a discharge of 50,000 c.f.s., the splash is considerably higher with the channel turned 10 degrees upstream than with it set at 0 degrees. With it set at 10 degrees upstream, the splash is 80 feet high, while for 0°, it is about 45 feet high. For the same discharge, the splash is practically identical for the channel set at 0 degrees and 5 degrees downstream. As the splash is much reduced and the general operation of the outlet more pleasing to the eye when the center line of the channel coincides with the center line of the spillway, this layout is recommended. Photographs A and B (plate V) show the jet discharging into the river for maximum discharge with the channel rotated 10 degrees upstream, and photographs C and D show the same jet discharging into the river with the channel and spillway on line as recommended.

A complete summary of all tests made on the Seminoe spillway can be found in the appendix of this report.

Acknowledgments

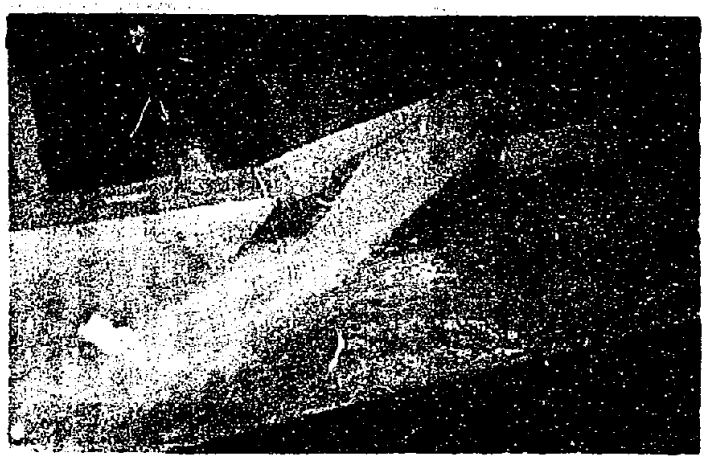
All laboratory work is under the general direction of E. W. Lane. The construction and testing of the Seminoe Stoney Gate spillway was under the supervision of J. B. Drisko. He was assisted by Junior Engineers H. M. Martin and L. R. Brooks who were in charge of construction and J. M. Buswell who directed the test crew. The office computations and the figures in this report were made by H. W. Brewer, R. K. Vierck, A. H. Neal, and E. C. Parks. The photographs were prepared by J. E. Warnock at Fort Collins.



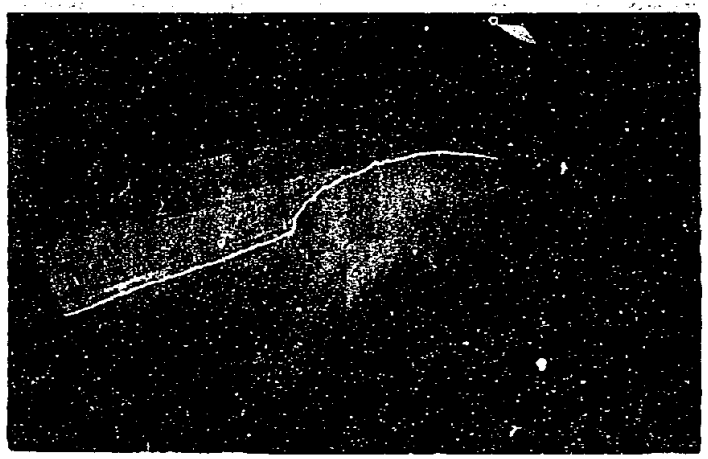
A. OUTLET CHANNEL DISCHARGING INTO RIVER
DISCHARGE 50,000 C.F.S.

B. SPLASH ON CANYON WALL
DISCHARGE 50,000 C.F.S.

ORIGINAL DESIGN
JET DIRECTED 10° UPSTREAM.



C. OUTLET CHANNEL DISCHARGING INTO RIVER
DISCHARGE 50,000 C.F.S.

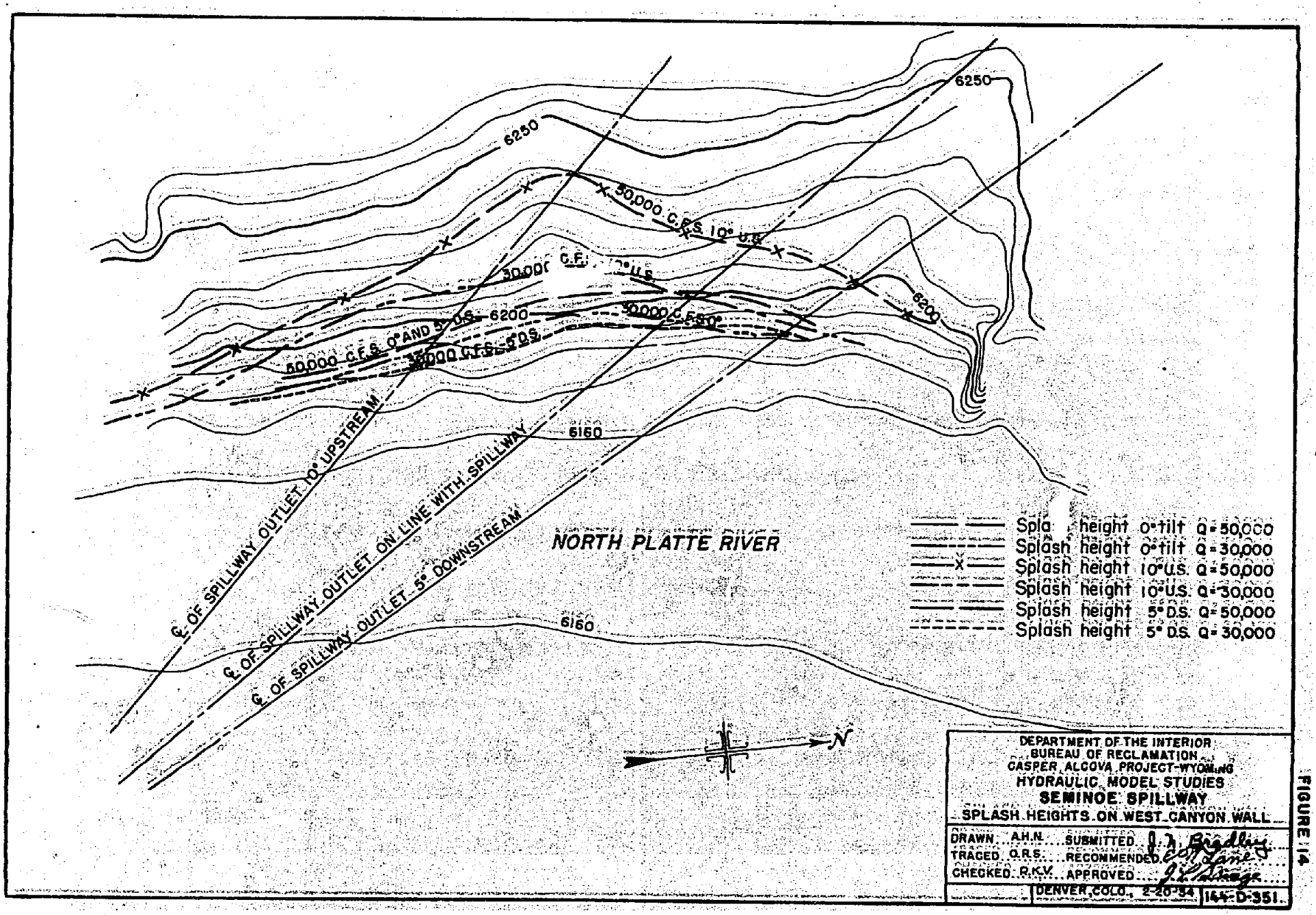


D. SPLASH ON CANYON WALL
DISCHARGE 50,000 C.F.S.

RECOMMENDED DESIGN
JET ON LINE WITH SPILLWAY.

OUTLET CHANNEL

PLATE V



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CASPER ALCOVA PROJECT-WYOMING
HYDRAULIC MODEL STUDIES
SEMINOE SPILLWAY
SPLASH HEIGHTS ON WEST CANYON WALL

DRAWN A.H.N. SUBMITTED J. J. Bradley
TRACED O.R.S. RECOMMENDED Earl Lane
CHECKED R.K.V. APPROVED J. L. Savage
DENVER, COLO., 2-26-34 144-D-351

FIGURE 14

APPENDIX

SEMINOE SPILLWAY
CASPER ALCOVA PROJECT
LOG OF TESTS

Test No.	Approach	Gate Section	Piers	Pier Setting L Ft.	Pier Setting R Ft.	Discharge C.F.S.	Head on Crest Ft.	Gate Opening in Feet L	Gate Opening in Feet C	Gate Opening in Feet R	Remarks
1-1	Original	Original	Original with Tip	C.L.	C.L.	50,000	50.0		All Open		Run with and without plasticine in the pier section.
2-1	"	"	Original	"	"	Various	Various		Various		Demonstrated-Run with and without fillet.
2-1	"	"	None	No Piers		"	"		"		Plasticine improved operation.
3-1	"	"	Orig. with Flex. Tail	C.L	C.L.	50,000	50.0		All Open		Tried various positions and curvatures of the left wing wall.
3-2	"	"	"	"	"	57,000	54.0		"		Runs greater than designed discharge.
3-3	"	"	"	"	"	62,500	--		"		Runs greater than designed discharge.
4-1	Revised	Original Revised	Long Hinged	Various	Various	Various	Various		Various		A 16' semi-circular left wing wall was used.
4-2	"	"	"	"	"	"	"		"		A 12' semi-circular left wing wall was used.
4-3a	"	"	"	C.L.	In 0.31'	"	"		"		A 20' semi-circular left wing wall was the best radius.

APPENDIX (Continued)

SEMINOE SPILLWAY
CASPER ALCOVA PROJECT
LOG OF TESTS

Test No.	Approach	Gate Section	Piers	Pier Setting L Ft.	Pier Setting R Ft.	Discharge C.F.S.	Head on Crest Ft.	Gate Opening in Feet L	Gate Opening in Feet C	Gate Opening in Feet R	Remarks
4-3b	Revised	Original Revised	Long Hinged Without Tailpieces	C.L.	In 0.62'	Various	Various		Various		A 16' semi-circular left wing wall was used.
4-3c	"	"	"	"	"	"	"		"		Extended right side instead of using radius. 16' radius on left wing wall.
5-1	"	Gate Section B	Short	C.L.	C.L.	50,000	50.82'		All Open		Layout No. 1 demonstrated-Flow bad.
5-2	"	"	"	"	"	Various	Various		Various		Splash heights in river for discharges of 50,000-40,000-30,000-20,000-10,000 and 5,000 C.F.S.
6-1	"	"	"	"	"	"	"		"		Splash heights plotted on contour map for discharges of 50,000-30,000 and 10,000 C.F.S. - Outlet 10° upstream.
7-1	"	"	Long Hinged	"	"	50,000	49.74'		All Open		Flow satisfactory-Floor of chute entrance flattened.
8-1	"	"	"	"	"	"	50.1' to 50.6		"		Raised entrance cut and observed difference in headwater.

APPENDIX (Continued)

SEMINOE SPILLWAY
CASPER ALCOVA PROJECT
LOG OF TESTS

Test No.	Approach	Gate Section	Piers	Pier Setting L Ft.	Pier Setting R Ft.	Discharge C.F.S.	Head on Crest Ft.	Gate Opening in Feet L	Gate Opening in Feet C	Gate Opening in Feet R	Remarks
9-1a	Revised	Gate Section B	Long Hinged	C.L.	C.L.	Various	Various		Various		Same as 6-1 except that outlet is on center line of tunnel.
9-1b	"	"	"	"	"	"	"		"		Same as 6-1 except that outlet is 5° downstream.
10-1	"	Gate Section C	Short	"	"	50,000	50.1		All Open		Layout No. 2-Flow poor.
11-1	"	"	Long Hinged	In 1.88	In 3.12	50,250	51.12		"		Tunnel flow good-Chute flow rough-High fin at end of piers.
11-2a	"	"	"	"	"	20,000	50.0	13.36	13.36	13.36	Same setup as 11-1-Flow bad.
11-2b	"	"	"	"	"	20,000	50.0		Various		Same setup as 11-1 to determine the best position of the gates.
12-1	"	Recommended	"	In 0.94	In 0.94	50,250	50.70		All Open		Flow through the chute is good.
12-2	"	"	"	"	"	34,520	50.34	21.25	27.81	26.25	Same setup as 12-1.
12-3	"	"	"	"	"	20,380	50.82	11.88	16.88	13.75	Same setup as 12-1.
12-4	"	"	"	"	"	10,370	51.06	6.10	8.44	5.31	Same setup as 12-1.

APPENDIX (Continued)

SEMINOE SPILLWAY
CASPER ALCOVA PROJECT
LOG OF TESTS

Test No.	Approach	Gate Section	Piers	Pier Setting L Ft.	Pier Setting R Ft.	Discharge C.F.S.	Head on Crest Ft.	Gate Opening in Feet L	Gate Opening in Feet C	Gate Opening in Feet R	Remarks
12-5	Revised	Recommended	Long Hinged	In 0.94	In 0.94	Various	Various		Various		Coefficient of discharge runs.
13-1	"	"	"	C.L.	C.L.	50,110	51.0		All Open		High fin at center of chute.
14-1	"	"	"	In 0.47	In 0.47	50,250	50.94		"		Fin still in center of chute.
15-1	"	"	"	C.L.	"	50,390	50.94		"		Flow fairly good-Fin left side.
16-1	"	"	"	"	In 0.94	50,390	50.94		"		Flow rougher than 12-1.
17-1	"	"	"	In 0.47	In 0.94	50,390	51.18		"		About the same as 12-1.
18-1	"	"	"	In 0.94	In 0.94	50,250	51.18		"		Pier piezometer readings.
18-2	"	"	"	"	"	29,000	51.24	21.25	20.78	22.19	"
18-3	"	"	"	"	"	10,320	51.36	6.10	9.38	5.15	"
18-4	"	"	"	"	"	Various	Various		Various		Coefficient of discharge runs.