UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

STUDY OF STILLING POOL AT STATION 25 + 19 SOUTH CANAL - UNCOMPAHGRE

Hydraulic Laboratory Report No. 200

ENGINEERING AND GEOLOGICAL
CONTROL AND RESEARCH DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

APRIL 10, 1946

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Engineering and Geological
Control and Research Division
Denver, Colorado
April 10, 1946
(Originally prepared May 7, 1936)

Laboratory Report No. 200
Hydraulic Laboratory
Compiled by: C. W. Thomas

Reviewed by J. E. Warnock

Subject: Study of flow conditions in stilling pool of chute at Station 25+19 in the South Canal of the Uncompahgre Project.

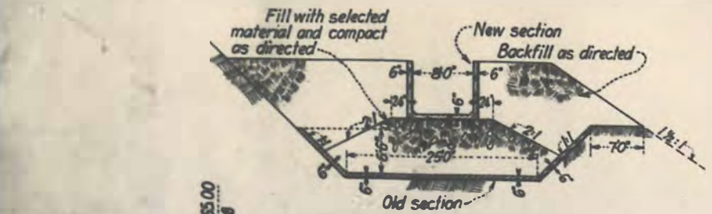
INTRODUCTION AND SUMMARY

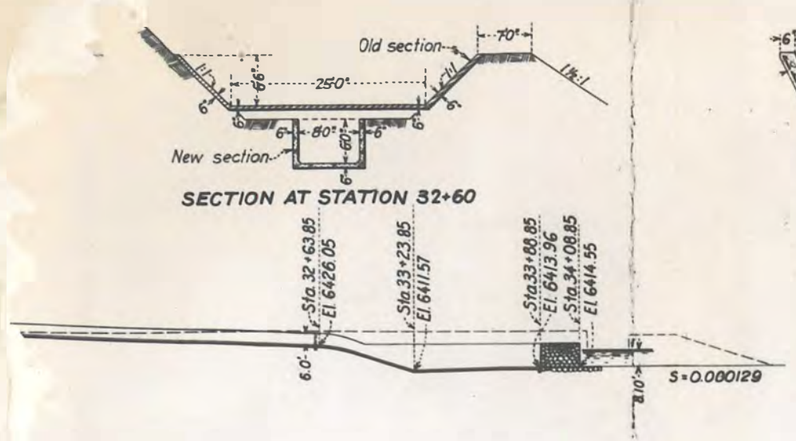
Purpose of investigation. When water was turned into the South Canal about April 1, 1936, some discussion arose concerning the action of the stilling pool of the chute at station 25+19, constructed during the winter 1935-36, figures 1 and 2. In order to ascertain if flow conditions in the structure are the same as those indicated by the model tested in the Denver laboratory of the Bureau of Reclamation (Technical Memorandum No. 458) and whether or not the existing field conditions are the same as those under which the model was tested, pictures were taken and visual observations were made of the flow conditions in the stilling pool. Data were also taken from a staff gage set in the tailwater and from the recording gage operated by the Uncompahgre Valley Water Users Association (figure 3A). From data received from Mr. Tobin, hydrographer for the Water Users Association, a rating curve was plotted for the canal section above the chute (figure 4).

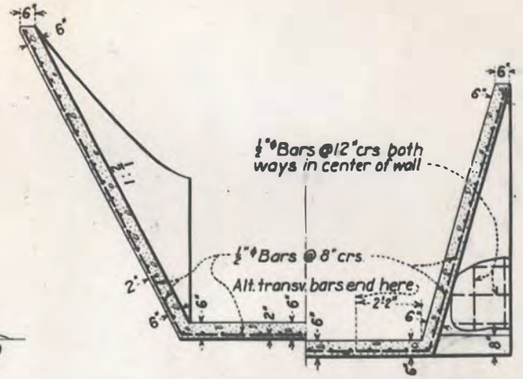
This report is very brief and contains merely an outline of what has been done and the observations and conclusions of the engineers stationed at the Montrose Hydraulic Laboratory. The report has been prepared for the purpose of recording what has been accomplished and to stimulate thought concerning future procedure.

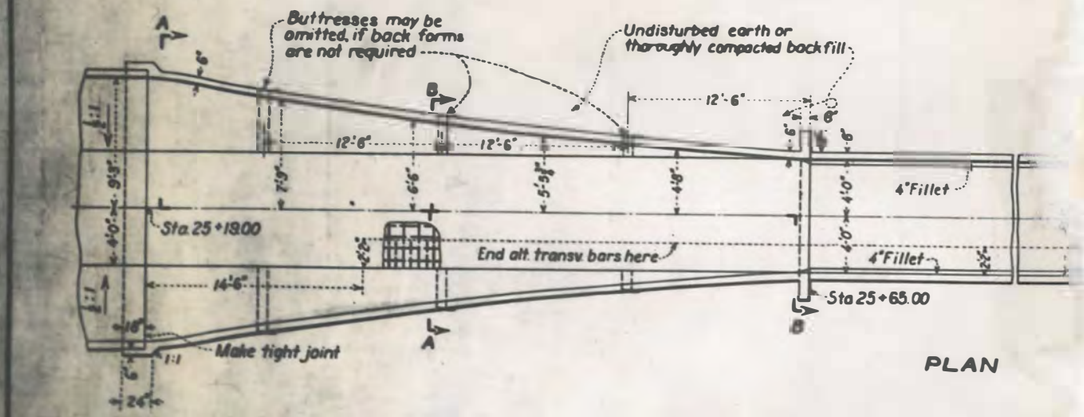
Summary and conclusions. Observations made of flow conditions in the stilling pool of the chute at station 25+19 on the South Canal have led to the following conclusions.

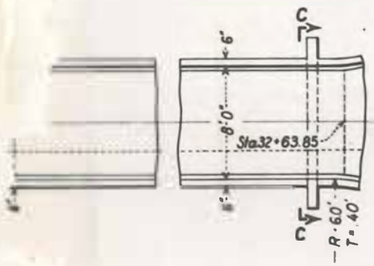
SPECIFICATIONS NO. 636

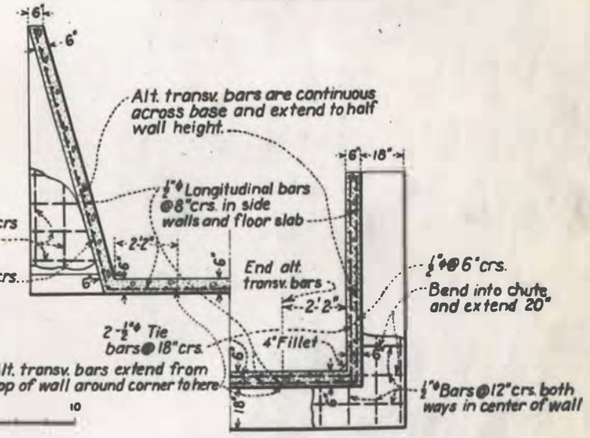


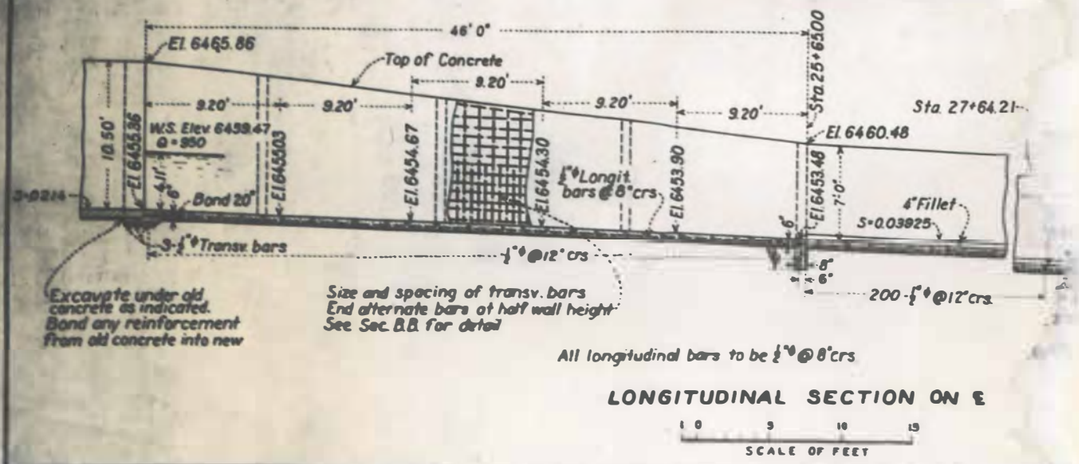


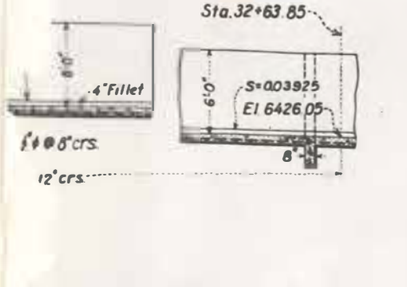


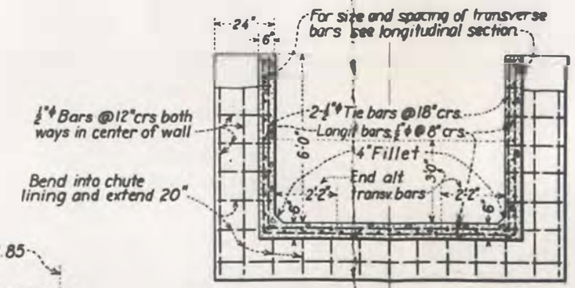












NOTES

All reinforcement shall be placed so that the centers of bars in the outer layer are 2" from face of concrete, unless otherwise shown.
Lap bars 40 diameters at splices.
Thickness of slabs to vary uniformly between dimensions shown.
Stations and elevations shown on profile refer to invert, unless otherwise noted.
Base of entire structure, including transition and stilling pool, to be placed on undisturbed earth or thoroughly compacted backfill.

ESTIMATED QUANTITIES

ENTIRE STRUCTURE

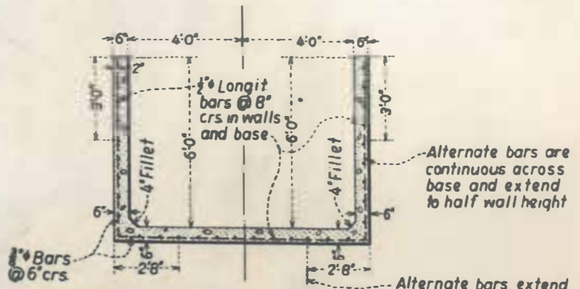
Concrete.....500 Cu. yd.
Reinforcement.....47,000 lbs.

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
UNCOMPAHGRE PROJECT-COLORADO

SOUTH CANAL STA.25+18 CONCRETE CHUTE DROP INLET AND CHUTE

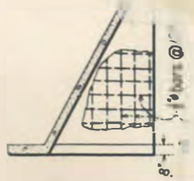
DRAWN: KEB | SUBMITTED: W.K. McBirney
TRACED: T.O.T. | RECOMMENDED: L.O. Nield
CHECKED: C.H.E. | APPROVED: O.C. Merrell

27402 | DENVER, COLORADO JAN 24 1938 SHEET 1 OF 2 | 31-D-43

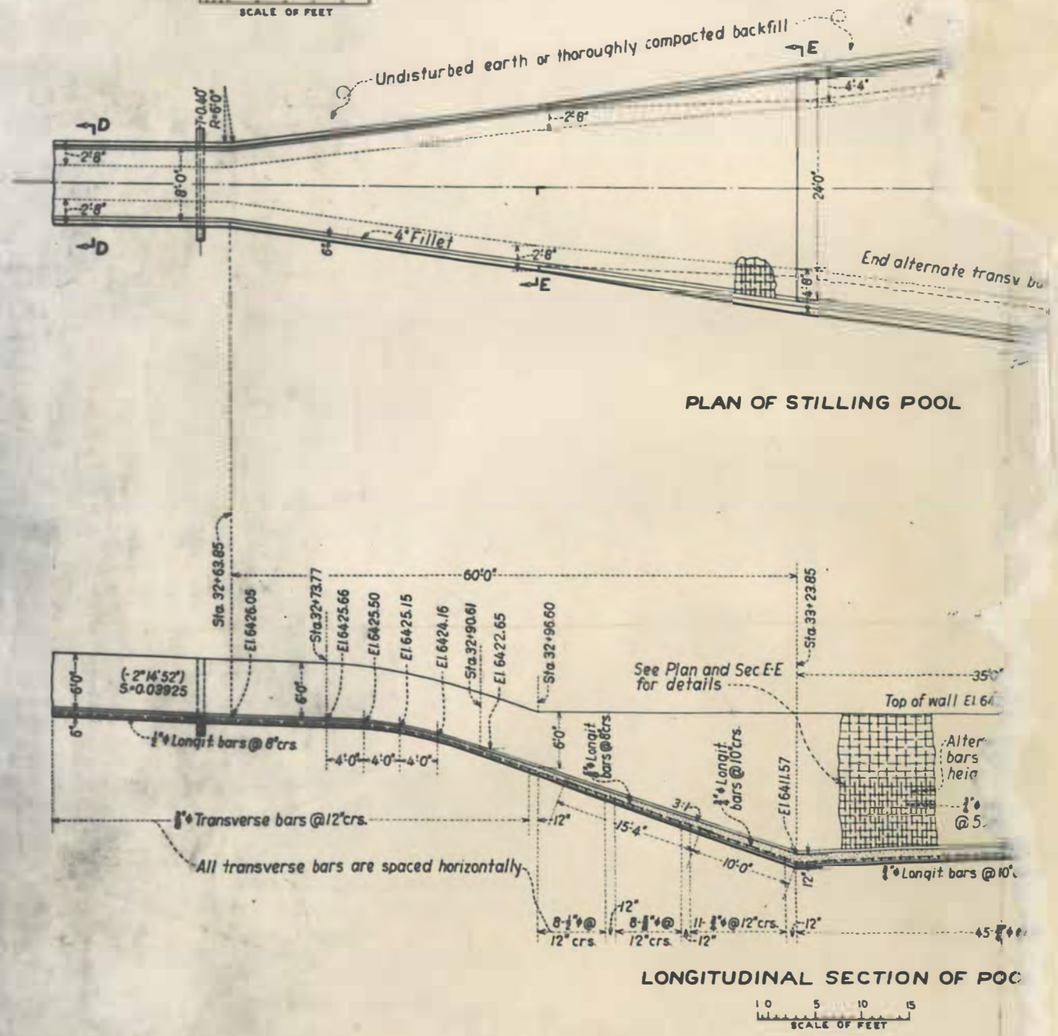


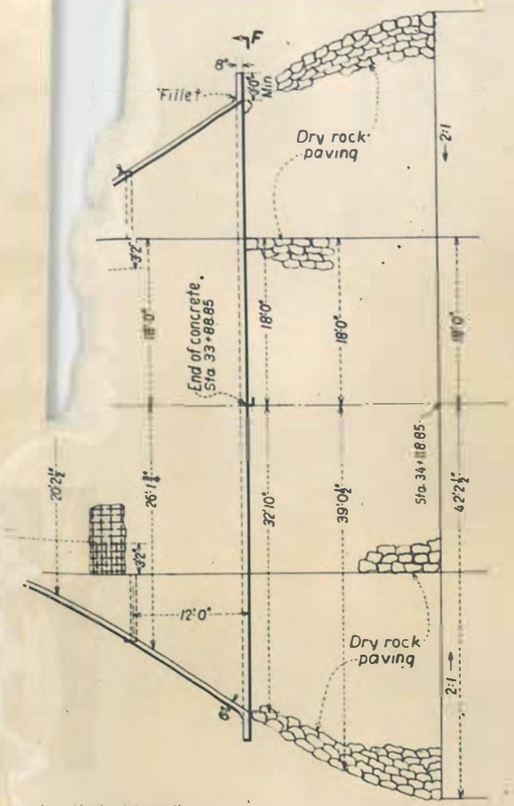
NORMAL SECTION D-D

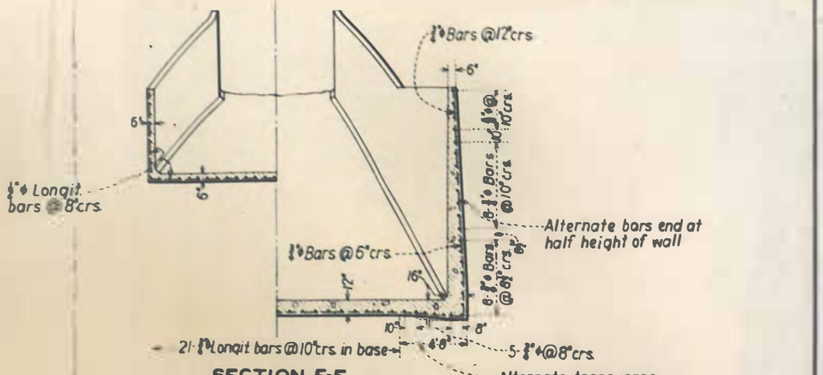
SCALE OF FEET 0 1 2 3 4 5



DETAIL OF BUT

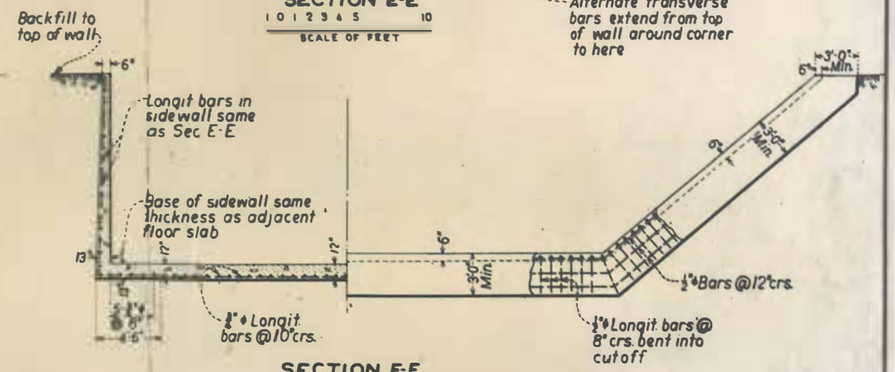




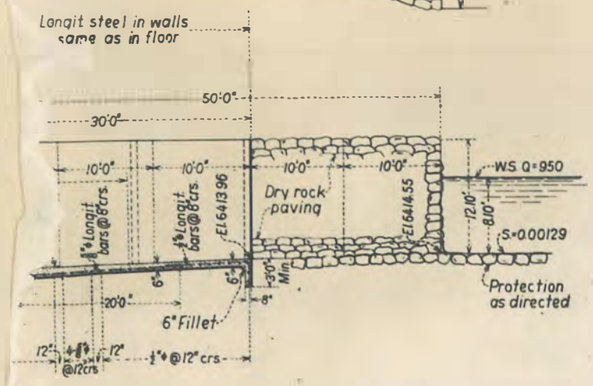


SECTION E-E

SCALE OF FEET 0 1 2 3 4 5 10



SECTION F-F



NOTES

All reinforcement shall be placed so that centers of bars in the outer layer will be 2" from face of concrete, unless otherwise shown.
Lap bars 40 diameters at splices.
Stations and elevations shown on profile refer to invert, unless otherwise noted.
Thickness of slabs to vary uniformly between dimensions shown.

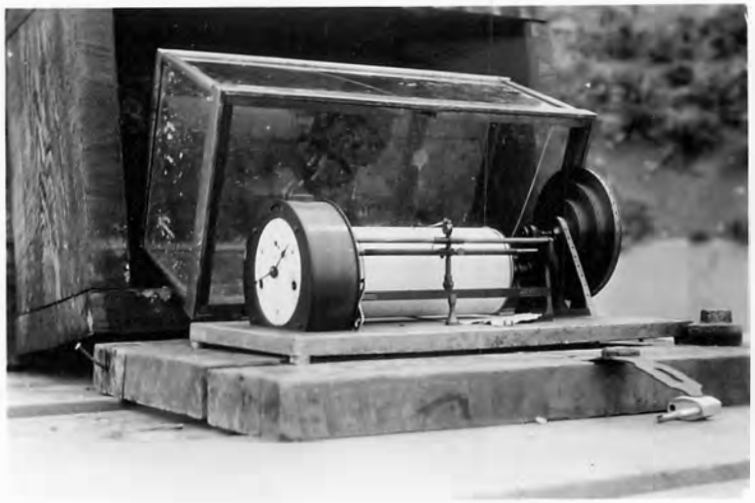
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
UNCOMPAHGRE PROJECT-COLORADO

SOUTH CANAL STATION 25+18

CONCRETE CHUTE DROP STILLING POOL

DRAWN K.E.B. SUBMITTED: W. H. Bigney
TRACED C.V.R. RECOMMENDED: U. P. Holder
CHECKED C.H.D. APPROVED: J. L. Meeker

27403 | DENVER, COLORADO JAN. 24, 1935 | SHEET 3 OF 3 | 31-D-44



A - Headwater recording gage
at Station 19 + 35

B - Tailwater staff gage
at Station 37 + 00

C - Break below Seven-drop section
Looking downstream

D - Break below Seven-drop section
Looking upstream

SOUTH CANAL - UNCOMPAHGRE PROJECT - STILLING POOL OF CHUTE AT
STATION 25 + 19

FIGURE 3

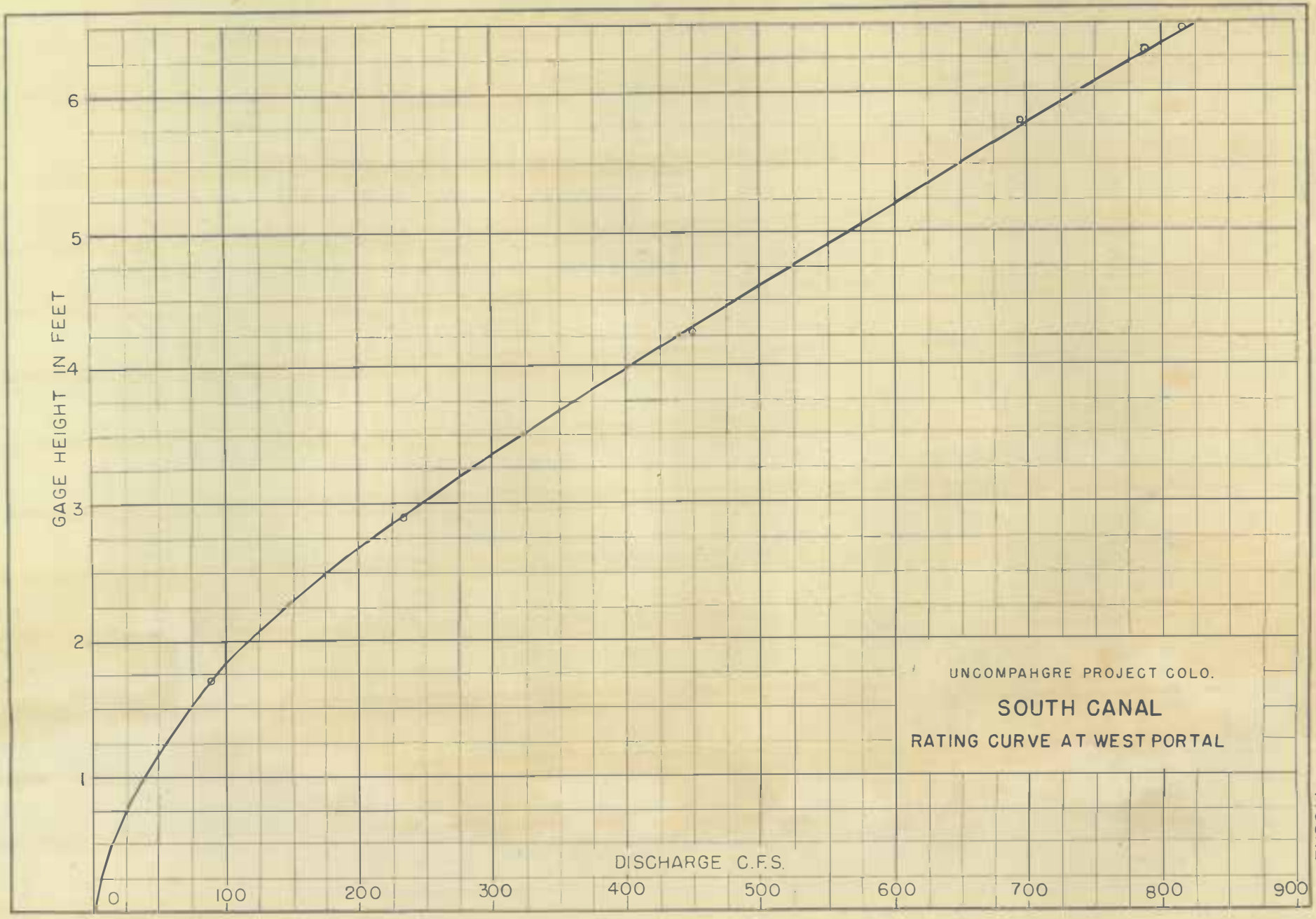

GAGE HEIGHT IN FEET
6
5
4
3
2
1
DISCHARGE C.F.S.
0
100
200
300
400
500
600
700
800
900
UNCOMPAHGRE PROJECT COLO.
SOUTH CANAL
RATING CURVE AT WEST PORTAL

FIGURE 4

The flow conditions in the pool are generally satisfactory. However, there is periodic splash that overtops the side walls of the pool near the point where the jet impinges on the tailwater. This splash would normally do no harm if returned to the pool by drains. The type of material in the backfill of this particular structure does not readily adapt itself to drainage and is inclined to slide when saturated. Should the backfill around the pool become saturated this tendency to slide would exert a tremendous pressure on the side walls and would very probably result in damage to the structure. In this specific instance higher side walls would correct the condition. Wooden splash walls have been installed which partly, but not entirely, eliminate the saturation of the backfill.

A wave or roller forms intermittently near the intersection of the jet and the backwater (approximately station "E") and moves rapidly downstream through the pool. There is an occasional surge that travels from one side wall toward the other. This action makes a rough water surface and causes a wave to travel along the banks of the earth section downstream from the pool and considerable erosion results. This erosion has been checked by dumping several yards of large boulders along the banks downstream from the end of the new lining and upstream from a section of old lining that formed part of the pool of the drop replaced by the chute. The specifications called for removal of the old drop, widening of the earth section and placing a rock paving on the bottom and sides for a distance of 20 feet from the end of the lined pool. Due to the lateness of the season and the consequent urgent need for water in the canal the contractor was allowed to withdraw from the job as soon as the concrete lining was poured. The concrete section of the old drop was left approximately 2½ feet above the floor of the new pool. The banks were not cleared and a slab of old lining projects approximately eight feet into the canal from the right bank a short distance below the new pool. The dumped riprap further restricted the channel below the pool and some of it had been carried by the water or rolled on top of the floor of the new pool.

If the canal section had been cleared and the dry rock paving placed according to specifications very little damage to the earth sides of the canal would have resulted. The additional width of the canal section would have allowed the roller to spread and it possibly would have been dissipated a short distance from the end of the lining.

In comparing the action in the prototype to that in the model; there is much more white water in the prototype than there was in the model. The total length of roller is slightly greater in the prototype than in the model.

In selecting the controlling dimensions of the wall, floor, sills, etc., of stilling pools from the results of model studies, it has been the usual practice to permit the design to be governed largely by the observed effectiveness of the jump and particularly by the measured elevations of the solid water in the model pools. Occasional drops of water and spray splashing into the air and over the sides have generally been ignored as of little concern in the design of pool walls.

Observations in the prototype stilling pool has directed attention to the fact that where saturation of the ground adjacent to such a pool may affect the design of the wall, the splash observed in model studies should receive careful consideration.

Reexamination of stilling pool models now in the laboratory reveals that, although the major hydraulic features of a pool may be entirely satisfactory, considerable splash is an almost invariable accompaniment. Some drops reach a height of three or four times the height of the pool walls, and adjacent floors are completely wetted.

It has been thought that the conditions cited above would be of interest to the design sections as indicating the desirability of providing for drainage or other protection of stilling pool embankments under similar circumstances.

DESCRIPTION OF STUDIES

Installations. Tailwater gage No. 1 (figures 3 and 5) was set on April 20, 1936, and levels were run to it from a bench mark to establish its relation to sea level datum. The gage was located on the right bank approximately 310 feet downstream from the end of the new lining. The zero of this gage is at elevation 6421.24, U.S.G.S. datum. Later a similar gage (No. 2) was placed farther out in the canal so as to record the lower flows, (figure 5).

On April 29, 1936, a break occurred in the floor of the canal below the section generally referred to as the "Seven-drop Section," (figure 3). It was necessary to shut the water out of the canal to make repairs. In changing the discharge in this canal the rate of change, whether an increase or decrease, is never more than 100 second-feet per hour. At this rate upwards of eight hours are required to empty the canal when it is flowing full and an equal amount of time is required to raise the flow from zero to maximum discharge. As soon as the water started to recede at the chute two men were stationed at the gages and instructed to record the gage reading every 15 minutes. This was done and the data were plotted on the tailwater curve sheet (figure 6).

After all of the flow was turned out of the canal several photographs were taken (figure 7) to show the condition of the channel immediately below the pool. To have a comparison by pictures of the flow conditions in the model and in the prototype, a grid such as was used on the model pool wall was painted on the right wing wall of the prototype pool with red and white kalsomine (figure 5).

The location of the grid system on the model was furnished by the Denver office. The grid consisted of four-foot squares on the center line projected upon the right wing wall. The vertical line J was at the intersection of the chute floor and the pool floor, and the upper horizontal line 12 feet above the same point.

The line J was located (figure 7D) and the grid system laid out from it. It was found from a comparison of the model and prototype

A - Tower from which pictures were taken

B - Chute and picture tower

C - Tailwater staff gages at Sta. 37 + 00

D - Grid lines on pool lining

SOUTH CANAL - UNCOMPAHGRE PROJECT - STILLING POOL OF CHUTE
AT STATION 25+19

FIGURE 5

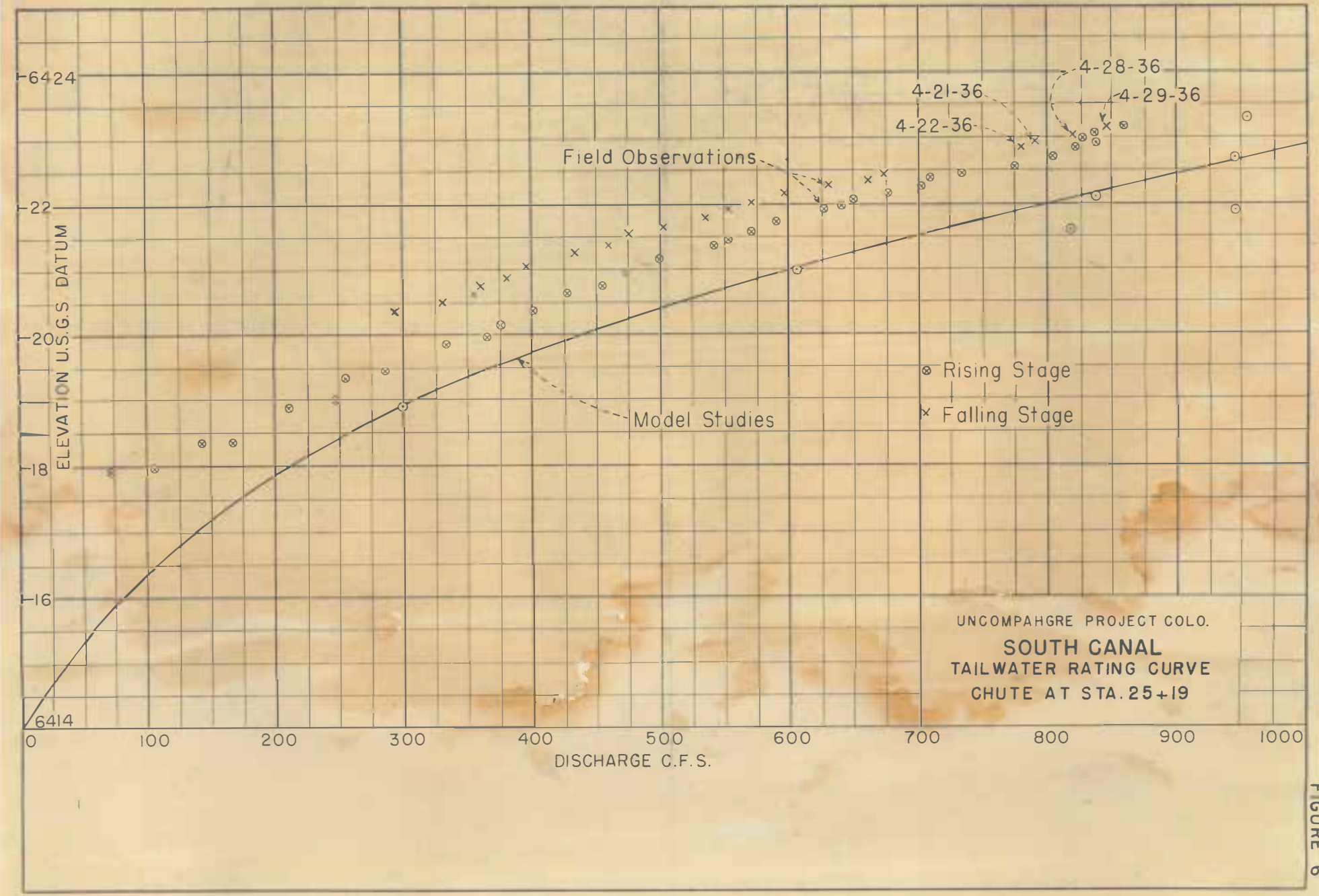

6424
22
20
18
16
6414
ELEVATION U.S.G.S. DATUM
0
100
200
300
400
500
600
700
800
900
1000
DISCHARGE C.F.S.
4-28-36
4-29-36
4-21-36
4-22-36
Field Observations
Model Studies
Rising Stage
Falling Stage
UNCOMPAHGRE PROJECT COLO.
SOUTH CANAL
TAILWATER RATING CURVE
CHUTE AT STA. 25+19

FIGURE 6

A - Restriction below stilling pool looking upstream

B - Restriction below stilling pool
Looking downstream

C - Painting grid lines on wall of
stilling pool

D - Painting grid lines on wall of stilling pool

SOUTH CANAL - UNCOMPAHGRE PROJECT - STILLING POOL OF
CHUTE AT STATION 25 + 19

FIGURE 7

pictures that the grid systems did not agree. A check of dimensions of the prototype grid system disclosed that due to an error in measurements the horizontal lines had been placed six-tenths of a foot lower than the same lines on the model. This error resulted because the pool was filled with water to depth of approximately 6½ feet and the top of the training wall was necessarily used as a control point.

It was necessary to construct a tower to obtain photographs of the flow conditions similar to those from the model. The point on this tower from which the photographs were taken was 122 feet from the centerline of the stilling pool and on a line perpendicular to the centerline at J. The base of the tower was at elevation 6454.52 while the top was at 6483.12 or 28½ feet above ground level (figure 5). The ground level was 27.87 feet above the top of the side walls of the pool.

Procedure. At 5:00 a.m. May 2, 1936, the headgate of the canal was opened allowing some water to pass into the tunnel. At 6:00 a.m. the gate immediately above the chute and slightly below the recording gage was opened and data were then recorded at both gages simultaneously. Beginning at the discharge of 300 second-feet, two still pictures and several feet of movie film were taken from the tower and several feet of movie film were taken from two positions near the pool. This procedure was followed at every 100 second-foot increase in discharge (figures 6, 7, 8, 9 and 10). This work of picture taking and gage reading continued until 2:00 p.m. at which time the discharge became constant at 825 second-feet.

All data obtained were computed and plotted on the model tailwater curve sheet (figure 2). In studying this sheet it will be observed that the points obtained during the fall show a higher tailwater elevation for a given discharge than the points obtained during the rise. This lag was expected because the grade in the earth section downstream is very flat. A mean curve through all the points obtained is consistently higher than the curve used for the operation of the model.

- - -

A - Discharge 300 second-feet

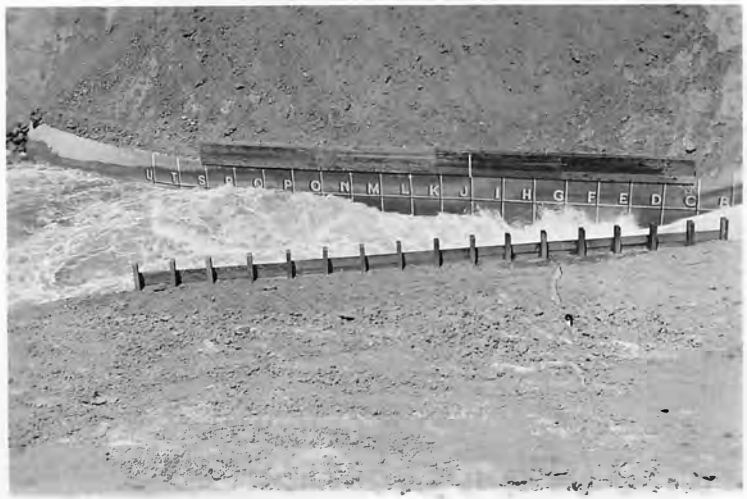
B - Discharge 400 second-feet

C - Discharge 500 second-feet

D - Discharge 600 second-feet

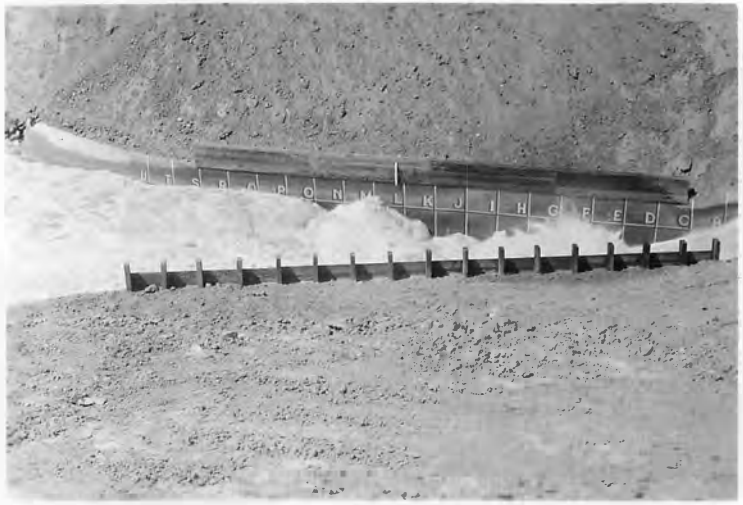
SOUTH CANAL - UNCOMPAHGRE PROJECT - STILLING POOL OF CHUTE AT STATION 25 + 19

FIGURE 8



A - Discharge 700 second-feet

B - Discharge 800 second-feet



C - From tower

D - From left bank - Looking upstream

DISCHARGE 825 SECOND-FEET

SOUTH CANAL-UNCOMPAHGRE PROJECT-STILLING POOL OF CHUTE AT STATION 25 + 19

FIGURE 9

A - Discharge 865 second-feet

B - Chute & pool at Station 25 + 19

Discharge approximately 650 second-feet

Spray from pool with discharge of 800 second-feet

D - Upstream end of hydraulic jump.

SOUTH CANAL

SOUTH CANAL-UNCOMPAHGRE PROJECT-STILLING POOL OF CHUTE AT STATION 25 + 19

FIGURE 10