UNITED STATES
DEPARTMENT OF THE INTERIOR
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WATER RESOURCES BRANCH

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EQUIPMENT FOR RIVER MEASUREMENTS

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PARSHALL FLUME TYPE OF ARTIFICIAL CONTROL

SUPPLEMENT TO 1933 EDITION OF
STRUCTURES FOR ARTIFICIAL CONTROLS

Arranged by

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THE PARSHALL FLUME TYPE OF ARTIFICIAL CONTROL.

At many river measurement stations artificial controls are necessary in order to stabilize the stage-discharge relation. (See "Equipment for river measurements.--Structures for artificial controls." Washington, 1933.)

One of the essential requirements in designing an artificial control is to obtain a structure that will retain its effectiveness under all conditions and continue to function in the manner for which it was designed. If the stage-discharge relation is not stabilized by the construction of the artificial control, and if the rating curve continues to shift, then the purpose for which the control was constructed has not been fully accomplished.

In many streams large quantities of silt, sand and gravel are moved along the bed, the finer particles sometimes being carried in suspension at high velocities. As the stage falls and the velocity decreases, a considerable amount of silt, sand and gravel may be deposited. Small streams having steep gradients ordinarily are more subject to deposits of sand and gravel than are large streams of flat slope, although any stream that has a shifting bed or that carries a large silt load may be similarly affected by silt deposits.

A change in the hydraulic conditions such as the construction of an artificial control which increases the depth of water and thereby reduces the velocity may be expected to produce a change in the stream bed. If the stream does not carry any considerable amount of silt or bed load, the bed may become stabilized under the new conditions and the control continue to function satisfactorily. On the other hand, if the bed load and silt movement are large, there may be continual changes in the section back of the control, so that, for the same stage, the slope of water surface and the velocity of approach immediately above the control may vary from time to time with resulting changes in the stage-discharge relation.

Various expedients have been used in the designs of artificial controls for the purpose of obtaining controls that will not be affected by silt and bed load deposits. The San Francisco district uses a design in which the profile of the control follows the shape of the stream bed at a height little if any above the natural surface of the ground. (See "Equipment for river measurements--Structures for artificial controls," page 13 and Plate 2.) Another design used to some extent in California and in the Honolulu district consists of a scour dam built a short distance upstream from the control. (See "Structures for artificial controls," pp. 14-15, 18-19, and Plate 3.) These methods appear to give satisfactory results where there is sufficient fall to permit their use and where there are no complications caused by flat slopes or changes in stream bed downstream from the structure.

The Parshall flume has been used to some extent in the Honolulu district on small streams that at times carry bed loads of gravel, boulders and debris. After experience with various types of artificial controls, the Honolulu district office expresses the opinion that "In general on small flashy streams in Hawaii the Parshall flume is considered the most satisfactory artificial control where size of stream and costs are not prohibitive." (See "Structures for artificial controls," page 19 and Plate 17.)

The Parshall flume as used in ditches and canals is usually of timber construction and designed to carry a certain maximum discharge (See "The Improved Venturi Flume" by R. L. Parshall, Trans. Am. Soc. C. E., 1926, Vol. 89, p. 841, also Bulletin 336, the Colorado Agricultural Experiment Station, Fort Collins, Col., March, 1928, and U. S. Dept. of Agriculture, Farmer's Bulletin No. 1683, January, 1932.) When built in accordance with standard designs the accuracy of the Parshall flume as a measuring device is believed to be within 5 per cent.

The peculiar advantages of the Parshall flume for use as an artificial control are that it is self cleaning and will pass large quantities of silt and debris, also that it is effective for use in measuring the discharge, or as an artificial control, when subjected to a relatively high degree of submergence and a rather wide range of backwater conditions downstream from the structure.

Parshall flumes are of various sizes and capacities, and may be designed to function effectively as artificial controls where the ratio between extremes in discharge is as much as 100 to 1, although the range in discharge under which the flume would be used as a measuring device in ditches or canals ordinarily might not exceed a ratio of about 50 to 1.

The ratio of the extremes in discharge for a natural stream on which an artificial control would be built might be as much as 1,000 to 1, therefore it is evident that the Parshall flume ordinarily would be effective for only a part of the entire range in discharge, and additional spillway capacity is required for the higher discharges.

When used in connection with an overflow section of artificial control which is intended to be permanent, the Parshall flume should be built of concrete as an integral part of the control structure. The records of stage should be obtained in the usual manner by a water stage recorder suitably located a short distance upstream from the control. For this type of structure, and in order that there may be no deposit of silt and debris between the gage and the control, the intake to the gage well should be not more than 10 or 15 feet upstream from the intersection of the spillway with the river bank, the line of the spillway being at a 45 degree angle with the direction of flow.

Discharge measurements should be obtained for the entire range of stage, although provision for staff gages on the side wall and throat of the flume may be made in the design so that the theoretical discharge may be computed and compared with the discharge as measured by current meter. Small stilling wells may be built into the concrete wall for convenience in obtaining the readings, and to increase their accuracy.

The overflow section or sections should be so designed that there will be no deposit of silt or debris in the pool back of the spillway. In other words, the entire structure should be self cleaning. It is believed that this may be accomplished by extending the spillway sections upstream at 45 degree angles from the side walls of the flume, and by designing the spillways as shown in the drawing.

The cost of the Parshall flume with the spillways built at 45 degree angles will, of course, be considerably greater than the cost of other and simpler types of artificial controls. Consequently the construction of this type of control might be warranted only where the character of the stream and the condition at the site are such that a simpler type of structure would not prove satisfactory in operation because of changes in the stage-discharge relation.

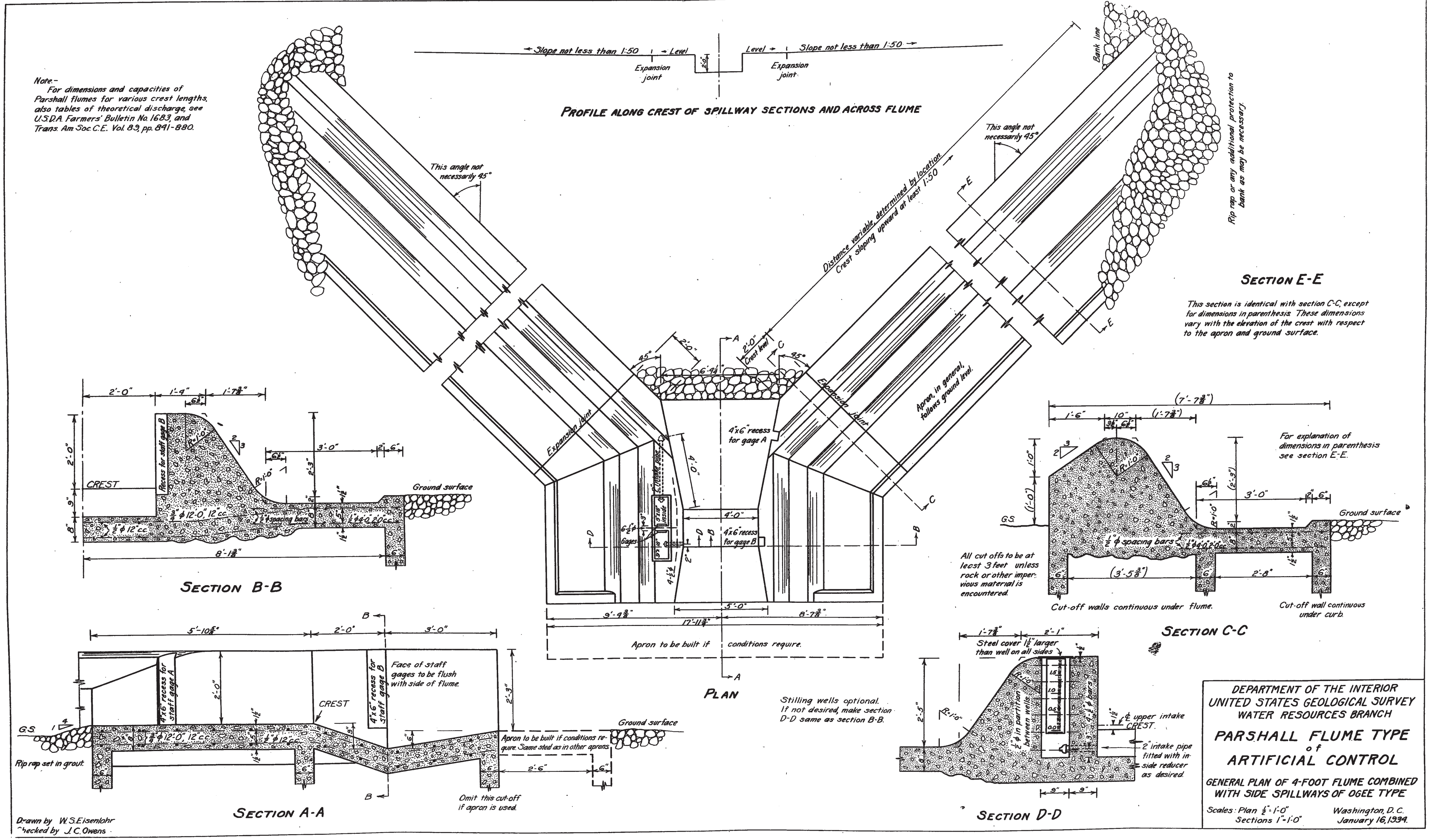
The attached drawing shows the design for a Parshall flume type of artificial control having a flume capacity of about 48 c.f.s. before overflow of the spillway sections. For discharges greater than 48 c.f.s., the control will consist of the combination of the flume and spillways.

The minimum discharge for which this size of flume might be expected to function satisfactorily is about 1.3 c.f.s. for a depth of 0.2 foot at head gage A. If the minimum discharge is likely to be less than 1.3 c.f.s. it might be desirable to use a smaller size flume or to use a combination of two flumes of different sizes as shown in "Equipment for river measurements.--Structures for artificial controls," Plate 17.

In order to obtain standard dimensions for Parshall flumes of various sizes, and to decide upon the size of flume to be used, reference should be made to U. S. Dept. of Agriculture Farmer's Bulletin No. 1683 mentioned above.

The design of any artificial control structure, especially the design for a Parshall flume type of control, should be made to satisfy the conditions at the particular site where the control is to be built, and it is not considered advisable to attempt to standardize the designs, except as to general principles. The width of the stream and its upstream and downstream profiles, the nature of the bed and the flow characteristics, especially for maximum and minimum stages, should be considered before deciding upon the width and elevation of the flume or the elevation and profile of the spillway crest.

The cost of a Parshall flume type of control will, of course, vary with the size of the flume, the length and height of the spillway sections, the amount of coffer dam work required, and the difficulties encountered in the construction. For a river 100 feet wide, using a 4-foot Parshall flume with side walls 2 feet high and spillway sections as shown in the attached drawing, about 70 cubic yards of concrete will be required.



Note.-
For dimensions and capacities of Parshall flumes for various crest lengths, also tables of theoretical discharge, see U.S.D.A. Farmers' Bulletin No. 1683, and Trans. Am. Soc. C.E. Vol. 89, pp. 841-880.
Slope not less than 1:50
Level
Expansion joint
Level
Slope not less than 1:50
Expansion joint
PROFILE ALONG CREST OF SPILLWAY SECTIONS AND ACROSS FLUME
This angle not necessarily 45°
This angle not necessarily 45°
Distance variable, determined by location.
Crest sloping upward at least 1:50
Bank line
Rip rap or any additional protection to bank as may be necessary.
SECTION E-E
This section is identical with section C-C, except for dimensions in parenthesis. These dimensions vary with the elevation of the crest with respect to the apron and ground surface.
Expansion joint
Expansion joint
Apron, in general, follows ground level.
Crest level
4"x6" recess for gage A
4"x6" recess for gage B
Intake pipe
inside
Gages
Apron to be built if conditions require.
PLAN
Stilling wells optional. If not desired, make section D-D same as section B-B.
CREST
Recess for staff gage B
Ground surface
spacing bars
SECTION B-B
For explanation of dimensions in parenthesis see section E-E.
G.S.
Ground surface
spacing bars
All cut offs to be at least 3 feet unless rock or other impervious material is encountered.
Cut-off walls continuous under flume.
Cut-off wall continuous under curb.
SECTION C-C
4"x6" recess for staff gage A
CREST
4"x6" recess for staff gage B
Face of staff gages to be flush with side of flume.
Ground surface
Apron to be built if conditions require. Same steel as in other aprons.
G.S.
Rip rap set in grout.
Omit this cut-off if apron is used.
SECTION A-A
Steel cover 1½" larger than well on all sides
bars
in partition between wells
upper intake CREST
2" intake pipe fitted with inside reducer as desired.
SECTION D-D
Drawn by W. S. Eisenlohr
Checked by J. C. Owens
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH
PARSHALL FLUME TYPE
of
ARTIFICIAL CONTROL
GENERAL PLAN OF 4-FOOT FLUME COMBINED WITH SIDE SPILLWAYS OF OGEE TYPE
Scales: Plan ⅛" = 1'-0"
Sections 1" = 1'-0"
Washington, D.C.
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