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HYDRAULIC LABORATORY

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

Hydraulic Laboratory Report No. Hyd-315

RESEARCH AND GEOLOGY DIVISION



BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

June 15, 1951

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Branch of Design and Construction
Research and Geology Division
Denver, Colorado
June 15, 1951

Laboratory Report No. Hyd-315
Hydraulic Laboratory
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D. M. Lancaster

Subject: Progress report on studies of flow characteristics of the Sparling 24-inch open-flow meter

PURPOSE

The purpose of this progress report is to summarize in one source the results of tests conducted to date on the Sparling 24-inch open-flow meter. The present series was made to evaluate the registration accuracy for various flows, approach conditions, and two sizes of straightening vanes. The structural properties and design principles involved were not investigated.

PRELIMINARY CONCLUSIONS

The registration accuracy of this meter is dependent upon the upstream approach conditions and the use of straightening vanes. When adequate vanes are in place immediately upstream of the meter, accuracy is better than plus or minus 2 percent for flows from 2 cubic feet per second to 27 cubic feet per second, regardless of the angle of approach at the turnout and with full gate opening.

The percentage accuracy range is not appreciably affected by the size of straightening vanes used, 8 inches or higher, but the mean percentage accuracy is dependent upon their size.

The meter must be attached to the mounting brackets prior to opening the head gate for any flows over about 7 cubic feet per second because the force of the moving water prevents safe positioning. Over a rate of 10 cubic feet per second it is virtually impossible for two men to install the meter.

THE INVESTIGATION

General Description of the Meter

The meter and mounting brackets are shown in Figure 1. Aluminum is the principal material, being used for the three-bladed

propeller, tubular column, and register case. Both mounting brackets are also of cast aluminum. With brackets installed at each measuring station, the meter may be transported wherever needed and quickly anchored in place. The top bracket has provision for a lock to prevent removal by unauthorized persons.

The register at the top of the tubular column shows the total volume of water which has passed the propeller. A transmitter can be provided to totalize the flow at some point removed from the measuring station or to make a recording of flow volume. Registration may be in acre feet, as in the case of the meter tested, acre inches, miners inch hours, miners inch days, cubic feet, or gallons.

The meter in correct operating position is shown in Figure 2. The outlet pipe must be nearly flush with the tail wall if there is to be sufficient clearance between it and the tubular column. Such a set-up will place the propeller fully inside the discharge pipe. The axis of the propeller should coincide with that of the discharge pipe. Submergence at the pipe face must be complete, and a minimum velocity of 0.5 foot per second is required.

Meters are available in sizes from 14 inches to 72 inches.

Test Procedure

The meter was installed at the discharge end of a 24-inch pipe 23 feet long, as shown in Figure 3. Control of the rate of flow was accomplished with valves in the main supply line. The turnout gate in the head box was kept fully open for all tests. Water level in the tail box was controlled by a tail gate, and was never allowed to drop below complete submergence of the pipe. Early tests at low flows were made in some cases with a bare minimum of submergence; later tests were made with at least 1 foot in excess of that required.

Registration of the meter was compared to the measurements made with one to four venturi meters, depending upon the rate of flow. These venturi meters had been calibrated volumetrically at an earlier date. The time element was measured by a stop watch.

With the pipe flowing full, and tail water depth above the minimum, sufficient time for stabilization of the rate of flow and elimination of excess air was allowed prior to each test run. The length of each run was determined by the time required for at least one-tenth acre-foot to pass the meter. For most high rates of flow a considerably greater volume than this passed because of the time consumed recording venturi readings. Whenever the results of a test were abnormal to the indicated trend, the test was repeated.

The above procedure was used for each of three approach conditions and two vane sizes, in combinations. Temporary wing walls were built into the head box (see Figure 3) to force the water to enter the pipe from different directions. With the left-hand wall removed, and the back and right-hand walls in place, approach was at 90 degrees to the pipe axis from the left. Removing the right-hand wall and replacing the one on the left produced a similar approach from the right. Leaving the walls on the right and left sides in position, and removing the back wall, allowed the water to enter the pipe along its axis. The two approaches at 90 degrees to the pipe axis are thought to create more severe conditions than any which will be encountered in the field.

Three vanes of 12-gage galvanized iron were employed in later tests at equiangular spacing to reduce the effect of spiral rotation of the water introduced by an unsymmetrical approach, Figure 4. Each was fastened to the pipe at only five points to avoid inordinate disturbance of the boundary flow. The fasteners were made of 3/16-inch strap iron. The downstream ends of the vanes were installed coplaner with the upstream end of the meter.

Test Results

The first series of tests was made with no vanes in the pipe for three approach conditions, normal, left, and right approach. Figure 5 is a graphical summary of the series. The results of each condition show a clear separation in relative position so as to leave no doubt as to the importance of maintaining control of the approach. Presumably, other curves could be produced which would lie between the limits of the upper and lower curves for intermediate angles of approach, and probably with no greater range than those shown. The scattering of points at low flows is an indication of the relative instability of a system without vanes.

An approach from the right caused a vortex to form in the head box with counterclockwise rotation. At low flows the forces producing the vortex were not great enough to make the accompanying funnel visible in the plastic pipe section immediately downstream of the head wall; at higher flows, however, the funnel appeared well into this section as an oscillating air spiral. The same direction of rotation prevailed at the meter nose, and as can be seen from the shape of the propeller blades, a retardation of rotational velocity resulted. Thus, the meter tended to register low.

For an approach from the left, the vortex rotation was clockwise with a similar air trail in evidence at high flows. The angle of force on the propeller blades was then steeper than normal

and consequently the resultant force causing rotation was larger than normal for any given flow. Thus, the meter tended to register high.

If the level of normal approach is accepted as a base for comparison of curves, then the effect toward retardation to a constant lower angular velocity is considerably greater than that toward acceleration to a constant higher angular velocity.

The second series of tests was made with two sizes of vanes to evaluate the correctional effect of their use. As shown in Figure 4, the first size used was 10 inches high. This size left only a 4-inch-diameter circle free in the pipe. Later the size was reduced to an 8-inch height which the meter manufacturer considers adequate. The series is summarized graphically in Figure 6. Tests were limited to an approach from the right.

Here again the curves show clear separation in position, indicating the influence of vane size. The stability at all flows is improved, particularly at the lower ones. Considering the two series of tests, then, it is evident that the use of vanes is not necessarily the complete answer to correct registration, but rather is a means in obtaining accurate registration. If the vane size is made standard and the corresponding calibration used, registration should fall within a reasonable percentage accuracy range. This statement will need verification, as briefly outlined below.

Efforts were made to install the meter at various rates of flow. It was discovered that beyond 7 cubic feet per second one person could not safely position it, and over a rate of 10 cubic feet per second two men were unable to install it. This may or may not be a disadvantage, depending on whether installation is to be accomplished prior to delivery of water. Inasmuch as the meter is of the totalizing type and not primarily a rate indicator, the matter may be of minor importance.

Future Tests

No tests were made with different gate openings. It is planned to ascertain the effect of restricting flow at the head box with the 8-inch vanes in place. Heretofore, the velocity distribution across any diameter has been assumed to follow the usual pattern for a closed conduit. The restriction will undoubtedly produce unsymmetrical velocity distribution on a vertical plane. Whether the length of test section is sufficient to allow a redistribution is unknown. A supplementary report will be issued on the findings.

No further tests without vanes are contemplated.



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

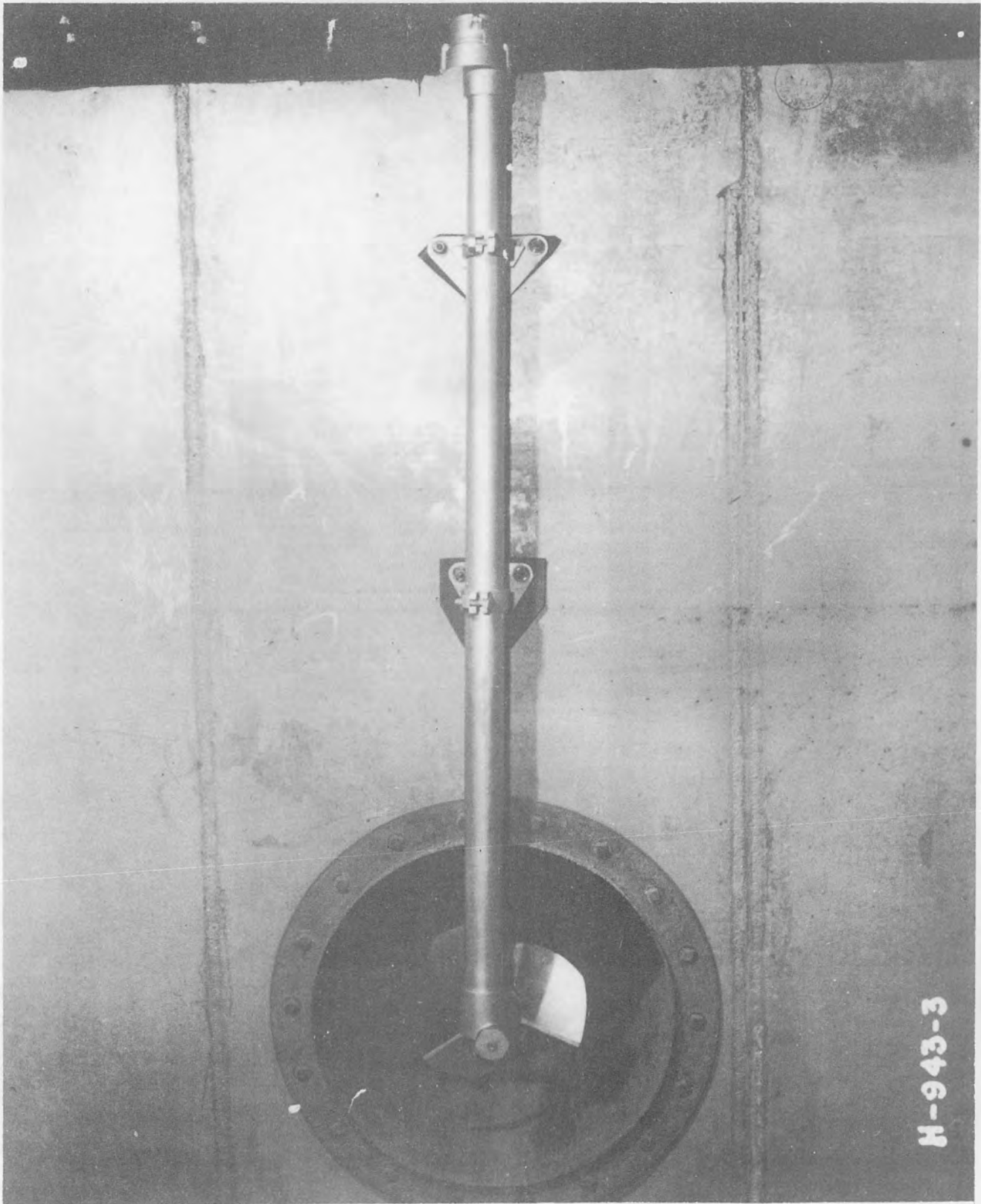
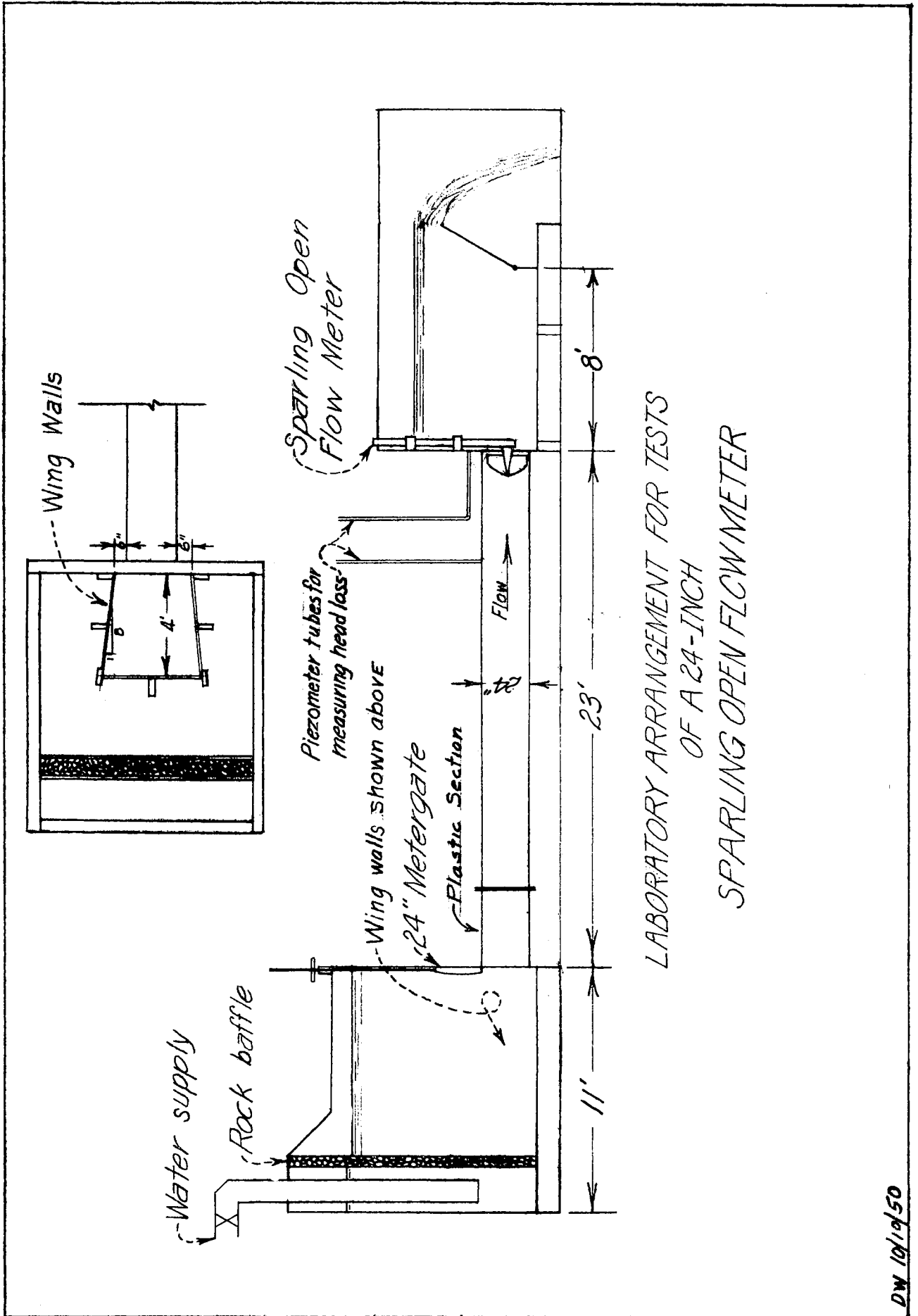
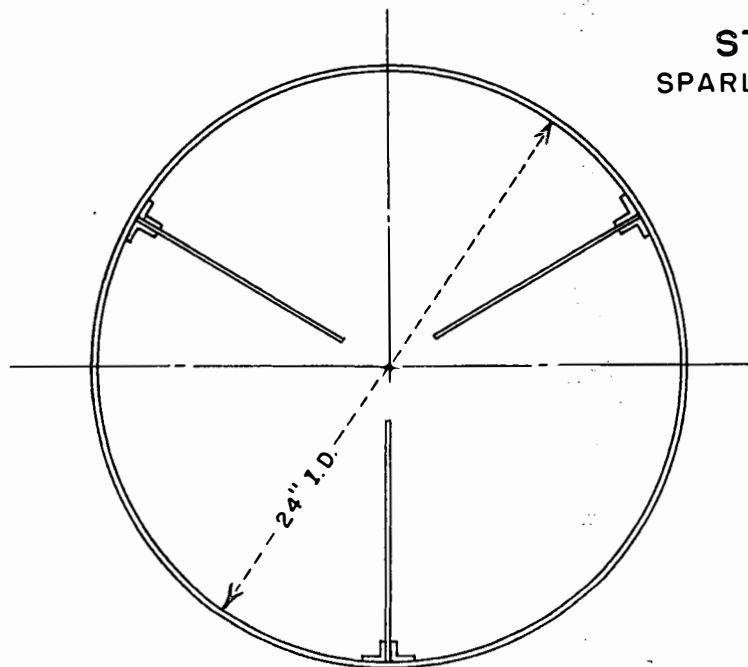


Figure 2 - Sparling 24-inch open-flow meter in correct operating position. Straightening vanes are not shown.

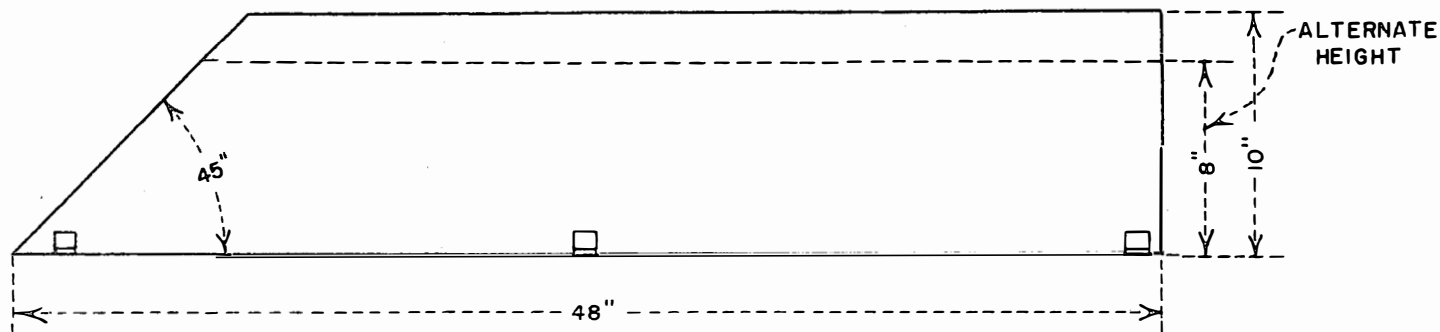


LABORATORY ARRANGEMENT FOR TESTS
OF A 24-INCH
SPURLING OPEN FLOW METER

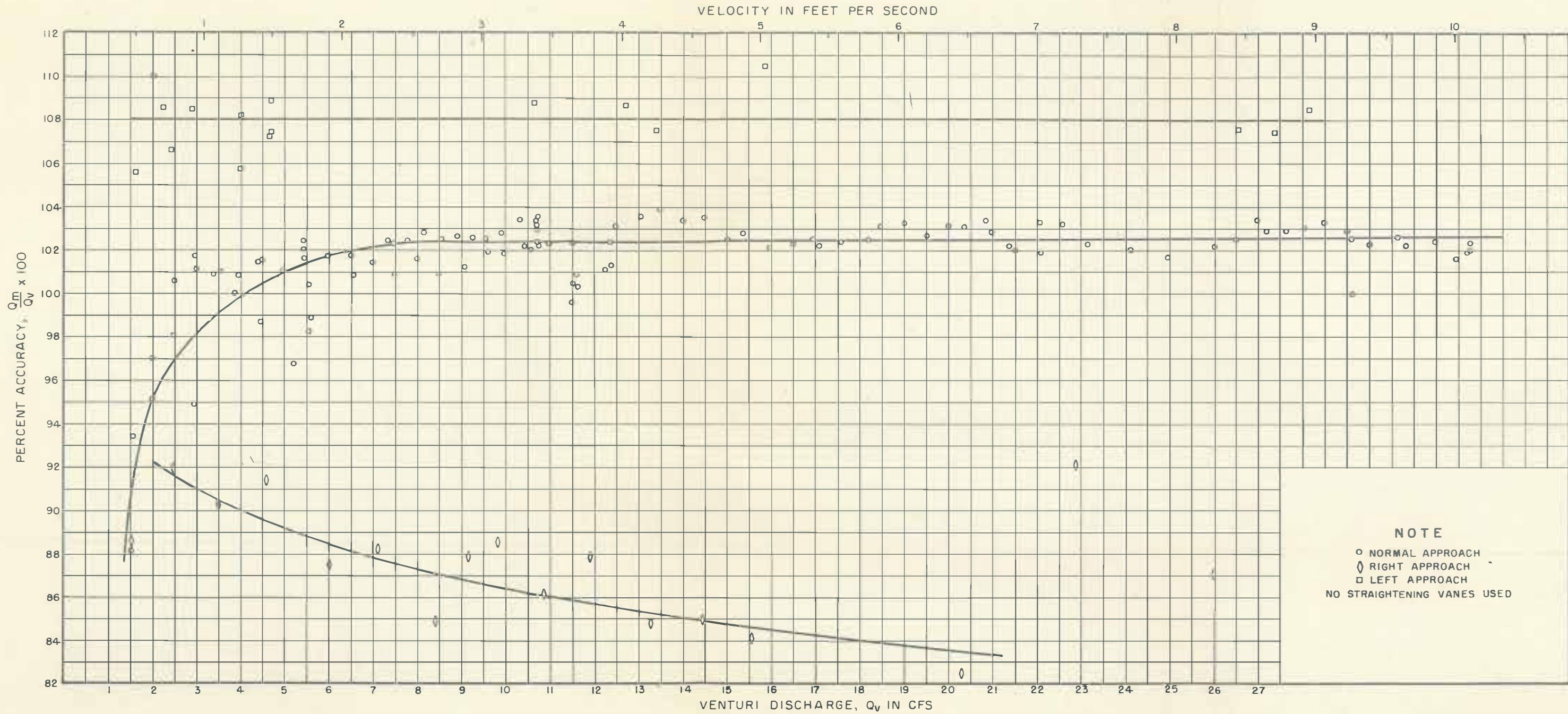
STRAIGHTENING VANES
SPARLING 24-INCH OPEN-FLOW METER



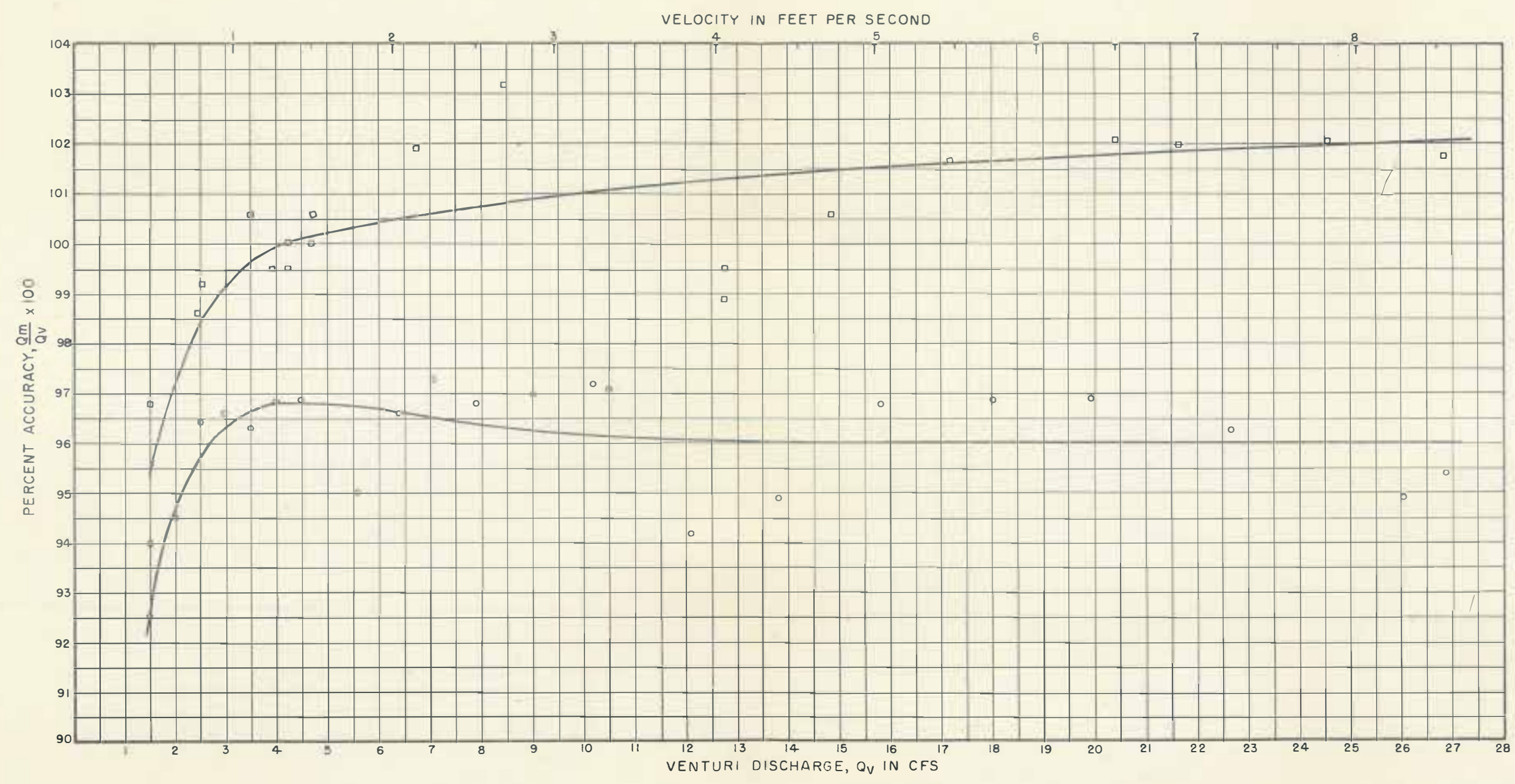
PLACEMENT VIEW



GENERAL DIMENSIONS



CALIBRATION CURVES
SPARLING 24-INCH OPEN-FLOW METER



NOTE
 ○ RIGHT APPROACH, 8-INCH VANES
 □ RIGHT APPROACH, 10-INCH VANES

CALIBRATION CURVES
 SPARLING 24-INCH OPEN-FLOW METER

