UNITED STATES PATENT OFFICE

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WATER CHANNEL CONTROL GATE

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5 Claims. (Cl. 61—25)

This invention has to do generally with gate structures for controlling the flow of water in channels, which may vary in width from relatively narrow canals or channels, to the greater widths encountered in dam spillways. Particularly the invention is directed to improvements in flow control gates mounted for vertical swinging movement between raised water passing positions and a lowered position in which the gate rests on the channel bed to substantially close the water flow through the channel.

Considering as typical the conventional types of spillway gates, the usual practice has been to employ one or more gates each of which has a rigid and relatively heavy face portion extending straight transversely of the channel. Because of the water pressure loads, it has been considered necessary to make the gates of rigid, strongly reinforced construction entailing considerable masses and weights of material. Then, due to the great weight of heavy gates, or gate face, it has been desirable to compensate for the otherwise excessive power that would be required to elevate the gate, by employing counterweighted or bascule type constructions, involving the use of additional masses and materials and at corresponding expense.

The present invention represents a distinct departure from such conventional practices in that it is predicated on certain principles rendering it possible to reduce to a widely contracted minimum the material and weight requirements of the gate proper, and to eliminate if desired, such additional features as a counterweighting structural component of the gate. Briefly, the invention contemplates gates shaped so that the loads due to hydrostatic pressures are transmitted to the supports by tension in the metal or other material forming the gate face and bending moments are substantially eliminated. Under such conditions it becomes possible to depart from the usual rigid and relatively massive construction, in favor of a gate face formed of thin flexible sheet metal having, notwithstanding its light weight and easy manipulability, all the structural and functional requirements of an efficient flow control gate.

Considered more particularly in its structural aspects, the present gate is mounted for vertical swinging movement on hinges or trunnions at directly opposite sides of the channel and extends downstream with increasing curvature from each point of support to the center of the gate. The exact form of the gate will depend in each instance on the distance between supports, on the depth of the channel, and on the elevation of the supports above the bottom of the channel, and this form is theoretically a double curved surface similar to that which would be produced by the revolution of a hyperbola passing through the centers of the hinge or trunnion supports. In appearance the gate may be likened to a visor on a helmet or to a hammock swung to one side. In general, horizontal or inclined sections of the gate face which pass through hinge supports will be approximately hyperbolic in form, having the sharpest curvature in the center of the span where the hydrostatic pressures are greatest and progressively less curvature toward each end.

In the case of a large gate it will generally be advisable to provide, in addition to horizontal curvature, curvature in vertical planes so as to prevent distortion of the gate under possible unbalance lateral forces. Such stiffening of the gate face may be omitted in the case of small gates.

It is contemplated that a gate or gates of this visor-type may be shaped so as to transmit all water loads to the hinge supports by tension in the gate face without substantial bending moments with the gate closed and the water level at the top of the gate. By reason of its inherent flexibility the gate will deform sufficiently to adapt itself to the hydrostatic pressures resulting from any other depth of water in the channel behind the gate without introducing substantial bending moments in the steel or other material forming the gate.

As will appear, the invention is applicable to single gate unit installations, as within canals or other relatively narrow channels, or to multiple unit installations within wide channels, as for example dam spillways. For the latter purpose, I may employ a series of connected or integrated gate sections or units having the above described characteristics and mounted for simultaneous vertical swinging movement.

It will be understood that the gate unit or units may be operated in their opening and closing movement by any suitable means. Merely as illustrative, an appropriate elevating mechanism may be carried by a pier located in the channel at the downstream side of the gate and operatively connected to the gate face.

All of the various features and objects of the invention, as well as the details of certain illustrative embodiments, will be understood to better advantage from the following description of the accompanying drawings, in which:

Fig. 1 is a general plan view showing an inter-
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connected series of the gate units for controlling the water flow in a relatively wide spillway channel;

Fig. 2 is an enlarged cross section on line 2—2 of Fig. 1;

Fig. 3 is a sectional view of a portion of the channel base receiving one of the gate sections, and taken on line 3—3 of Fig. 1;

Fig. 4 is an enlarged sectional view taken on line 4—4 of Fig. 1;

Fig. 5 is an enlarged fragmentary cross section on line 5—5 of Fig. 2;

Fig. 6 is an enlarged cross section taken on line 6—6 of Fig. 4;

Fig. 7 is a plan view showing a single gate unit as used for controlling the flow through a relatively narrow channel.

Referring first to Fig. 1, the gate assembly generally indicated at 10, is shown to be positioned transversely within a channel 11, for example a dam spillway channel, defined at its sides by the concrete walls 12. The gate assembly 10 comprises a plurality, typically three, of gate units including the outer units 13 and integrally connected intermediate unit 14. The outer units 13 are shown to be mounted for vertical swinging movement at the channel sides 12, as by suitable hinge structures generally indicated at 15. At their junctures, the units 13 and 14 are connected to arms 16 pivotally mounted for swinging movement within upstanding portions 17 of the concrete channel bed, as by appropriate hinges generally indicated at 18, and typified by hinge bearings 19 terminally embedded in the concrete.

Referring particularly to Figs. 2, 4 and 5, each gate unit has, as previously indicated, the shape and moving characteristics of a vertically swinging visor, the gate face being formed of thin flexible material 20 such as sheet steel. As viewed in Fig. 1, or at any horizontal plane through the gate, the face 20 will be seen to be concave downstream of the channel from the hinge locations 15 and 18. And as viewed in Figs. 2 and 4, the gate face 20 will be seen to have vertical concavity in all vertical planes across the gate, the vertical curvature at the transverse center of the gate face preferably having its center at substantially the hinge line. It is found that when given substantially the described shape, the hydrostatic upstream load tends to be assumed uniformly at all corresponding depths by the sheet metal 20 and to be resisted by tension in the metal. Any departure from the true theoretical shape in the gate curvature as initially fabricated, is compensated by the inherent flexibility of the gate and its conformability to the applied pressures.

The sheet metal face 20 may be given any suitable reinforcement to resist unbalanced lateral forces without affecting its ability to conform to the hydrostatic loads on the gate face. Such reinforcement should be in vertical planes, preferably at locations spaced transversely of the gate to preserve its flexibility between the points of reinforcement. Typically, the sheet 20 is shown to be reinforced by transversely spaced internal ribs 22 each consisting essentially of a hollow, light weight beam having parallel sheet metal sides 23 and an inner longitudinally straight plate 24. By reason of their shape characteristics and hollow formation, the beams 22 adequately support and reinforce the face 20, while, minimizing the addition to the gate weight required for its reinforcement.

Referring to Figs. 4 and 5, the outer ends of the units 13 are shown to be connected to the hinges 15 in each instance by a pair of arms 25 to which the sheet 20 is welded. The arms are attached to bearing rings 26 engaging a spherical hub 27 which in turn is rotatable on the hinge pin 28 carried by bracket plates 30, the latter being against the inclined compression concrete shoulder 31 and being strongly fixed in place by bolts 32 embedded in the concrete. The brackets may be additionally anchored by the connected and concrete embedded tie rods 33.

It will be understood that in the down or closed position illustrated in Fig. 4, the bottom edges of the gates are intended to rest on the bottom surfaces of the channel, and therefore that the channel will be shaped accordingly. Thus as illustrated in Fig. 3, that portion 11b of the channel controlled by an individual gate unit, as for example the intermediate unit 14, has sloping sides 34, the angularity and curvature of which varies longitudinally of the channel section so that when dropped to its down position, the bottom edges of the gate will contact the channel walls to substantially close the flow of water through the channel.

As previously indicated, any suitable means may be employed for raising and lowering the gate units. Merely as illustrative, I have shown the gate assembly to be operated by power driven hoists conventionally indicated at 35, carried by concrete piers 36 positioned centrally and opposite the nose of each gate unit at the downstream side thereof. Each hoist may comprise a motor driven power unit 37 (the motors of all the hoists being synchronized to operate together) connected by cable 38 running over pulley 39 with the gate face at its transverse center. The cable connection with the gate preferably is made by way of an arcuate beam 40, see Figs. 2 and 5, carried by the gate face and having a connection as at 41 with the cable 38. Thus the beam 40 serves as a vertically swinging segment from which the cable extends in tangential relation at all open positions of the gate, one of which is indicated in Fig. 4 by the broken lines 42.

In Fig. 7 I show a variational embodiment of the invention in the form of a single gate unit 43 having the same shape and structural characteristics as the substantially the illustrated shape, 14, and contained in a relatively narrow channel or canal 44. As before, the lateral extremities of the gate are mounted by hinges 45 supported by the concrete side walls 46 of the channel, for vertical swinging movement. And again as before, the gate may be controlled in its opening and closing movements by an appropriate hoist 47 connected to the gate face by cable 48 and carried on the downstream pier 49.

I claim:

1. The combination comprising a water channel having sides sloping inwardly to the base of the channel, a flow control gate extending transversely within the channel, hinges at opposite sides of the channel mounting the gate for vertical swinging movement and between which the gate has continuous extent to seat on the bottom and sides of the channel, a metal forming the face of the gate and variably deformable at different depths in accordance with the different water pressures applied to the upstream side of the gate at those depths, and rigid reinforcing members attached to said sheet metal face and relatively movable to permit the above-mentioned deformation of the face, said gate face being curved concavely in a horizontal plane and
downstream direction and being curved concavely downstream in a vertical plane.

2. The combination comprising a water channel having sides sloping inwardly to the base of the channel, a flow control gate extending transversely within the channel, hinges at opposite sides of the channel mounting the gate for vertical swinging movement and between which the gate has continuous extent to seat on the bottom and sides of the channel, flexible sheet metal forming the face of the gate and variably deformable at different depths in accordance with the different water pressures applied to the upstream side of the gate at those depths, and rigid reinforcing members attached to said sheet metal face and relatively movable to permit the aforesaid deformation of the face, said gate face having approximately hyperbolic concavity in a horizontal plane and downstream direction and being curved concavely downstream in a vertical plane.

3. The combination comprising a water channel having sides sloping inwardly to the base of the channel, a flow control gate extending transversely within the channel, hinges at opposite sides of the channel mounting the gate for vertical swinging movement and between which the gate has continuous extent to seat on the bottom and sides of the channel, flexible sheet metal forming the face of the gate and variably deformable at different depths in accordance with the different water pressures applied to the upstream side of the gate at those depths, spaced vertically extending reinforcing ribs attached to the upstream side of said sheet metal face and relatively movable to permit the aforesaid deformation of the face, said gate face being curved concavely in a horizontal plane and downstream direction and being curved concavely downstream in a vertical plane and the top and bottom edges of the gate being relatively convergent from the transverse center of the gate to said hinges.

4. The combination comprising a water channel having sides sloping inwardly to the base of the channel, a flow control gate extending transversely within the channel, hinges at opposite sides of the channel mounting the gate for vertical swinging movement and between which the gate has continuous extent to seat on the bottom and sides of the channel, flexible sheet metal forming the face of the gate and variably deformable at different depths in accordance with the different water pressures applied to the upstream side of the gate at those depths, rigid reinforcing members attached to said sheet metal face and relatively movable to permit the aforesaid deformation of the face, said gate face being curved concavely in a horizontal plane and downstream direction and being curved concavely downstream in a vertical plane, a pier in the channel at the downstream side of the gate, and means carried by the pier and connected to the gate for swinging the gate vertically.

5. The combination comprising a main water channel including a plurality of parallel inner channels each having sides sloping inwardly to the base of the channel, a flow control gate structure extending transversely across the main channel and comprising a plurality of sections extending in series transversely of the channel, hinges at opposite sides of each section mounting the section for vertical swinging movement and between which the section has continuous extent to seat on the bottom and sides of one of the inner channels, flexible sheet metal forming the face of each section and variably deformable at different depths in accordance with the different water pressures applied to the upstream side of the gate at those depths, rigid reinforcing members attached to said sheet metal face and relatively movable to permit the aforesaid deformation of the face, the face of each section being carried concavely in a horizontal plane and downstream direction and being curved concavely downstream in a vertical plane, spaced piers in the main channel at the downstream side of the gate structure, and means carried by said piers and attached to said sections for swinging the structure vertically.

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