HYD 38

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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HYDRAULIC LABORATORY REPORT NO. 38

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PROGRESS REPORT ON PARKER DAM GATE TESTS - VIBRATION STUDIES

By

V. L. STREETER

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Denver, Colorado

September 13, 1938

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Engineering and Geological Control
and Research Division
Denver, Colorado
September 13, 1938

Laboratory Report No. 38
Hydraulic Laboratory
Compiled by: V. L. Streeter

Subject: Progress report on Parker Dam gate tests - Vibration studies.

PURPOSE OF STUDIES

A model of one of the five stoney gates in Parker Dam was constructed and tested in the Denver hydraulic laboratory during January and February 1937. These tests were made primarily to insure there would be no harmful vibrations of the gate. Coefficients of gate discharge were also obtained as well as pressure and water surface profiles on the crest for various gate openings.

DESCRIPTION OF THE MODEL

Parker Dam is an arch dam with five stoney gates, 50 by 50 feet, mounted in the spillway section. Plan, elevation, and section of the spillway structure are shown in Figure 1. The model consists of a part of the dam including one of the gates, extending downward 45 feet below the crest and 27.5 feet each side of the gate. Model construction was of galvanized iron and steel with the exception of the crest which was made of plaster of paris and cement. A groove in the crest filled with lead provided a seal for the lower edge of the gate. Rubber tubing fastened against the upstream face of the gate provided scale for the sides. The prototype gate will consist of horizontal plate girders with a 9/16-inch skin plate on the upstream face. The gate assembly is shown in Figure 2. The model gate was designed with a radius of gyration of the lower horizontal members such that the free period of the model gate would be $1/\sqrt{30}$ of the prototype. The model gate was made from a solid steel plate 5/8-inch thick, machined down to 1/4-inch thick, with ribs 3/8-inch high and 1/5-inch thick spaced on the downstream side of the plate similar to the spacing of plate girders in the prototype. The formula $t_n = \frac{2}{n^2} \frac{l^2}{k} \left(\frac{w}{ge}\right)^{\frac{1}{2}}$ (Applied Elasticity, Prescott, p. 211) was used to determine the free period of oscillation of the gate. (t_n = period of oscillation, n = mode, l = length of span, k = radius of gyration, w = weight per unit volume, e = Young's modulus, g = gravity.) Dimensions of one of the lower plate girders were used in the computations. The girder was assumed constant in section with a cross-sectional area of 107.25 square inches. The average moment of inertia was taken as $(70,000 \text{ in.})^4$ which resulted in a radius of gyration $\sqrt{I/A}$ = 2.133 feet. The free period of oscillation of the prototype gate is 0.048 seconds. As hydraulic time scales vary with the square root of the scale ratio, a period of $0.048/\sqrt{30} = 0.0088$ for the model horizontal beam should be obtained. With this period any hydraulic tendencies to set the gate in vibration should be similar in both model and prototype. Details of the model gate are shown in Figure 5.

Discharge through the model was measured with a "V" notch weir. Discharge varied from 0.200 to 9.76 second-feet or prototype for five gates from 7,100 to 240,380 second-feet. Maximum design discharge is 260,000 second-feet. Piezometer openings were made in the crest along the centerline of the gate openings. The positions of these holes may be seen on the graphs in the appendix which show pressures on the crest. Profiles of the water surface on the crest below the gate were obtained by means of a point gage fastened to a bar across the model.

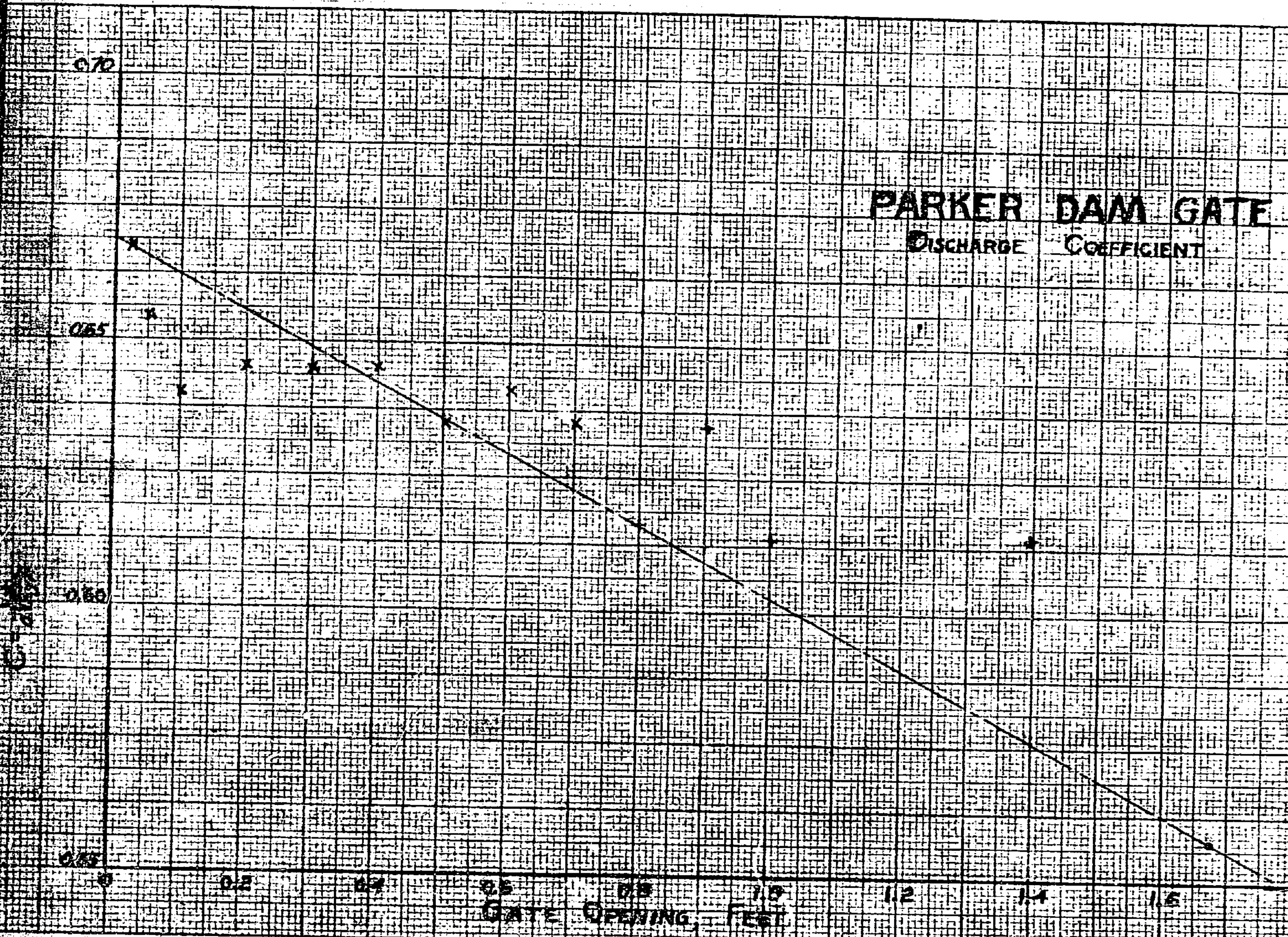
PROCEDURE

In the tests, a discharge was maintained for a given gate opening such that the upstream water surface remained 20 inches above the crest or at elevation 430 in the prototype. Tests to determine whether there were vibrations in the gate were made by placing the hand on the surface of the gate. It was reasoned that vibrations in the model which could not be detected with the hand could do no damage to the prototype. For each of the twelve gate openings water surface profiles were taken along the centerline of the crest downstream from the gate. Pressures along the crest were also taken for each gate opening.

RESULTS AND CONCLUSIONS

In all cases, no vibrations caused by water flowing under the gate could be discerned with the hand. Hence, it may be concluded that vibrations so small they cannot be noticed in the model will have no harmful effects on the prototype. Points showing measurements of pressure and water surface along the centerline of the crest are plotted on graphs in the appendix. For the small gate openings, 0.025 and 0.050 (9 inches and 18 inches prototype), the pressures on the crest appear greater than the depth of water. This is undoubtedly due to capillarity in the piezometer tubes. Pressures along the crest upstream from the gate were always positive. For gate openings up to 12 feet, the pressures were greater than 25 feet and are not shown on the graphs. The crest profile is correctly designed as the pressure along the length of the crest remains everywhere above atmospheric.

Gate coefficients are plotted against gate openings in graph (00) in the appendix. With the model, it was impossible to obtain the maximum discharge for which the gate was designed. Extrapolating the curve to give the lowest expected coefficient for maximum gate opening, a coefficient $C = \frac{Q}{A\sqrt{2gh}} = 0.56$ is obtained. Using this prototype Q for for full-gate opening with normal headwater at 50 feet above the crest is 300,000 second-feet. Maximum design Q is 260,000 for the five gates.


PARKER DAM GATE
DISCHARGE COEFFICIENT
0.70
0.65
0.60
0.55
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
GATE OPENING, FEET

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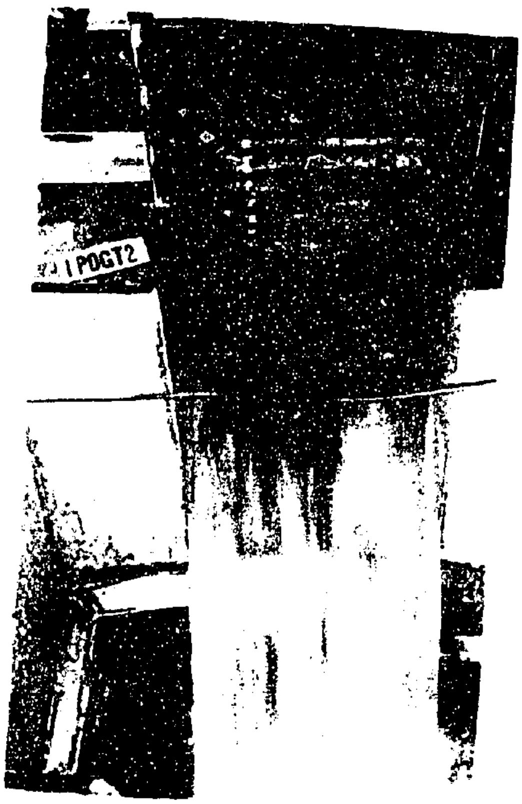
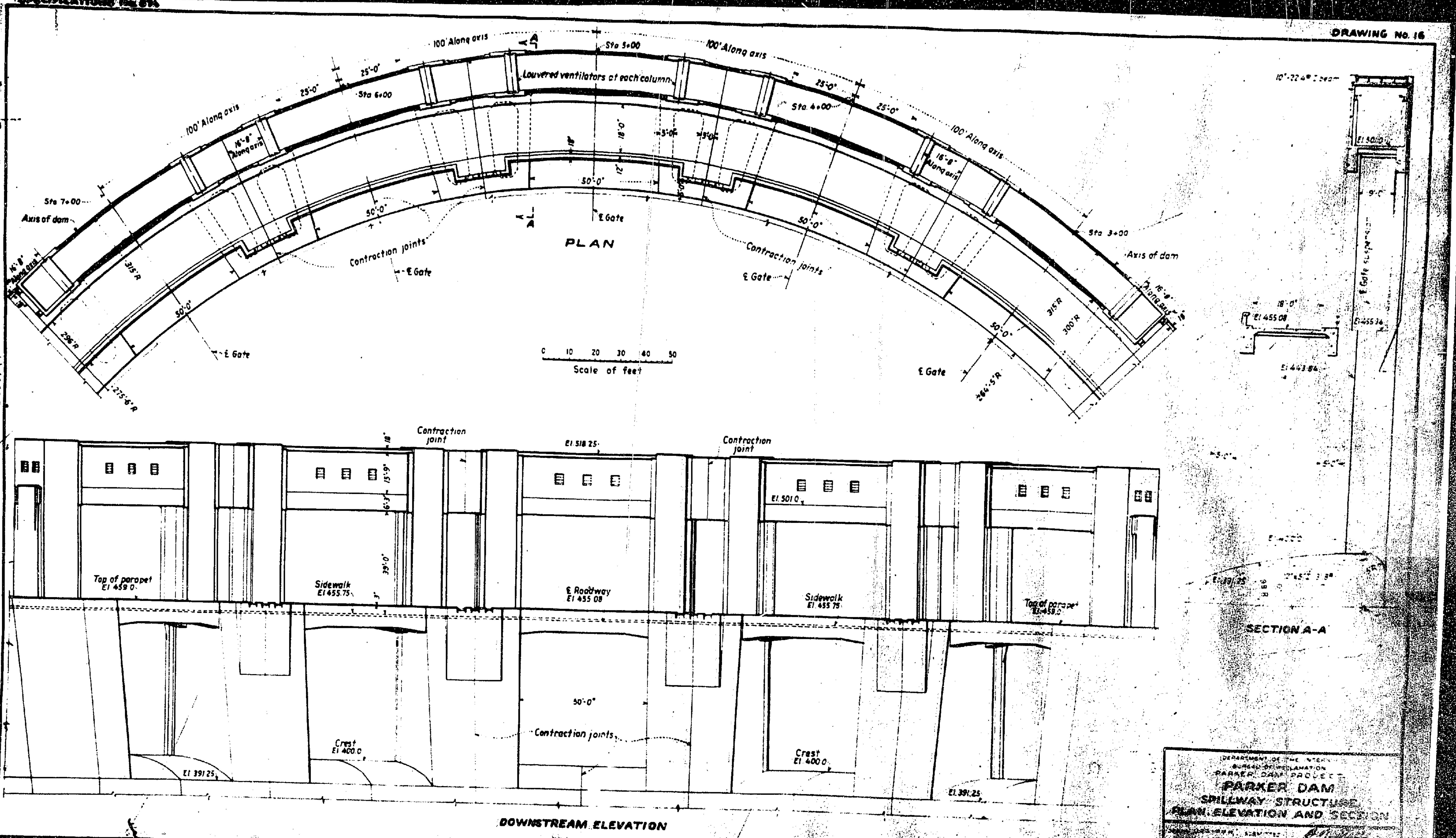
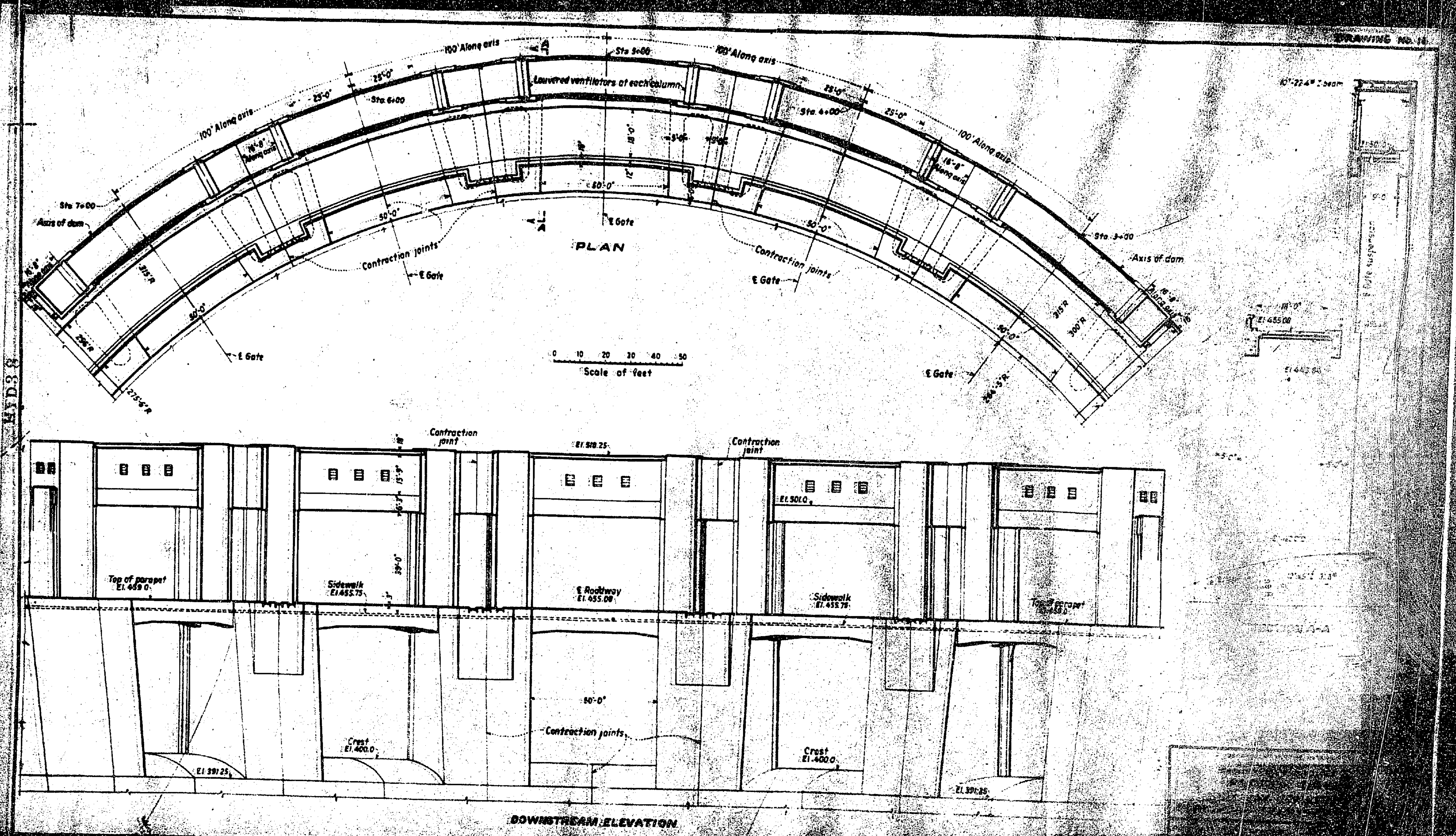
No Flow Looking Downstream



Small Discharge


DRAWING No. 16
100' Along axis
Sta 5+00
100' Along axis
Louvered ventilators at each column
25'-0"
Sta 6+00
Sta 4+00
100' Along axis
16'-8" Along axis
Sta 7+00
Axis of dam
315'R
50'-0"
Contraction joints
℄ Gate
PLAN
Sta 3+00
Axis of dam
300'R
296'R
275'-6"R
264'-5"R
0 10 20 30 40 50
Scale of feet
Contraction joint
El 518.25
15'-9"
6'-3"
39'-0"
El 501.0
Top of parapet
El 459.0
Sidewalk
El 455.75
℄ Roadway
El 455.08
Crest
El 400.0
El 391.25
Contraction joints
DOWNSTREAM ELEVATION
SECTION A-A
18'-0"
9'-0"
El 443.84
PARKER DAM PROJECT
PARKER DAM
SPILLWAY STRUCTURE
PLAN, ELEVATION AND SECTION



DRAWING NO. 11
100' Along axis
Sta 5+00
Louvered ventilators at each column
Sta. 6+00
Sta. 4+00
Sta. 7+00
Sta. 3+00
Axis of dam
Contraction joints
PLAN
℄ Gate
Scale of feet
Contraction joint
El. 510.25
Top of parapet El. 459.0
Sidewalk El. 455.75
℄ Roadway El. 455.08
Crest El. 400.0
El. 391.25
El. 501.0
DOWNSTREAM ELEVATION

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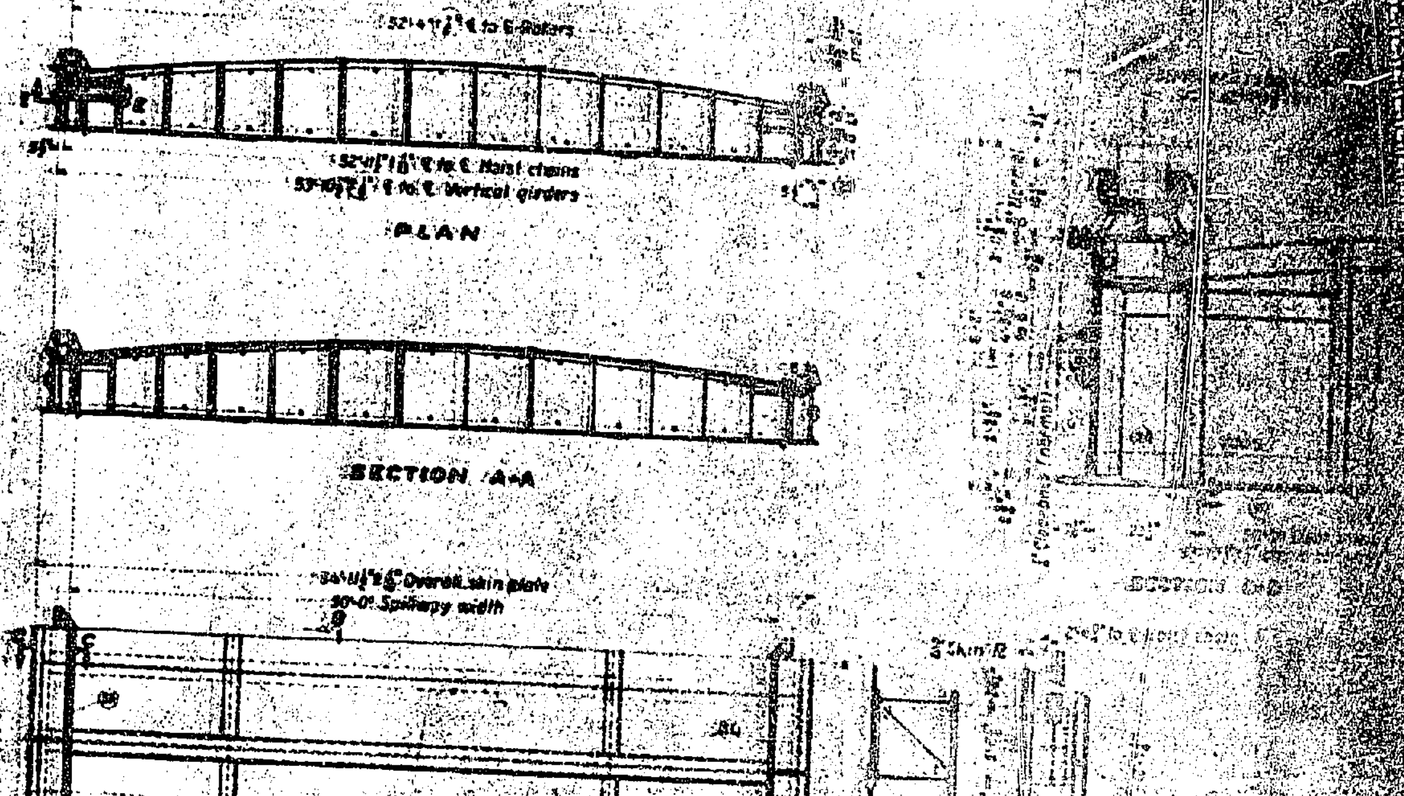
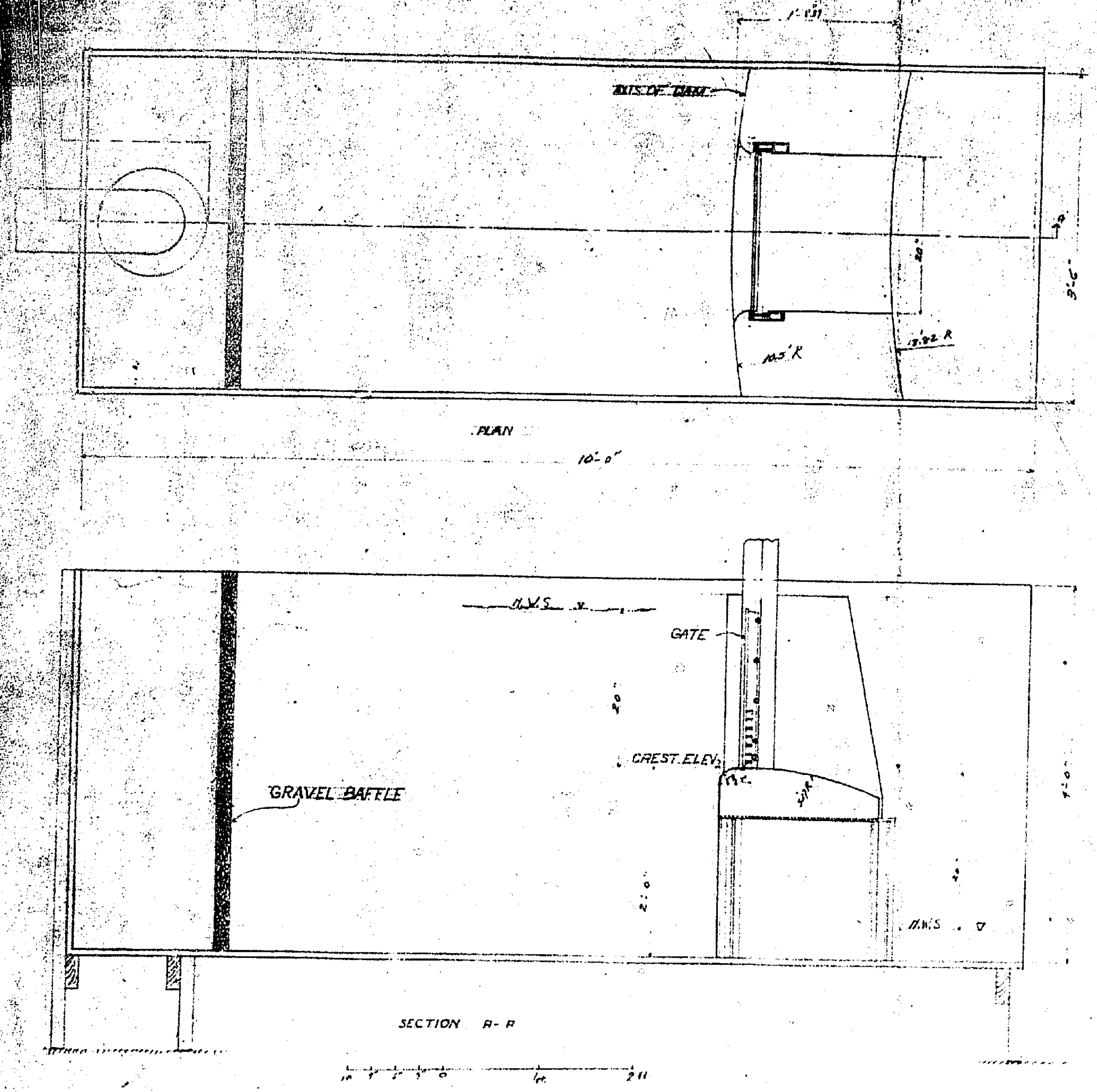
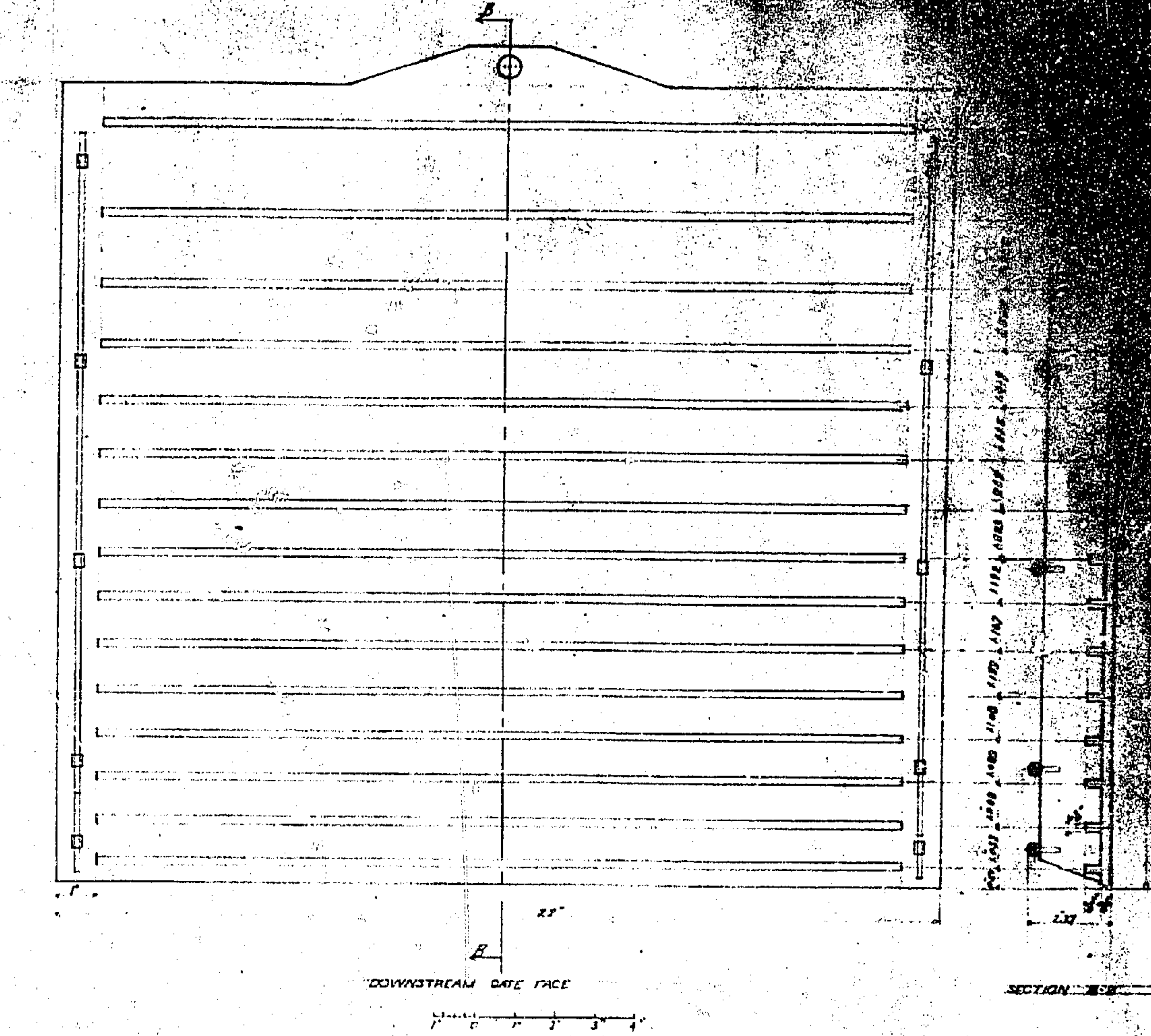


Hoist chains
Vertical girders
PLAN
SECTION A-A
Overall skin plate
Spillway width





GATE DETAIL

MODEL DETAILS
PARKER DAM GATE
MODEL SCALE — 1:30

FIG. 3

ASSEMBLY DETAILS

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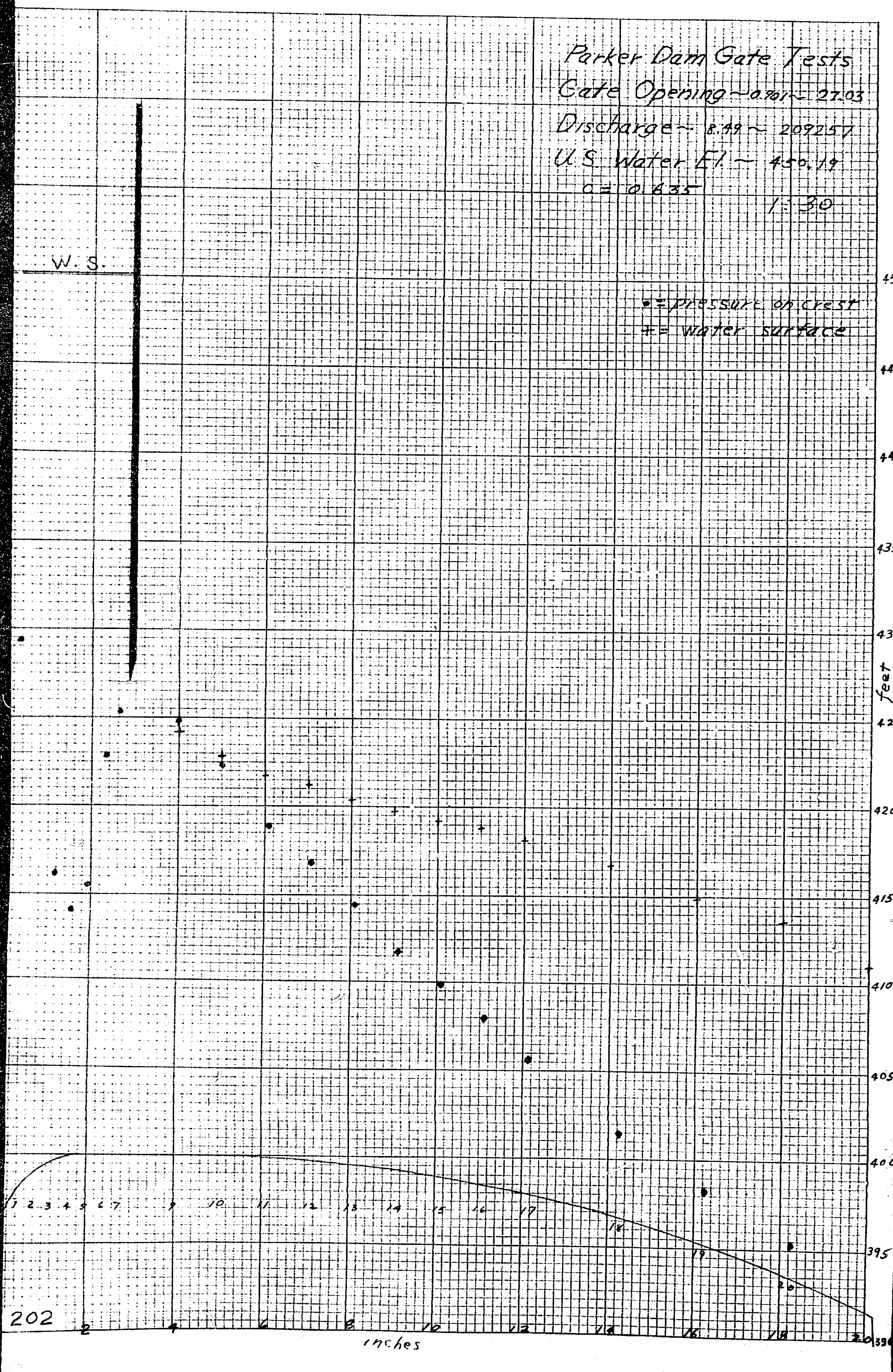
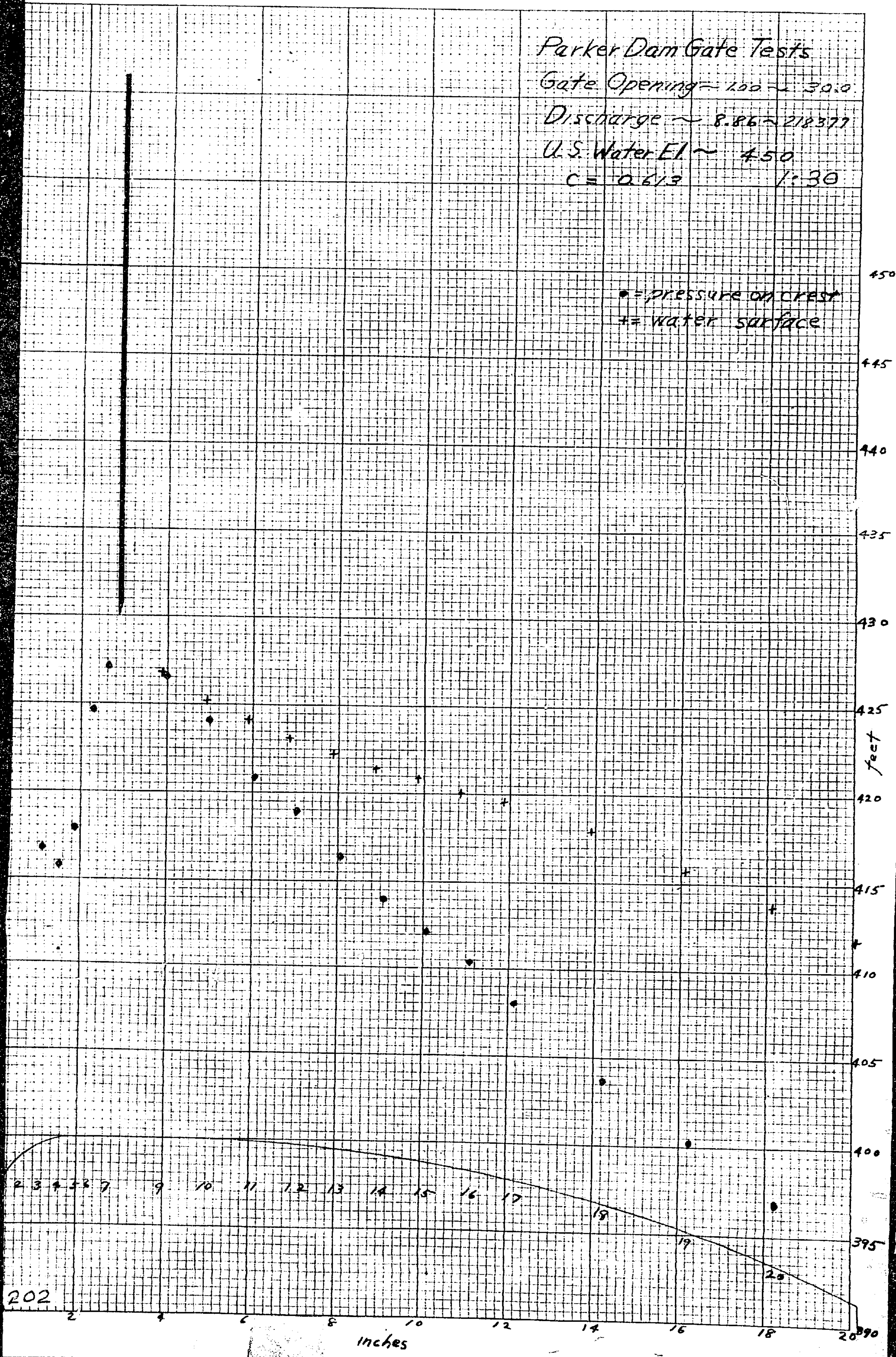
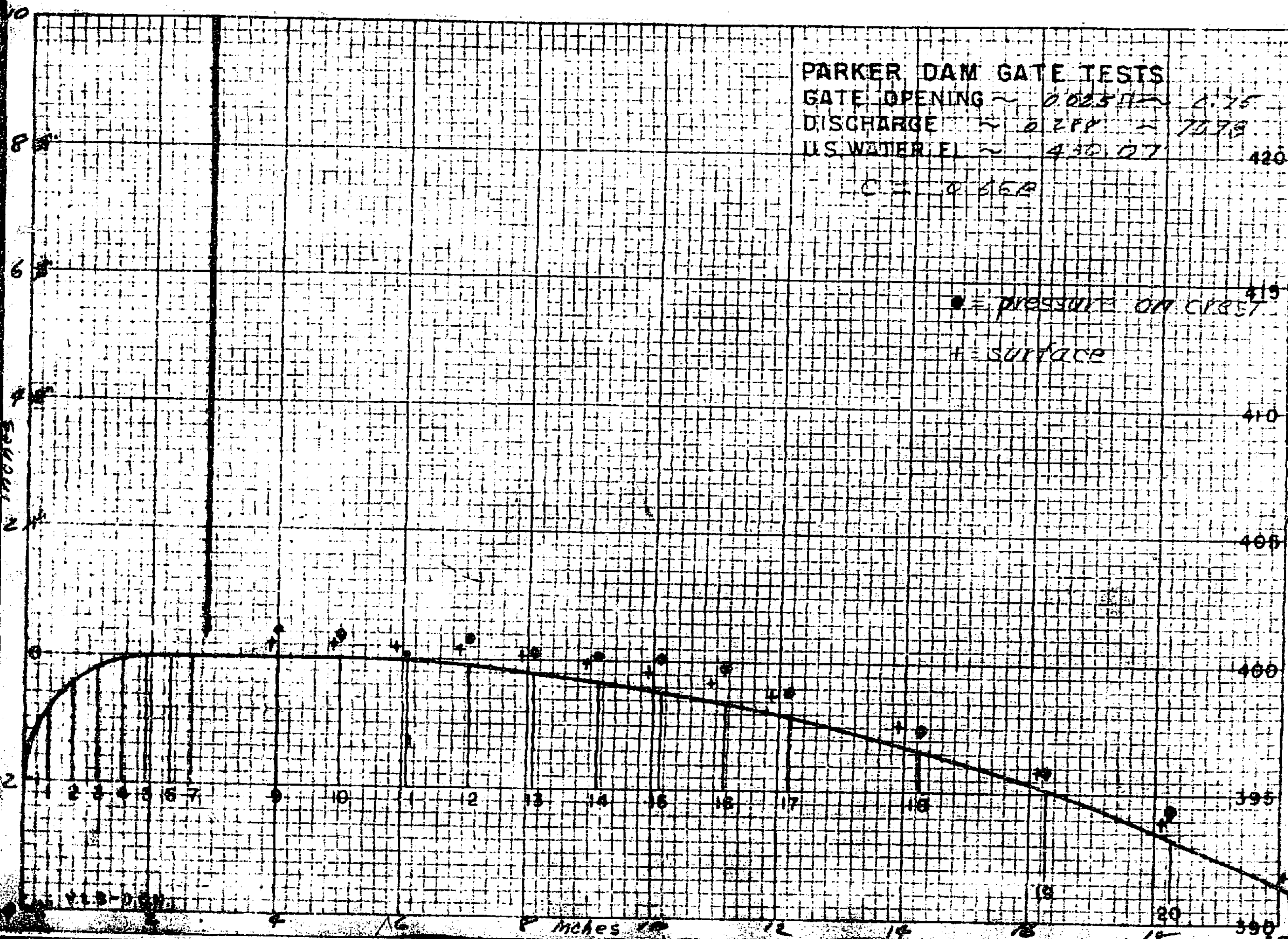


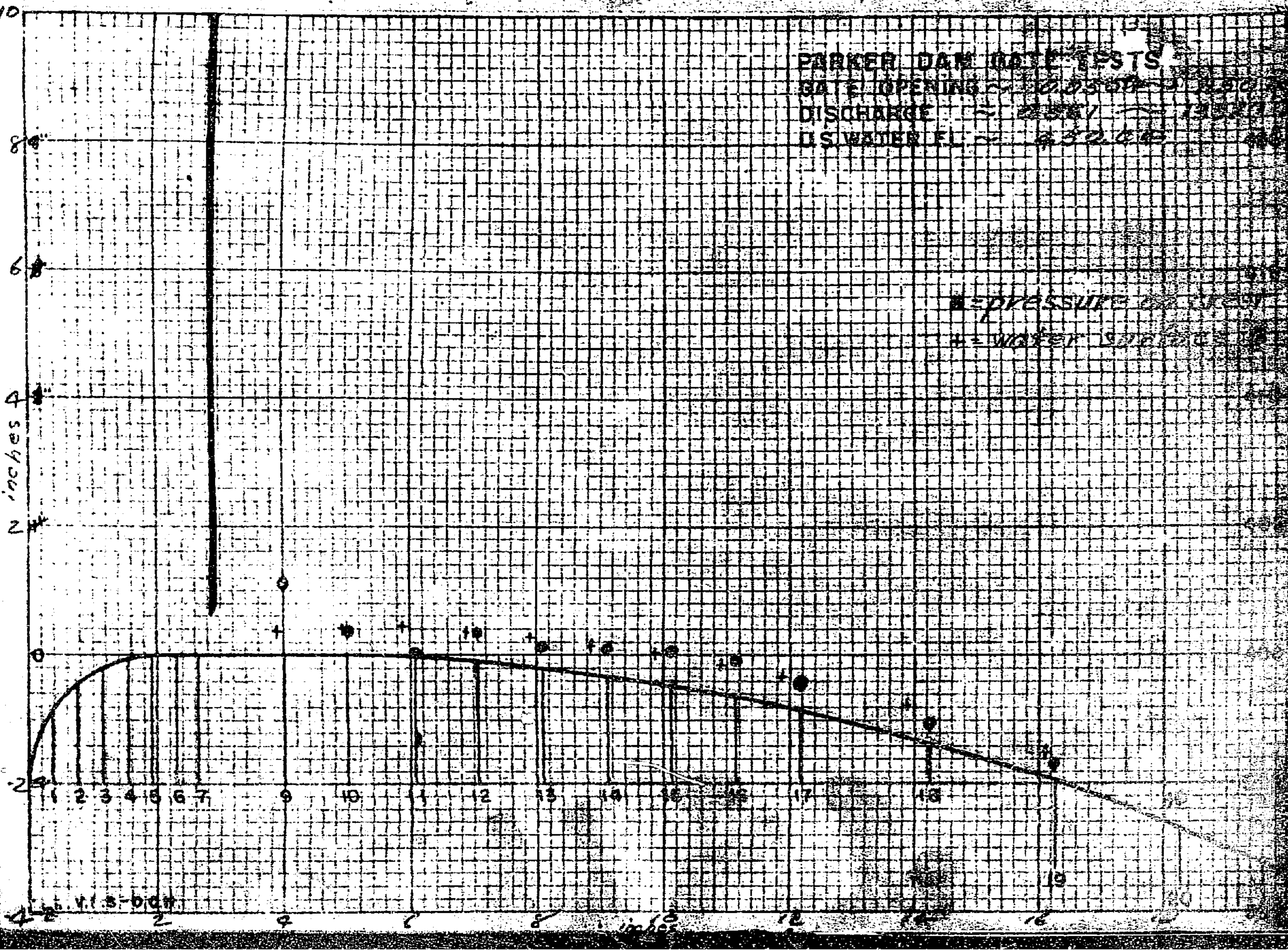
Parker Dam Gate Tests
Gate Opening ~ 0.901 ~ 27.03
Discharge ~ 8.49 ~ 209257
U.S. Water El. ~ 450.19
a = 0.635
1:30
W. S.
• = pressure on crest
+ = water surface
feet
450
445
440
435
430
425
420
415
410
405
400
395
390
inches
2
4
6
8
10
12
14
16
18
20
1 2 3 4 5 6 7
9
10
11
12
13
14
15
16
17
18
19
20
202



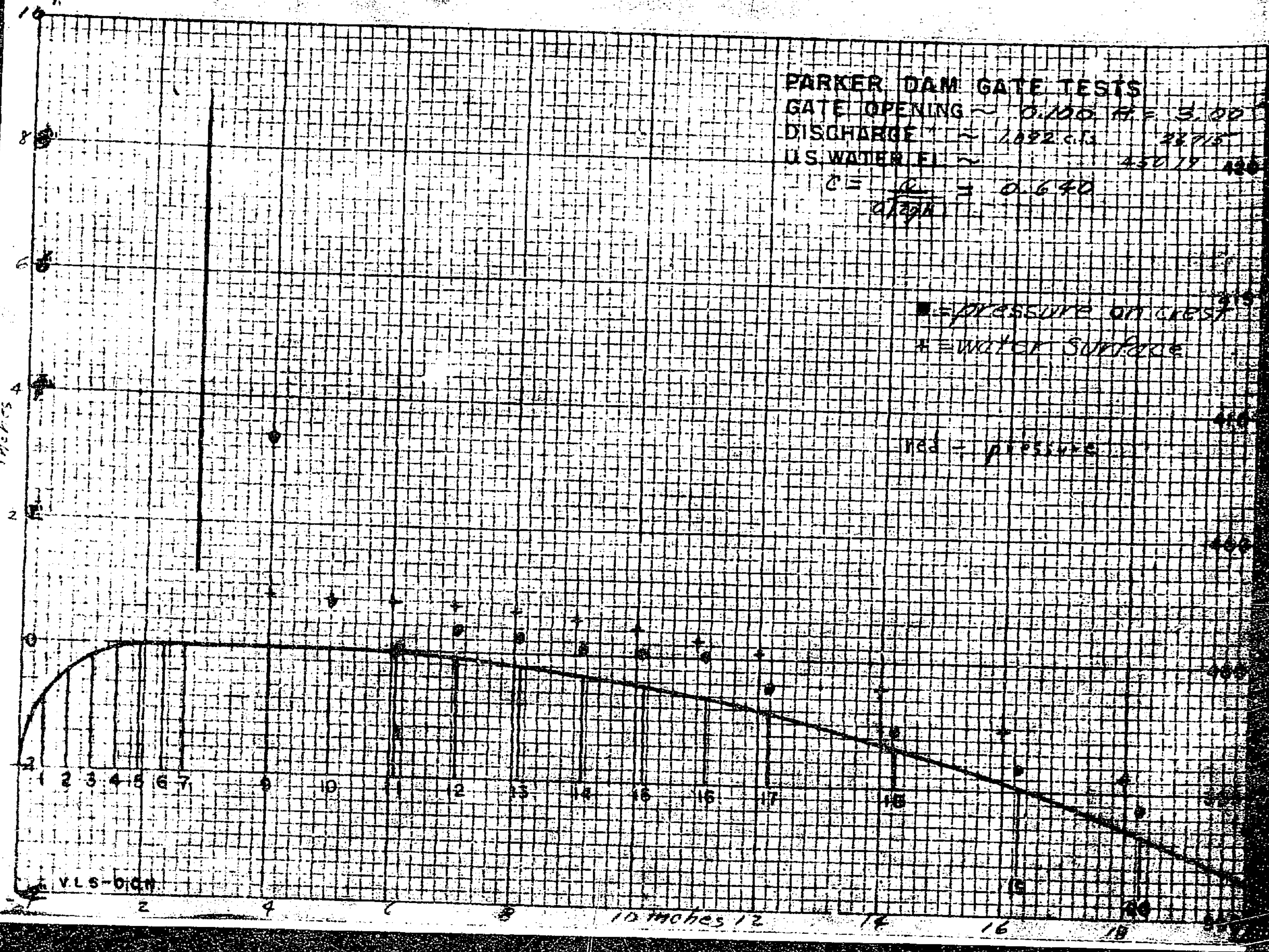
Parker Dam Gate Tests
Gate Opening ~ 2.00 ~ 30.0
Discharge ~ 8.86 ~ 218377
U.S. Water El ~ 450
C = 0.613
1:30
• = pressure on crest
+ = water surface
feet
450
445
440
435
430
425
420
415
410
405
400
395
390
inches
2
4
6
8
10
12
14
16
18
20
2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20
202

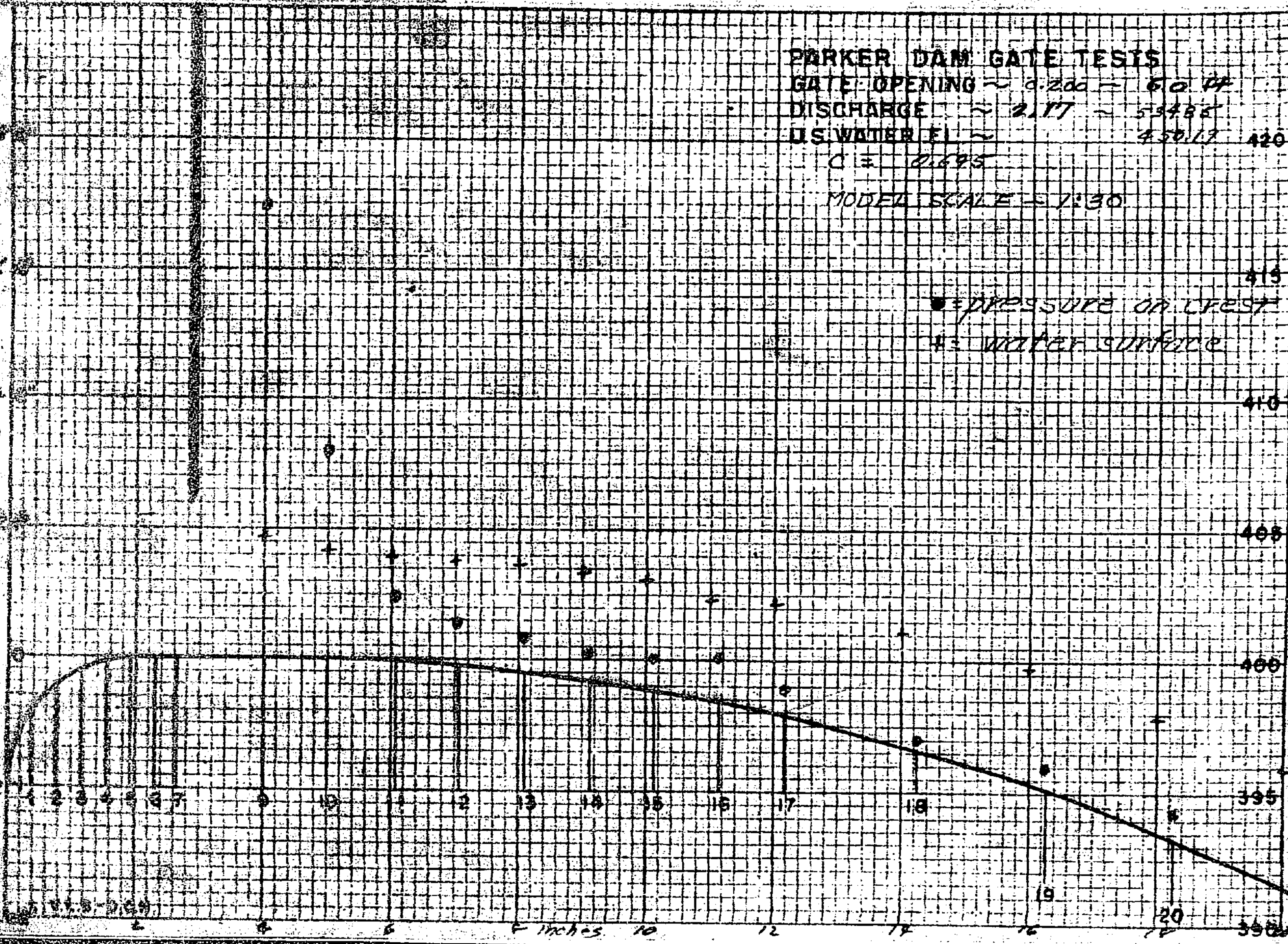

PARKER DAM GATE TESTS
GATE OPENING ~
DISCHARGE ~
U.S. WATER EL. ~ 430.07
● = pressure on crest
+ = surface
Inches
420
415
410
405
400
395
390

HYD



PARKER DAM GATE TESTS
GATE OPENING ~
DISCHARGE ~
D.S. WATER EL. ~
= pressure
+ = water
inches
inches


PARKER DAM GATE TESTS
GATE OPENING ~ 0.100 H = 3.00
DISCHARGE ~ 1.092 c.f.s. 22.715
U.S. WATER El ~ 450.17 430
C = Q / a√(2gh) = 0.640
■ = pressure on crest
+ = water surface
red = pressure
V.L.S-0.CH
inches
10 inches 12
1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20



PARKER DAM GATE TESTS
GATE OPENING ~ 0.200 = 6.0 FT
DISCHARGE ~ 2.17 ~ 53485
U.S. WATER EL ~ 430.17
C = 0.695
MODEL SCALE = 1:30
● = pressure on crest
+ = water surface
420
415
410
405
400
395
390
inches
1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20
2 4 6 8 10 12 14 16 18
inches

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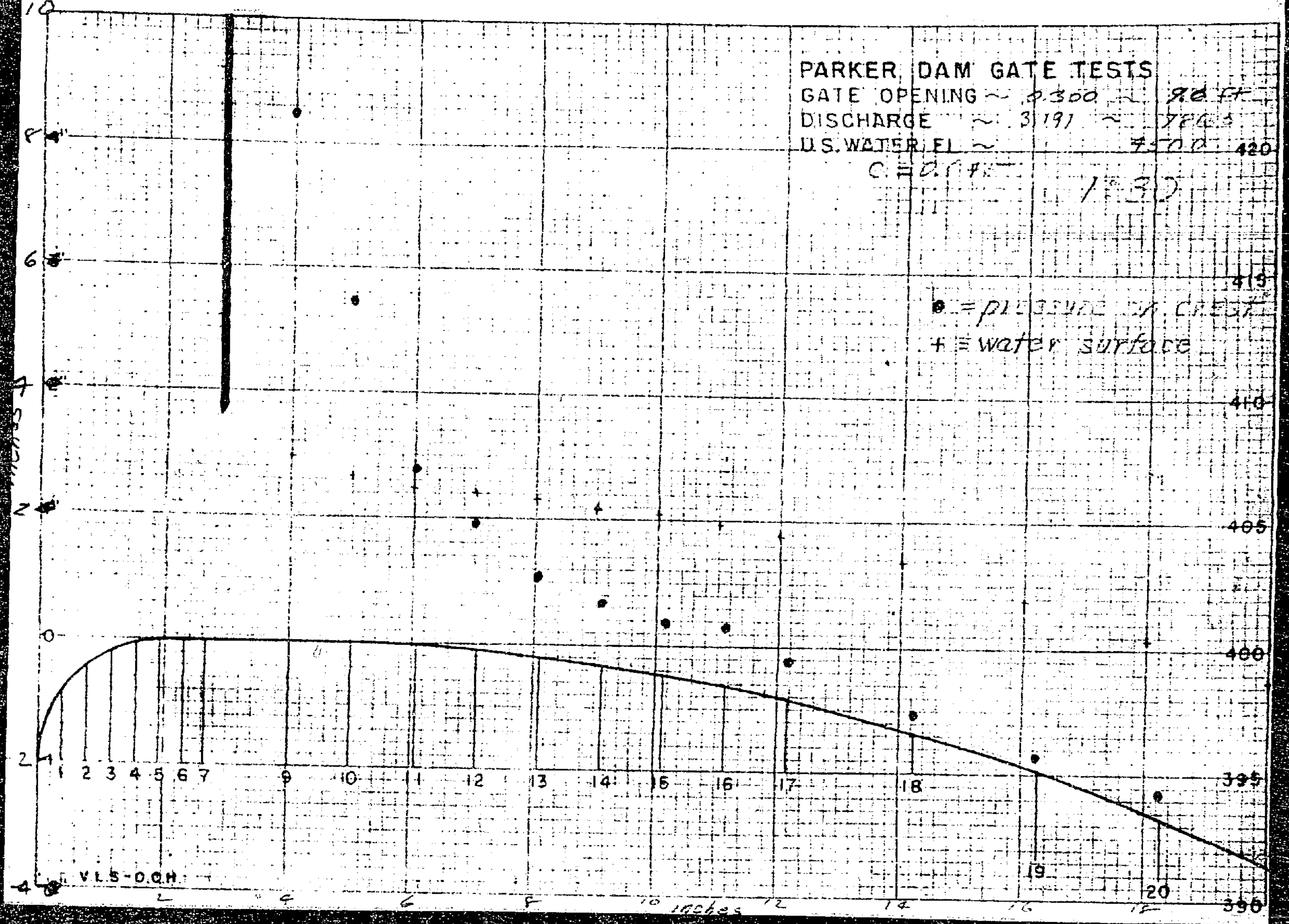
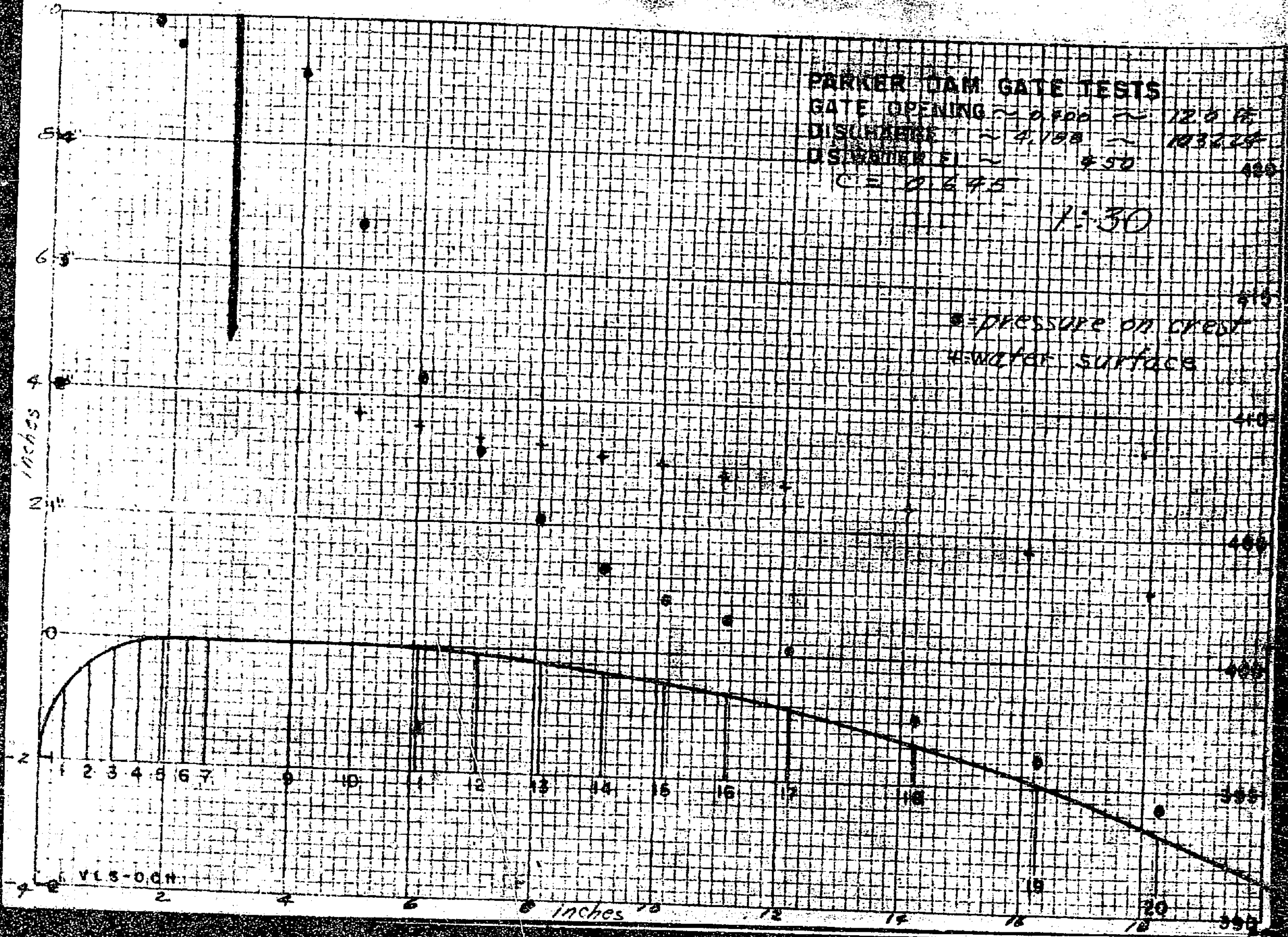
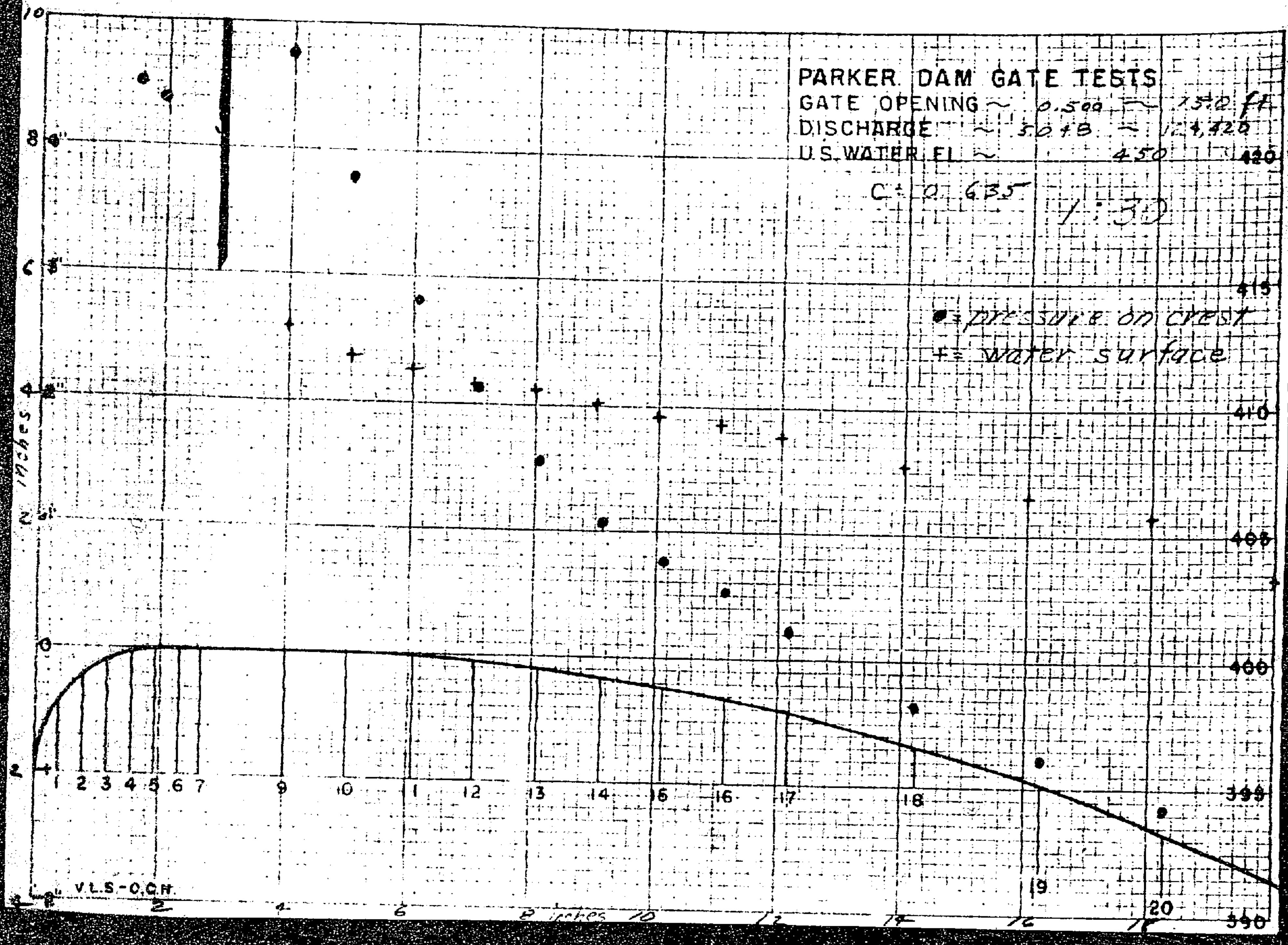

PARKER DAM GATE TESTS
GATE OPENING ~
DISCHARGE ~
U.S. WATER EL ~
● = pressure on crest
+ = water surface
inches
V.L.S-O.C.H.
420
415
410
405
400
395
390

HYD 38


PARKER DAM GATE TESTS
GATE OPENING ~ 0.400 ~ 12.0 ft
DISCHARGE ~ 4.188 ~ 103224
U.S. WATER El. ~ 450
C = 0.645
1:30
● = pressure on crest
+ = water surface
inches
inches
V.C.S.-O.C.H.


PARKER DAM GATE TESTS
GATE OPENING ~ 0.500 ~ 15.0 ft
DISCHARGE ~ 3.648 ~ 124,420
U.S. WATER EL ~ 450
C = 0.635
1:30
● = pressure on crest
+ = water surface
inches
V.L.S.-O.C.H.

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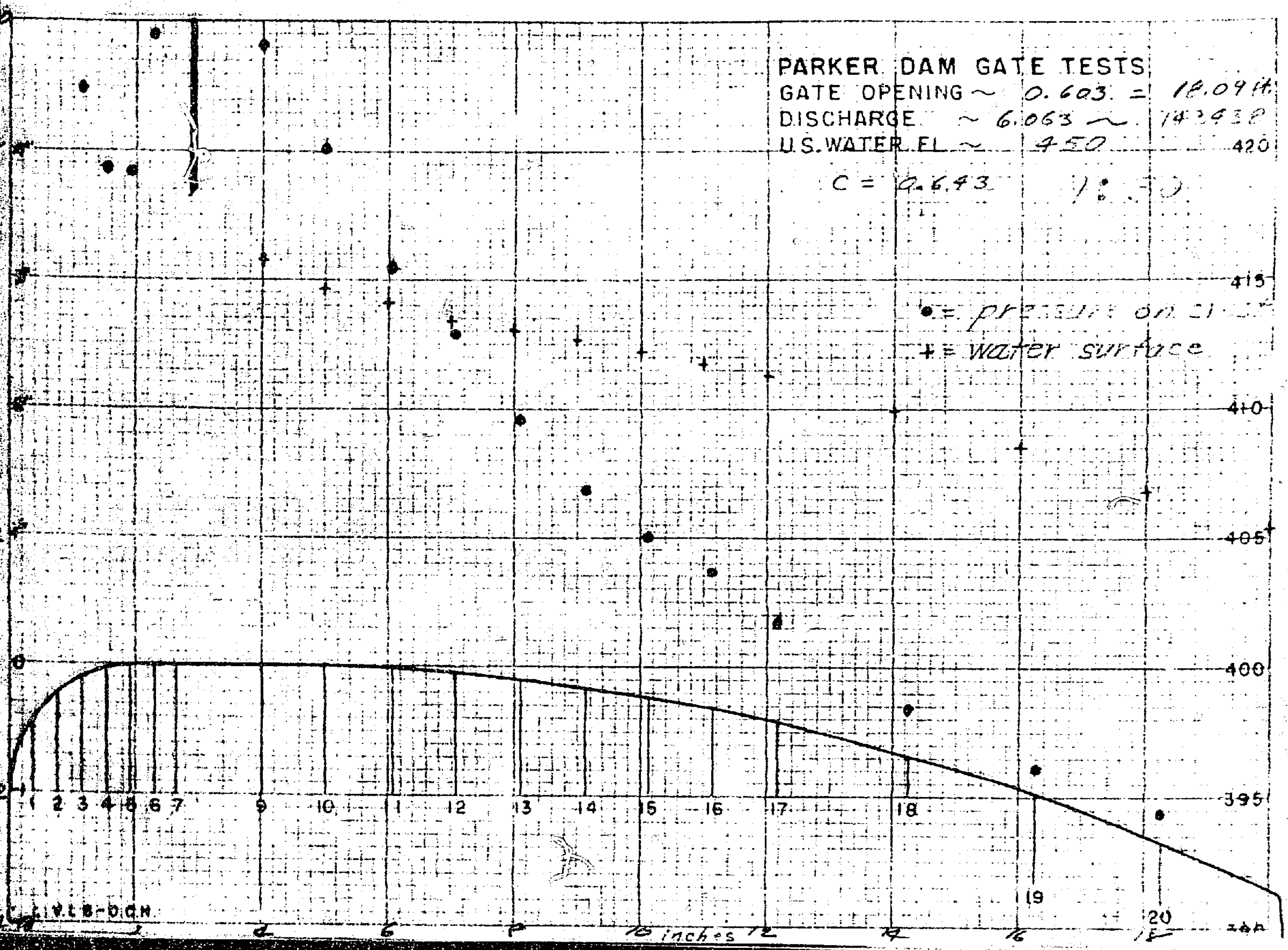
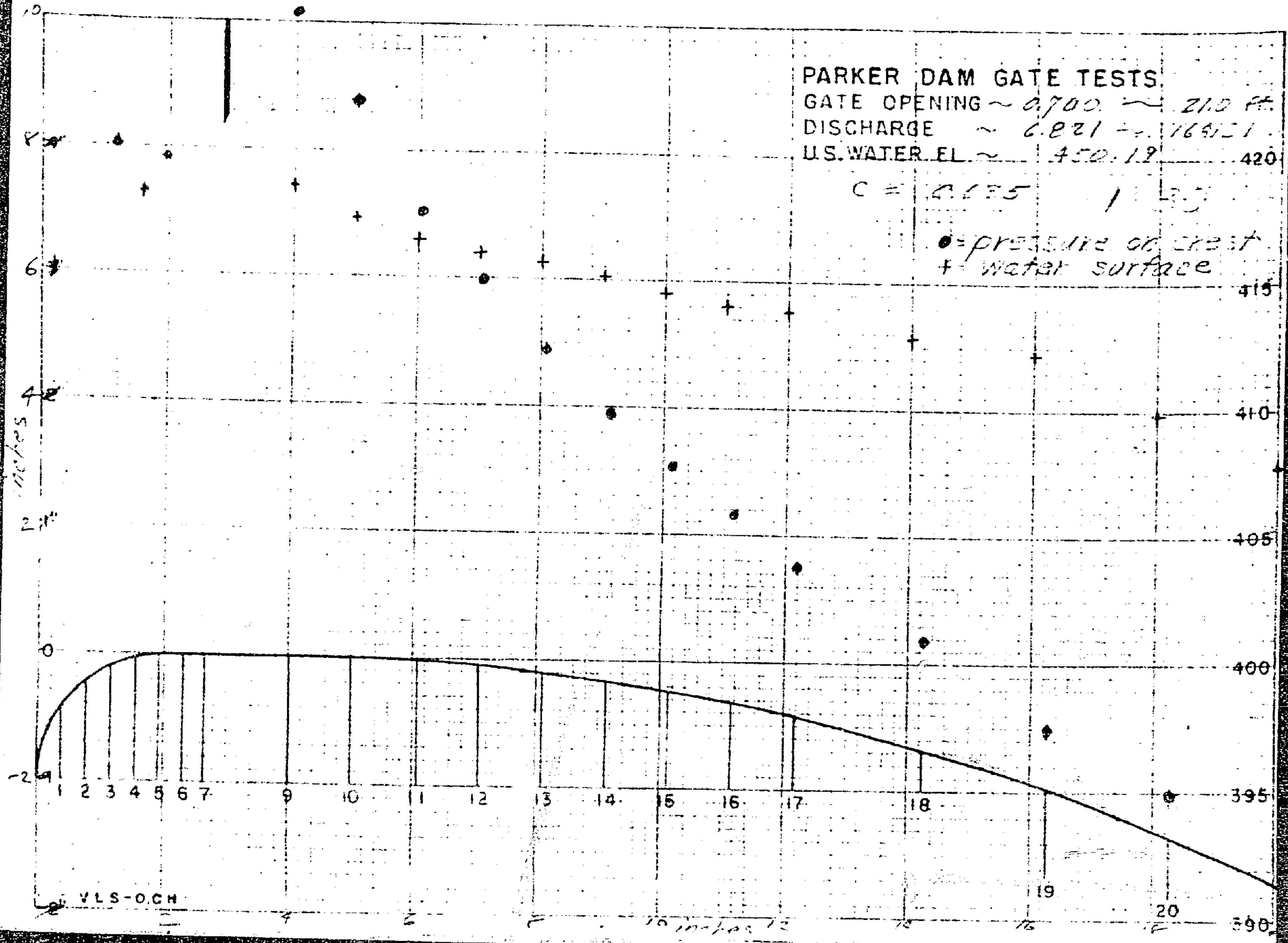
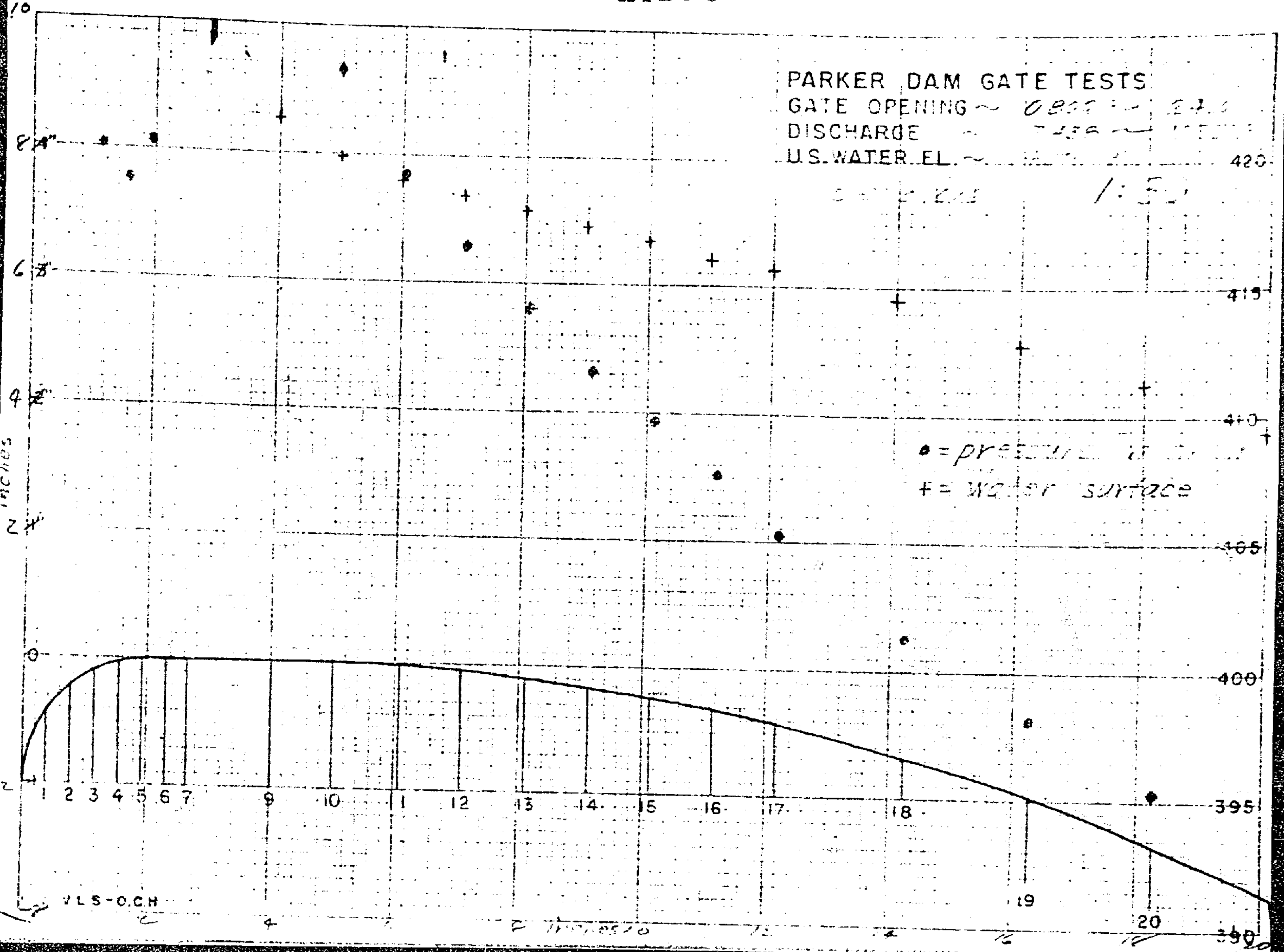
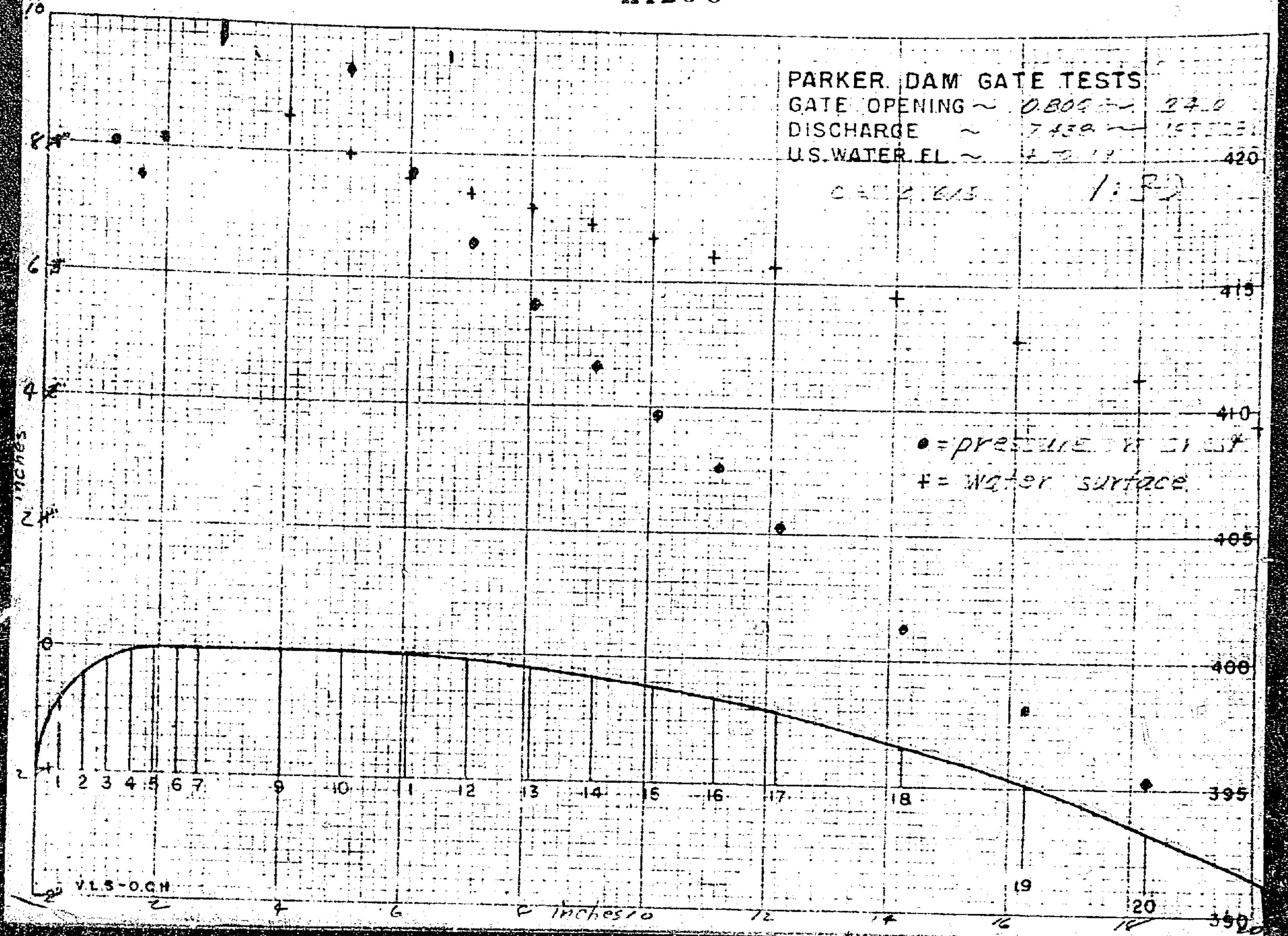

PARKER DAM GATE TESTS
GATE OPENING ~ 0.603 = 18.09 ft.
DISCHARGE ~ 6.063 ~
U.S. WATER EL ~ 450
C = 0.643
● = pressure on
+ = water surface
420
415
410
405
400
395
1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20
inches


PARKER DAM GATE TESTS
GATE OPENING ~ 0.700 ~ 21.0 ft.
DISCHARGE ~
U.S. WATER EL ~
C =
● = pressure on crest
+ = water surface
420
415
410
405
400
395
390
1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20
VLS-OCH

HYD 38


PARKER DAM GATE TESTS
GATE OPENING ~
DISCHARGE ~
U.S. WATER EL. ~
1:50
● = pressure
+ = water surface
Inches
10
8
6
4
2
0
420
415
410
405
400
395
390
1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20
VLS-O.C.H


PARKER DAM GATE TESTS
GATE OPENING ~ 0.809
DISCHARGE ~ 7430
U.S. WATER EL. ~
• = pressure
+ = water surface
V.L.S.-O.C.H.
inches
420
415
410
405
400
395
390