UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

SECOND PROGRESS REPORT ON STUDIES OF FLOW CHARACTERISTICS OF THE SPARLING 24-INCH OPEN-FLOW METER

Hydraulic Laboratory Report No. Hyd-327

ENGINEERING LABORATORIES BRANCH

DESIGN AND CONSTRUCTION DIVISION
DENVER, COLORADO

June 9, 1952

CONTENTS

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Laboratory Report No. Hyd-327
Hydraulic Laboratory
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Subject: Second progress report on studies of flow characteristics of the Sparling 24-inch open-flow meter

PURPOSE

This report is a summary of tests conducted on the Sparling 24-inch open-flow meter from June 15, 1951, to October 15, 1951. The purpose of the tests was to extend prior investigations on the registration accuracy of the meter to include the condition of a partially opened head gate. Previous work, described in Laboratory Report No. Hyd-315, dated June 15, 1951, dealt with the variations in registration accuracy caused by the use of flow straightening vanes, changing the size of straightening vanes, and the direction of approach to the discharge pipe.

FINAL CONCLUSIONS

The registration accuracy of the Sparling 24-inch open-flow meter is dependent upon the size of gate opening as well as the upstream approach conditions, the use of straightening vanes and their size, and the distance between the points of diversion and measurements. Any one of these variables will produce translations of the calibration curve; the range of percentage consistency for any particular curve, however, does not depart from the plus or minus 2-percent standard.

Restricting the gate opening has the further effect of raising the minimum discharge required to bring the calibration curve to the lower limit of the acceptable plus or minus 2-percent range band.

To use the meter under the conditions tested, a separate calibration curve would be required for each different gate opening, each size of straightening vane and different approaches, or for any combination of these variables.

THE INVESTIGATION

Figure 1 shows the meter assembly. Previous tests summarized in Laboratory Report No. Hyd-315 were concerned with the registration accuracy as influenced by upstream approach conditions, and the use of two sizes of straightening vanes. The test set-up shown in Figure 2 was used for all tests including those reported herein. Upstream approaches were varied by removing the left, right, or back wing walls in the head box, only one wall being removed for any one test. Three straightening vanes were placed with equiangular spacing in the pipe immediately upstream of the meter propeller. The length of 4 feet remained fixed, but the height was varied from 10 to 8 inches in successive tests. The meter was equipped with a 12-inch-diameter aluminum propeller.

The tests with which this report is concerned were to ascertain the effect of varying the gate opening in the head box, this new variable being imposed on a calibrated set of basic conditions. For comparative purposes the basic conditions chosen were those of a head-box approach from the right (right wing wall removed), 8-inch straightening vanes in place, and full gate opening. It was then assumed that the calibration curve obtained in previous tests for these conditions was correct. These conditions set up the worst approach to the gate possible in the laboratory model, and were considered to be as severe as any that would be encountered in the field, the conventional turnout being at right angles to the canal. Series of tests were made for three gate openings, 6, 12, and 18 inches. Testing at 6-inch gate opening was restricted to flows under 8.5 second feet because the head box was not high enough to permit the head required for greater flow.

The rate of flow was determined by volumetrically calibrated laboratory Venturi meters. Each series of tests began with an 18-inch gate opening, and was followed by an opening of 12 inches. Any change in the rate of flow was caused by an automatic increase in head necessary to pass water through the smaller opening; the position of the model control valve was not changed until the discharge was raised or lowered for the next series to begin again at 18-inch gate opening. This procedure had the advantage of high lighting any erratic result on a particular test because no two consecutive points on the calibration curves for the different gate openings were obtained in successive tests.

All tests at 6-inch gate opening were made in one series without intermediate changes to other openings. Successive points on the resulting calibration curve, however, were not necessarily obtained in consecutive tests.

Figure 3 is a graphical summary of all tests at the three gate openings. The three calibration curves can be compared to the curve obtained for assumed basic conditions which has been superimposed on the same plot. If this curve is taken as a base upon which to judge the effect of varying the gate opening, then it is apparent the effect is very pronounced. It would seem reasonable to expect the curves to approach that for full gate opening as the aperature increased in area; this is not borne out by the test data. No reason could be found for the downward slope at higher discharges of the curve for 18-inch gate opening, and the writer is inclined to believe this is either a reflection of a condition peculiar to the particular set-up, or the opening is at a critical point above and below which the curve may exhibit characteristics more nearly approaching those of the base curve. Also not clear is the reason for the milder slope at low discharges than is indicated on the curves for 6- or 12-inch gate opening.

The reverse curve shown in the curve for 12-inch gate opening cannot be ignored. Though it is much more pronounced here, a hint of such a reversal can be seen on the base curve, and, in Figure 5 of the first progress report, the test data for normal approach show undulations of unequal period which persist above 12 second feet. Since the evidence of such fluctuations was not considered positive as a general meter characteristic, the calibration curve was drawn to average the points. Recent work with the 12-inch Sparling open-flow meter at full gate opening, yet to be reported, indicates that meter may also have an undulating calibration curve. The amplitude of the waves is of no practical importance, being limited usually to plus or minus one-half-percent range. It is thought possible the condition of 12-inch gate opening serves to amplify an initial wave to the extent that succeeding undulations, such as occurred in the above figure, are overshadowed by it.

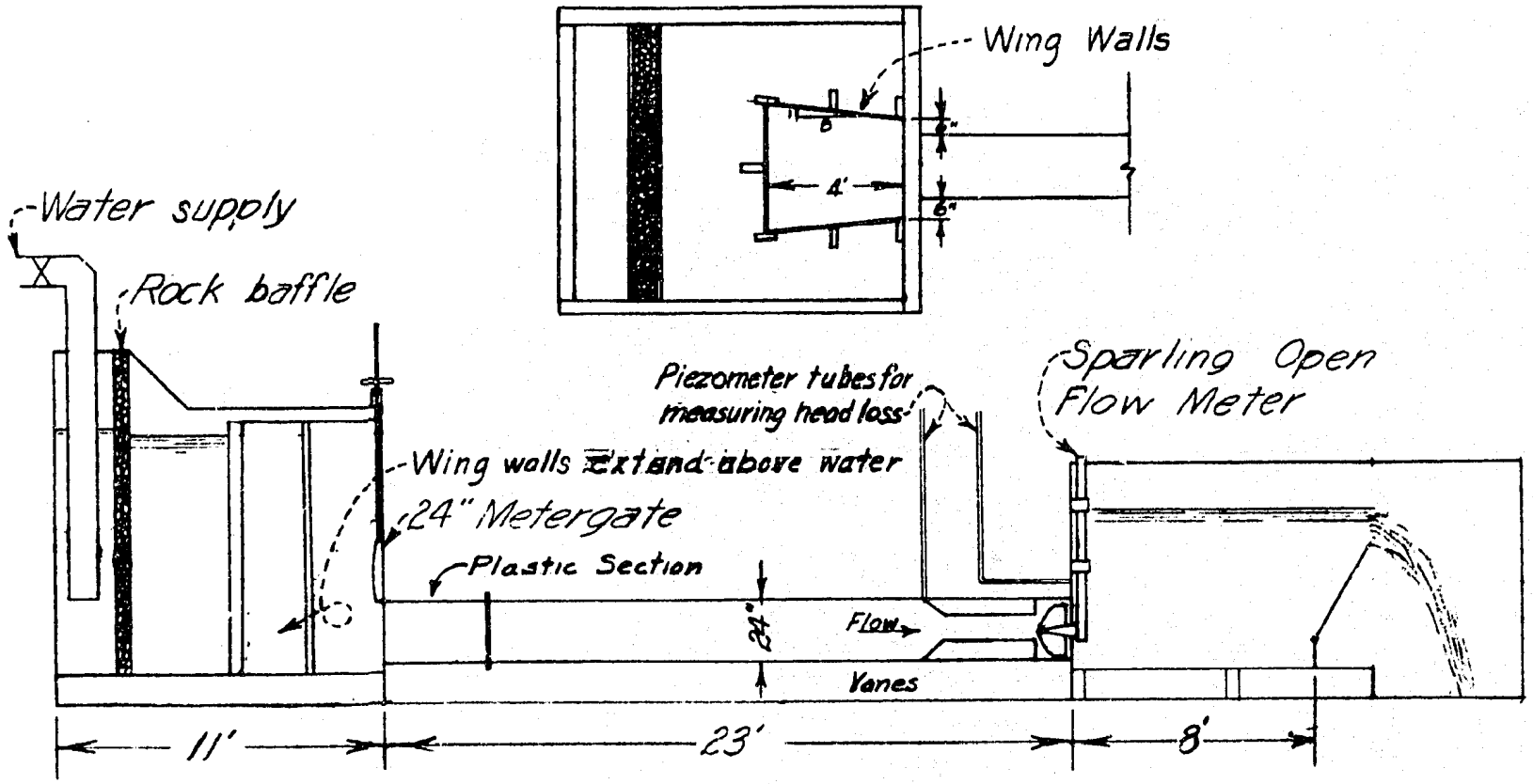
Little can be said of the limited curve on 6-inch gate opening unless its position, with respect to that for 12-inch gate opening, is interpreted to mean maximum vertical translation of the curve is accomplished at the latter opening. As would be expected there was a great deal of turbulence immediately downstream of the gate at 6-inch opening, even at low flows.

Turbulence at 18-inch gate opening was appreciable only at flows above 20 second feet. The air spiral accompanying the vortex in the head box was also in prominence in the plastic pipe section over that rate of flow. For the 12-inch gate opening, turbulence was noticeable at flows over 12 second feet, and the air spiral was intermittently visible above 15 second feet. Had the submergence of the gate been increased, the introduction of air by the vortex could presumably have been reduced. The volume of air carried through the pipe in any instance was not considered great enough to have affected test results.

Though no velocity distribution traverses were made, it is evident from comparison with the results of previous tests at full gate opening that the pattern is considerably upset by partially closing the gate. The 11.5 pipe diameters separating the meter from the gate are, therefore, insufficient for flow distribution to be restored to normal. In addition to producing a vertical translation of the calibration curve, varying the gate opening also translates the curve horizontally, indicating a greater range of lower discharges is necessary to reach the percentage accuracy and discharge of relative stability.

In making use of this meter, and in evaluating it, it is important to know the boundary conditions to be imposed upon it. It is advisable in the design of any distribution system in which it is to be used, to standardize the conditions under which it must operate, and to determine the calibration curve which accurately fits those conditions.

Figure 1--Sparling 24-inch open-flow meter and mounting brackets.



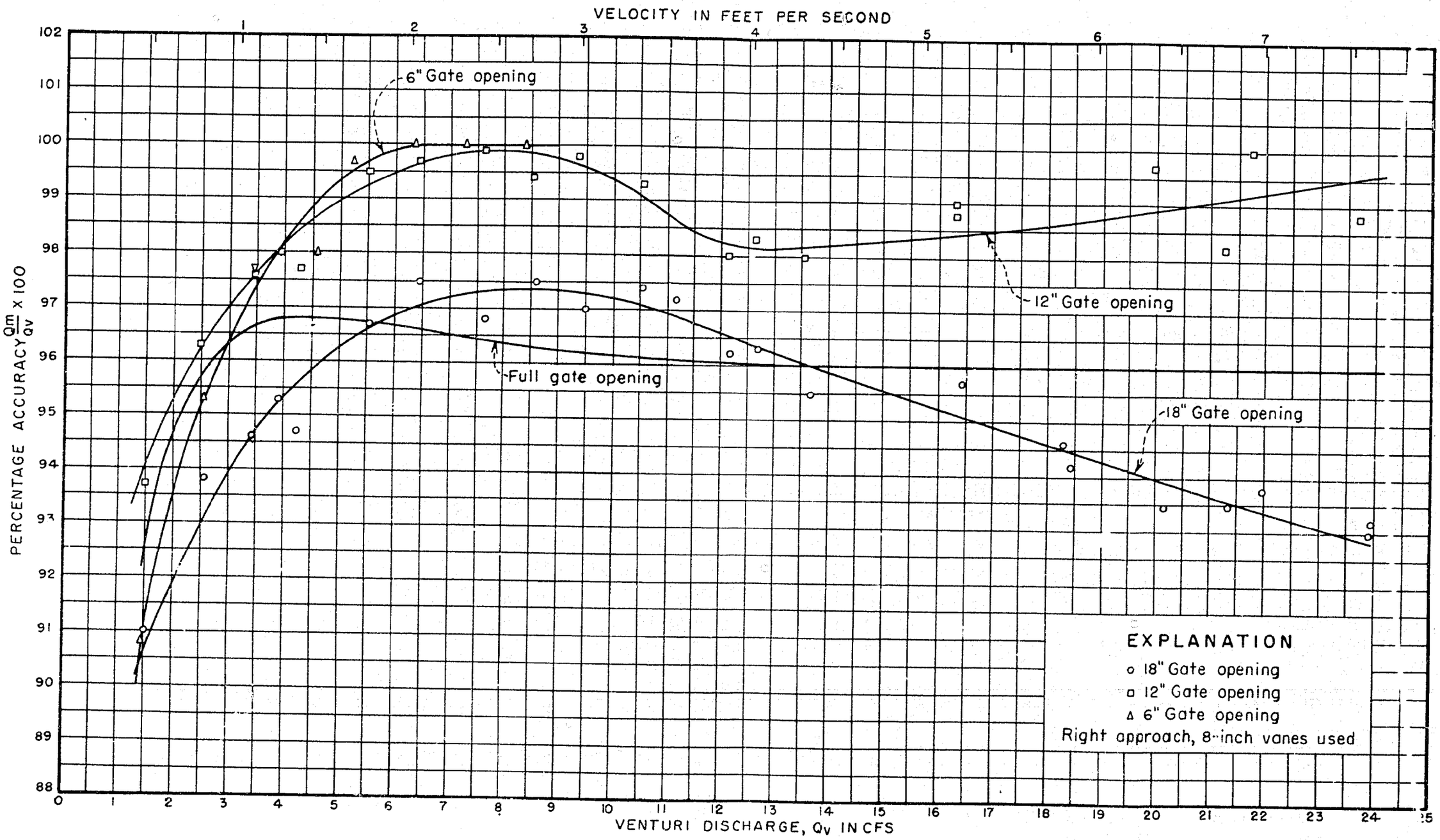
LABORATORY ARRANGEMENT FOR TESTS
OF A 24-INCH
SPARLING OPEN FLOW METER

FIGURE 2

REPORT HYD-327

251
DW 10/10/50

FIGURE 3
REPORT HYD. 27



CALIBRATION CURVES
SPARLING 24-INCH OPEN-FLOW METER

251

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