UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MULTIPLE SHUTTER GATE--BELLE GLADE PUMPING PLANT--HYDRAULIC MODEL TESTS CONDUCTED FOR CORPS OF ENGINEERS

Hydraulic Laboratory Report No. Hyd-362

ENGINGEERING LABORATORIES BRANCH

DESIGN AND CONSTRUCTION DIVISION
DENVER, COLORADO

October 31, 1952

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Laboratory Report No. Hyd-362
Hydraulic Laboratory Section
Compiled by: J. W. Ball
Checked by: D. J. Hebert

Subject: Multiple shutter gate--Belle Glade Pumping Plant--Hydraulic model tests conducted for Corps of Engineers

This report is in the form of a letter to Mr. George F. Snodgrass, Chief, Design Section, District Corps of Engineers, Jacksonville, Florida, presenting the data taken from a 1 to 11.8 model of a multiple shutter flap gate having three rectangular flaps. The report contains the data taken from the model and makes no attempt to analyze the results.

"Mr. George F. Snodgrass
Chief, Design Section
District Corps of Engineers
Post Office Box 4970
Jacksonville, Florida

Dear Mr. Snodgrass:

"The hydraulic model tests of the Belle Glade multiple shutter flap gate authorized by telegram of September 12, 1952, from your District Engineer have been completed. The 1 to 11.8 scale model transition and gate used in the tests was constructed by the Morse Brothers Machinery Company of Denver, Colorado. The objective of the tests as developed in preliminary discussions with Mr. L. H. Kessler, Chief Engineer of Hydraulic Engineering Department, Fairbanks, Morse and Company, was to obtain head losses for the gate and transition, with the gate flaps held in fixed positions. These data were to form the basis for evaluating the head losses of this type of gate and comparing them with those for a conventional circular flap gate. At your request, the test program was later expanded to include tests with wooden flaps weighted to correspond to the prototype flaps. The results of the tests are presented graphically on the two attached figures. The test set-up is shown by the seven attached photographs.

"Much of the data shown on the figures were taken during your visit of October 1 and 2 when the tests were observed also by Messrs. L. H. Kessler and H. L. Godwin of Fairbanks, Morse and Company, and B. B. Cox, J. B. Cross, and Dan Wilson of Morse Brothers Machinery Company. Head loss curves for the transition and gate with the three flaps at fixed angles, together with the head loss curves for the steel flaps unrestrained and the weighted wooden flaps unrestrained,

are shown on Figure 1. Head differentials at various discharges for the following listed conditions, together with a velocity head versus discharge curve based on the mean velocity in the pipe upstream from the transition are shown on Figure 2:

1. Transition section only

2. Transition section with gate frame only

3. Transition section with gate frame and 7.83-pound steel flaps

4. Transition section with the gate frame and 2.33-pound (weighted to scale) wooden flaps.

"A head differential versus discharge curve for a conventional 12-inch flap gate with a single circular flap, taken from page 243 of "Handbook of Cut-out and Drainage Practice" by Armco is included for comparison.

"The data on the figures are self-explanatory and may be used with other observations discussed subsequently to evaluate the various hydraulic characteristics of this particular gate design.

"During the tests with the 2.33-pound weighted wooden flaps unrestrained (weighted to represent 3,800-pound prototype flaps) it was noticed that the angle of the top flap was somewhat less than that of the middle and bottom flaps. Measurements at a discharge of 2.25 cfs (representing approximately 900 cfs prototype) established the angles as approximately 51 degrees, 60 degrees, and 61 degrees for the top, middle, and bottom flaps, respectively. The difference between the angle of the top flap and the other two might be explained by the fact that the upper surface of the top flap is subjected to relatively stagnant water while the corresponding surfaces of the others are subjected to the flow from the openings above them. The pressure on the upper surface of the top flap would therefore be greater than on the other two and the angle less. Time did not permit further exploration of this characteristic but undoubtedly you will wish to consider it in your contemplated pump model tests. The head loss curves for the three flaps fixed at equal angles (Figure 1) do not apply specifically to the case where the flaps are unrestrained, but can be used to ascertain the approximate angle of the steel and weighted wooden flaps at different discharges.

"Since it was established in the preliminary testing that the amount of downstream submergence did not influence the magnitude of the losses, no attempt was made to maintain the water at a particular level. The level varied from 0.9 to 2.2 feet above the center line

of the gate during the tests. The temperature of the water was about 69° F. The losses given on Figure 1 include dumping (exit) losses as well as those for the gate and transition. The losses were evaluated using the mean velocity in the pipe 12 inches upstream from the transition.

"Although the program did not include a study of the slamming of the flaps at pump shut-off, limited observations were made of this characteristic. Noticeable slamming occurred with the weighted wooden gates. The slamming seemed somewhat less for the steel gates. More rapid closure with the heavier flaps may account for the apparent difference.

"Two copies of this letter, with figures and photographs, are being sent to Mr. L. H. Kessler, Beloit, Wisconsin, and to Mr. B. B. Cox, Denver, Colorado, as requested during your visit. It is hoped that this letter report, together with attached graphs and photographs, will serve your purpose, as no further report is contemplated.

"As you know, the tests were more extensive than first contemplated; and the cost will exceed the preliminary estimate. Since this was discussed with and informally approved by you during your visit, no difficulty is anticipated in billing your office on Form 1080. This form will be submitted within the next few days.

Sincerely yours,

(Stamped) W. H. Price

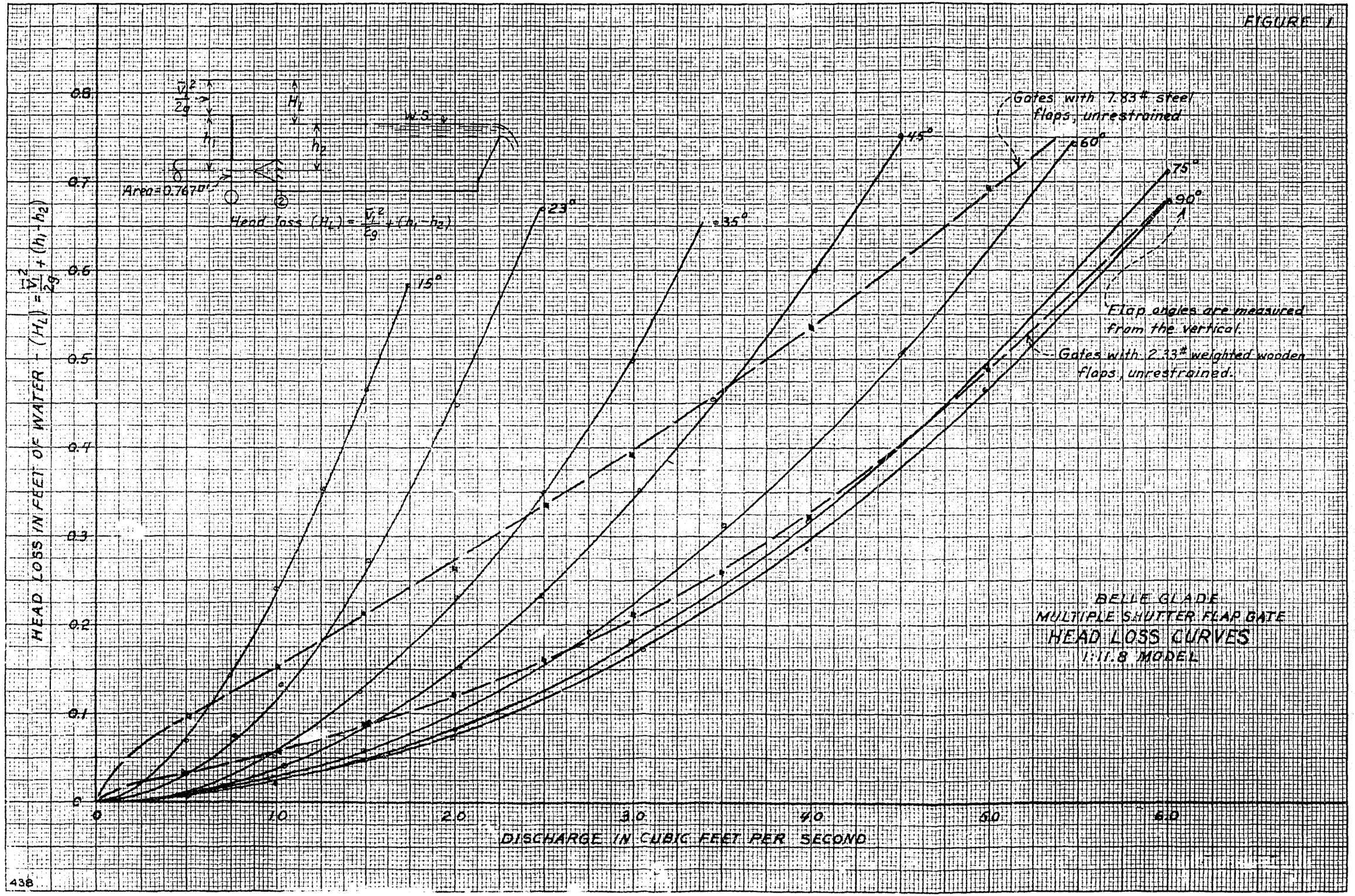
Walter H. Price, Chief
Engineering Laboratories Branch

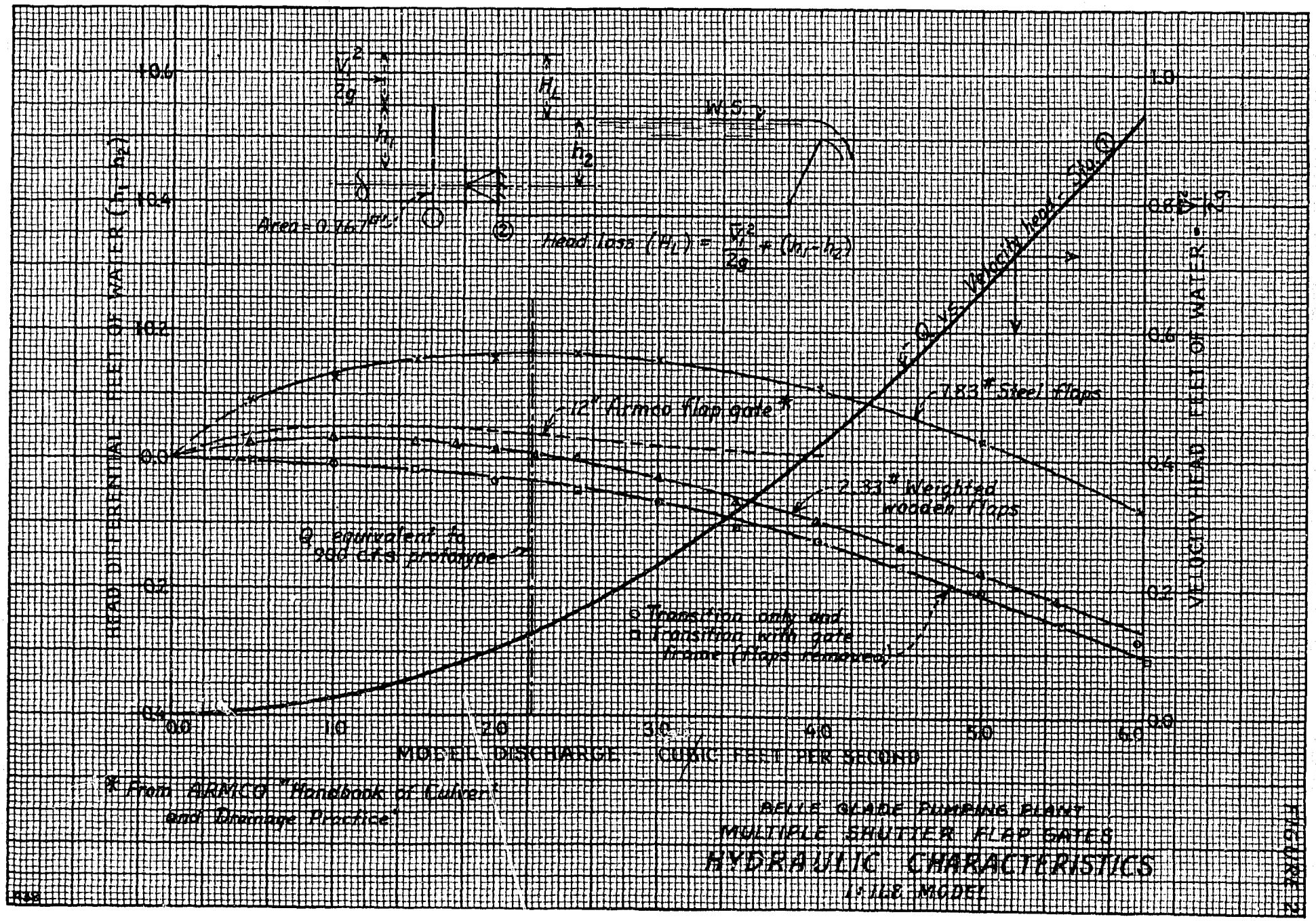
In duplicate

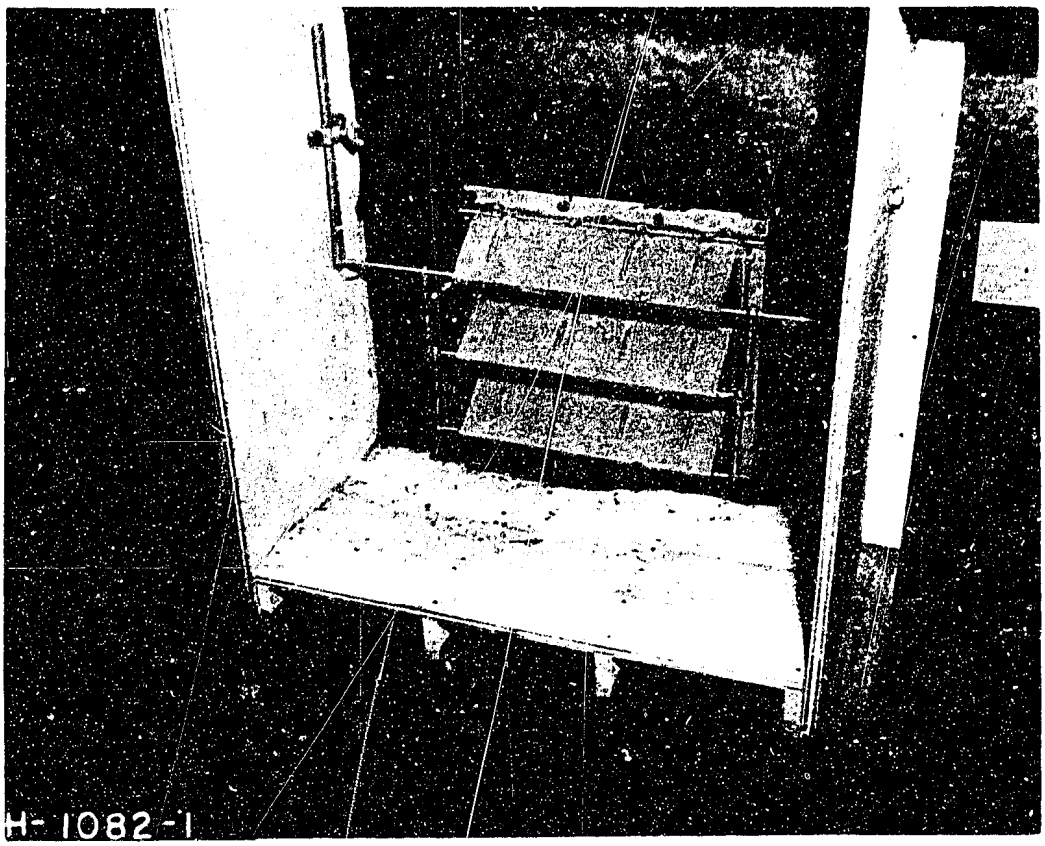
Enclosures

Copy to: Mr. L. H. Kessler, Fairbanks, Morse and Company,
Beloit, Wisconsin 2
Mr. B. B. Cox, Morse Brothers Machinery Company,
Denver, Colorado 2
(with enclosures to each)
Blind to: Head, Hydraulic Laboratory Section"

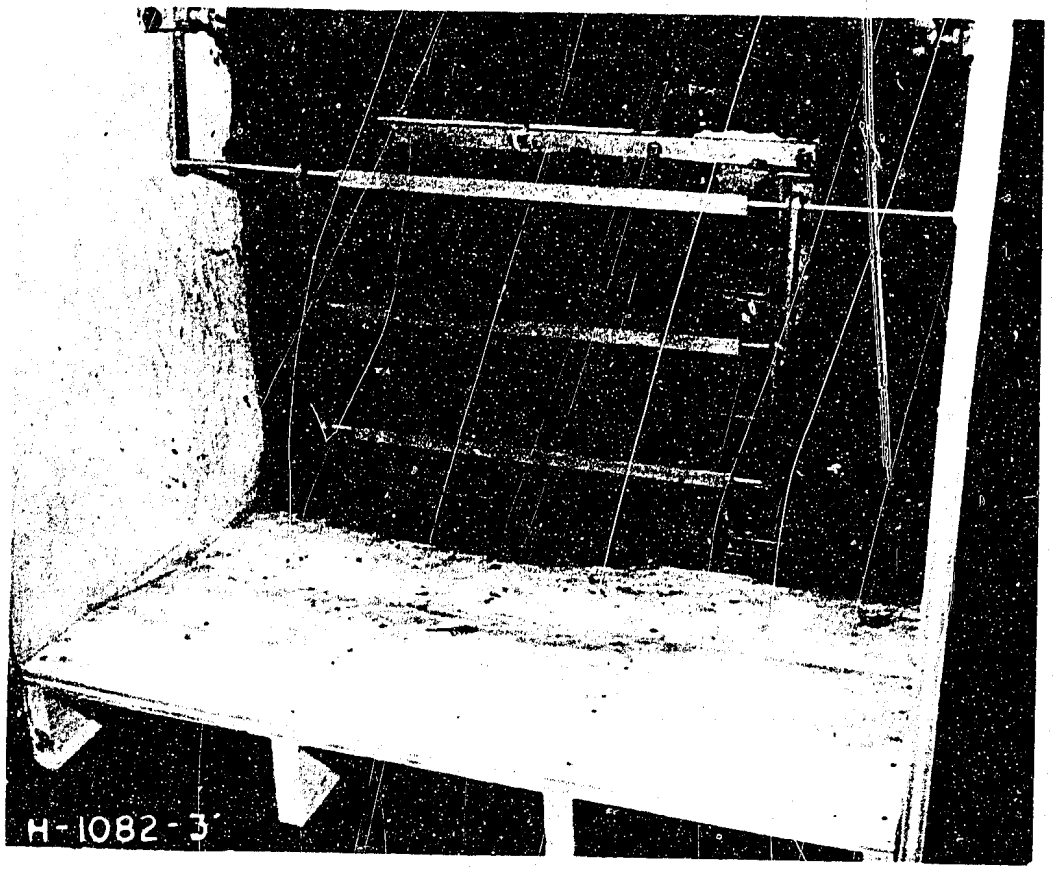
FIGURE 1


Gates with 7.83# steel flaps, unrestrained
Gates with 2.33# weighted wooden flaps, unrestrained.
Flap angles are measured from the vertical.
15°
23°
35°
45°
60°
75°
90°
Area = 0.767 □'
Head loss $(H_L) = \frac{V_1^2}{2g} + (h_1 - h_2)$
W.S.
$\frac{V_1^2}{2g}$
H_L
h_1
h_2
HEAD LOSS IN FEET OF WATER $- (H_L) = \frac{V_1^2}{2g} + (h_1 - h_2)$
DISCHARGE IN CUBIC FEET PER SECOND
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1.0
2.0
3.0
4.0
5.0
6.0
BELLE GLADE
MULTIPLE SHUTTER FLAP GATE
HEAD LOSS CURVES
1:11.8 MODEL


HEAD DIFFERENTIAL - FEET OF WATER ($h_1 - h_2$)
VELOCITY HEAD - FEET OF WATER - $\frac{V_1^2}{2g}$
MODEL DISCHARGE - CUBIC FEET PER SECOND
$\frac{V_1^2}{2g}$
h_1
h_2
H_L
W.S.
Area = 0.76 ft²
①
②
Head loss (H_L) = $\frac{V_1^2}{2g} + (h_1 - h_2)$
Q vs. Velocity head - Sta. ①
12" Armco flap gate *
7.83" Steel flaps
2.33" Weighted wooden flaps
Q equivalent to 900 c.f.s. prototype
○ Transition only and
□ Transition with gate frame (flaps removed)
* From ARMCO "Handbook of Culvert and Drainage Practice"
BELLE GLADE PUMPING PLANT
MULTIPLE SHUTTER FLAP GATES
HYDRAULIC CHARACTERISTICS
1:16 MODEL


H- 1082-1


H 82-2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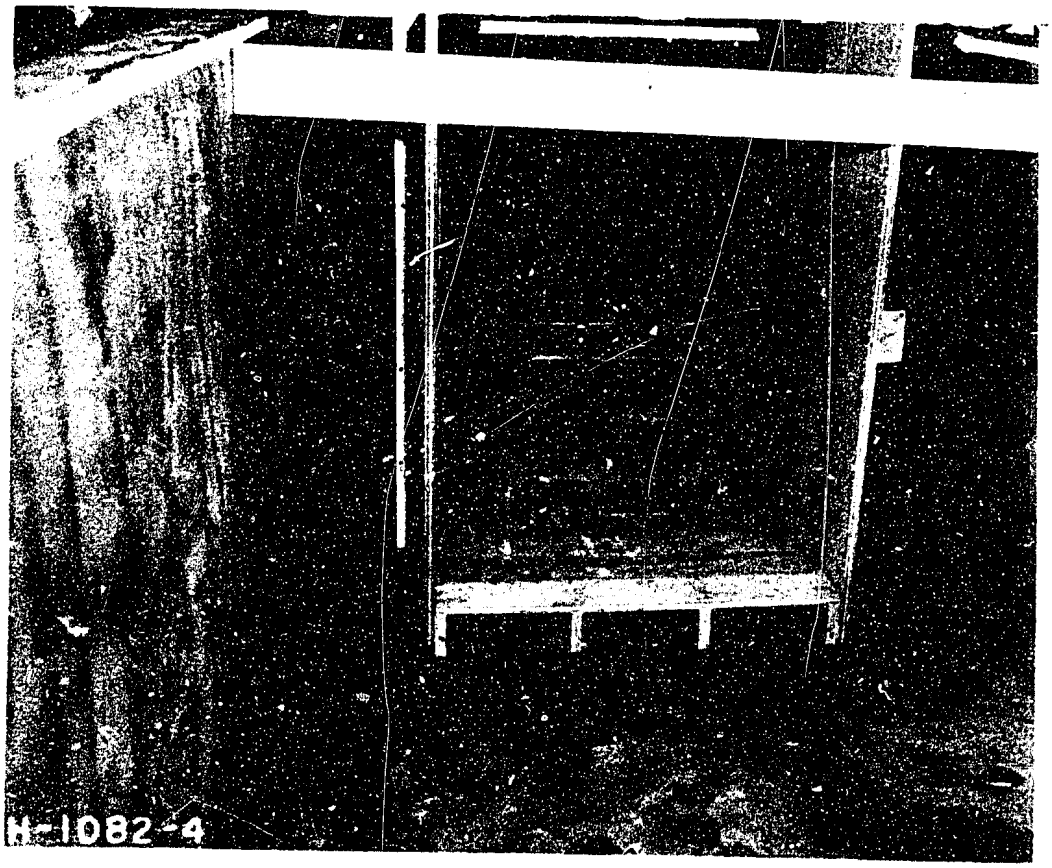
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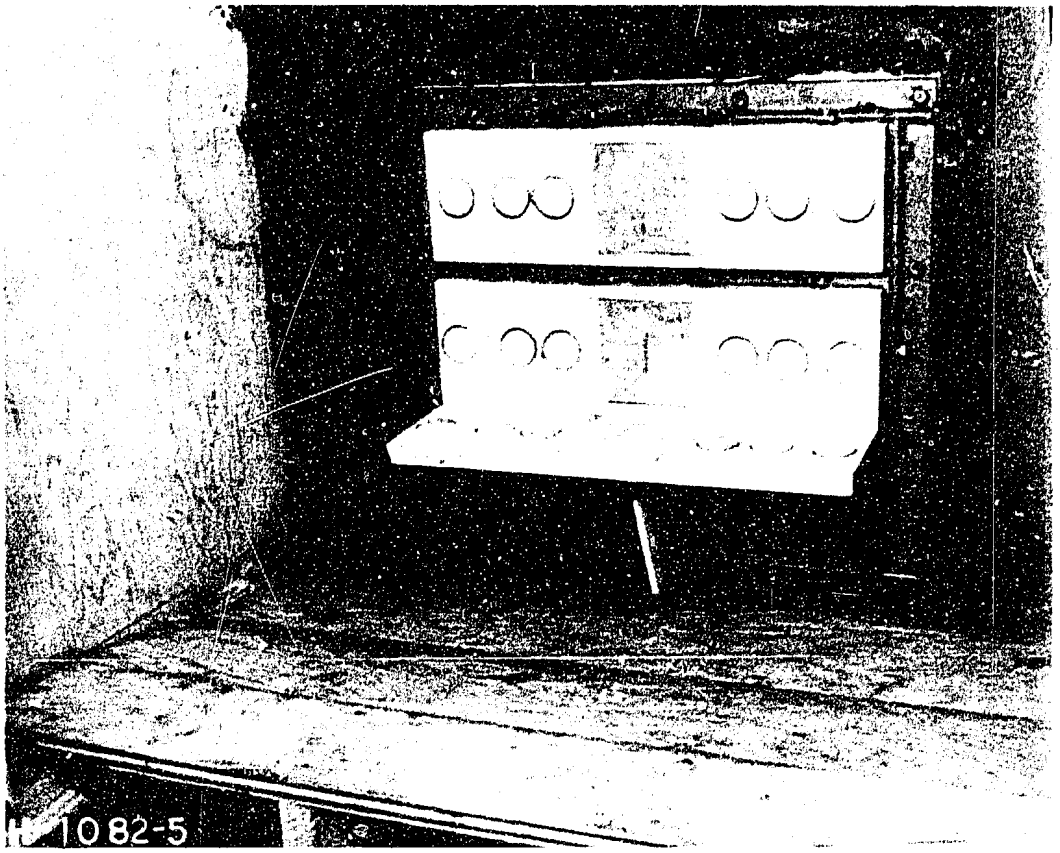
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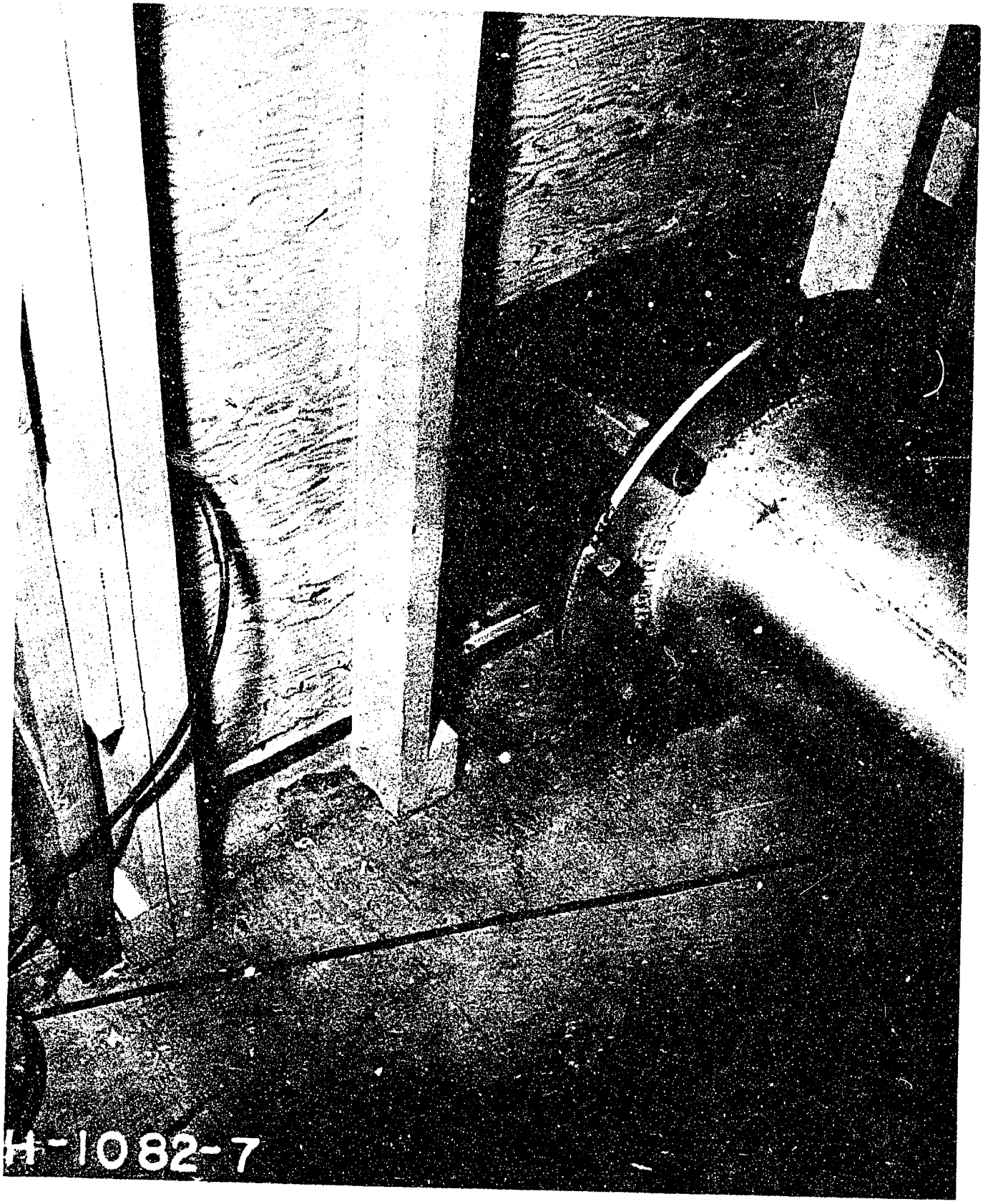
H-1082-6


H-1082-7