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WATERGATE WITH MEANS FOR PREVENTING OSCILLATIONS IN OVERFLOW

Filed July 31, 1967

2 Sheets-Sheet 1

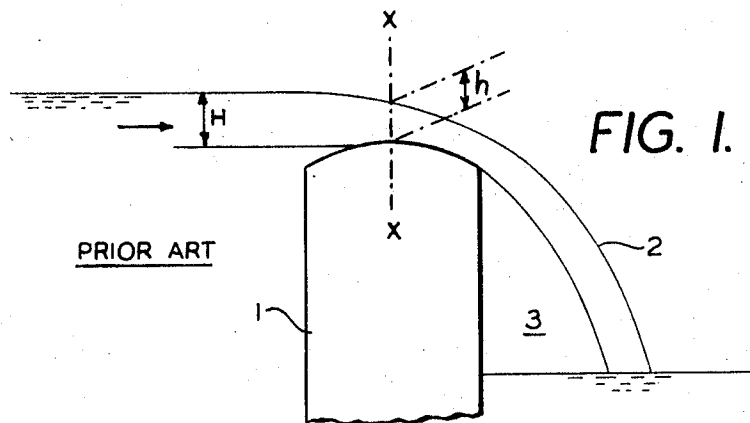


FIG. 2a.

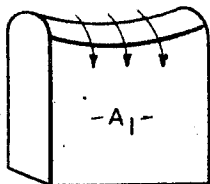


FIG. 2b.

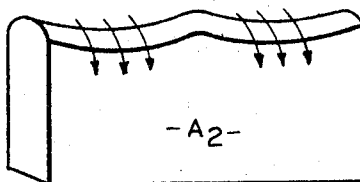


FIG. 2c.

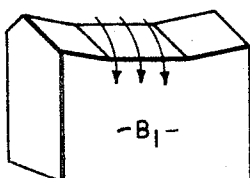


FIG. 2d.

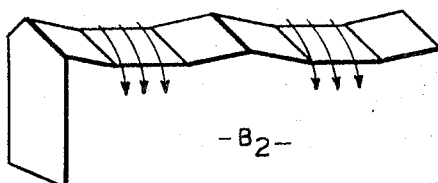


FIG. 2e.

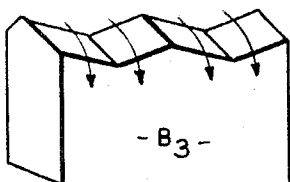
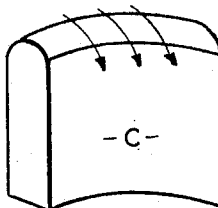


FIG. 2f.



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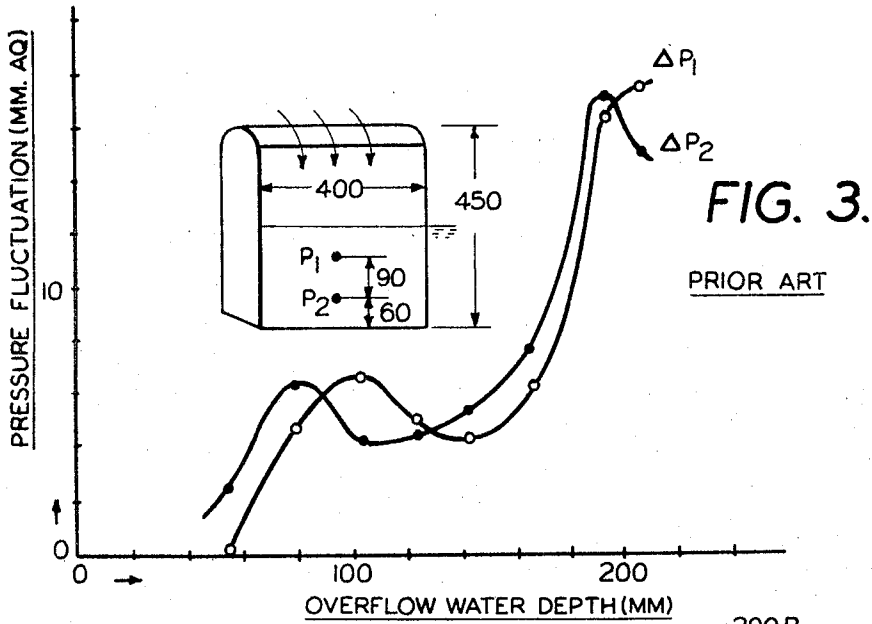
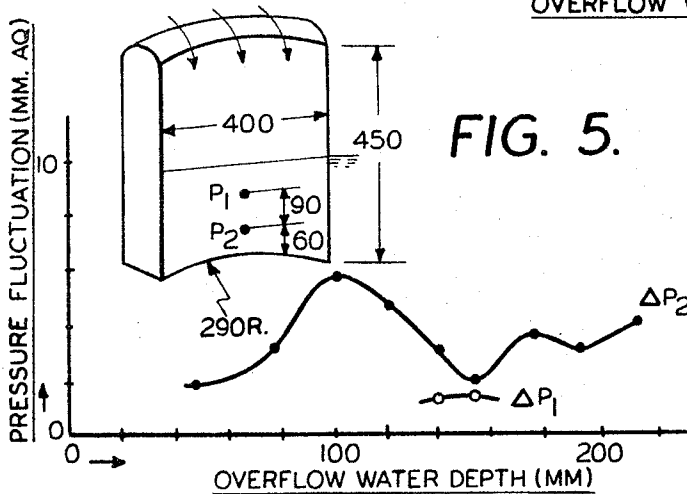
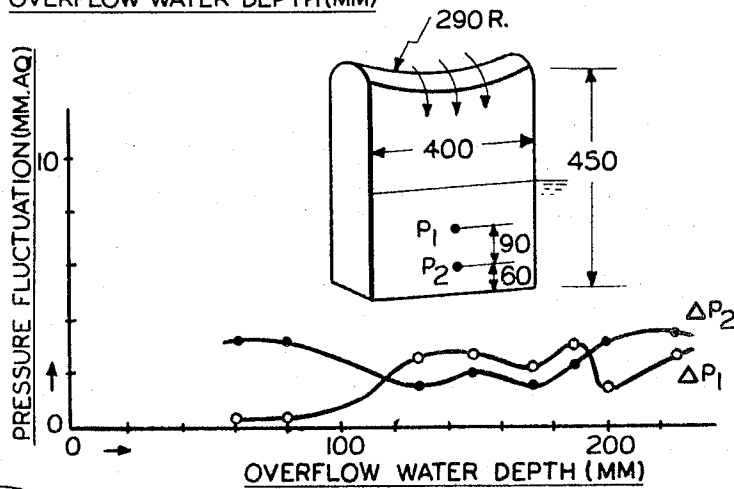


FIG. 4.



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WATERGATE WITH MEANS FOR PREVENTING OSCILLATIONS IN OVERFLOW

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6 Claims

ABSTRACT OF THE DISCLOSURE

Method of and means for preventing untoward oscillations in overflow-type watergates wherein the shape of the top edge of the gate is varied, over the entire gate width, either in up-and-down or in front-and-rear direction, thereby altering the oscillation characteristics of the overflow water against the respective portions of the gate. The critical depth of the overflowing water is altered from one section of the top edge to the other, for example along a concave or convex profile, thereby producing a stabilizing force which keeps the water in equilibrium.

The invention relates to a method of preventing untoward oscillations which hitherto could not be avoided or even reduced. Conventional spoilers can be eliminated and successfully substituted by the inventive expedients, resulting in a reduction of the magnitude of the oscillations to about one-fifth to one-tenth of previous values.

It is generally acknowledged that oscillations in watergates are caused by an intermittent air-breathing phenomenon taking place at the space formed behind the rear wall of the gate; and the overflowing water tends to produce a negative pressure (or a vacuum force) in the said space, as a result of air being engulfed by the water stream; and finally by a fluctuation of the water stream due to the above-mentioned phenomenon.

For these reasons, some of the conventional overflow-type watergates have been provided with air inlet pipes in the rear space so as to eliminate the negative pressure, and others have been provided with spoilers on their top sides.

Actually, the conventional expedients have shown some results in preventing oscillations which are merely due to the vacuum in said space. The gate oscillation as a whole, however, has remained unpreventable by conventional means, and consequently those skilled in the art believe that there should be some other cause for the oscillations besides the aforementioned phenomenon. On this problem, some theories have been presented but they have not yielded any definite solution or even explanation to make the points clear.

The present invention is concerned with a method of and means for preventing such oscillations which start from theoretical considerations on the causes of oscillations in overflow-type watergates, and are based on the deduction that oscillations occur when even a slight change exists in the critical overflow depth, and they continue as a regular oscillation, intending to break the regularity of the oscillations of the gate portions due to the overflow stream.

The invention contemplates varying the shape of the top edge of the gate in either the vertical or the horizontal direction, through the entire gate width, thereby controlling the different oscillation characteristics for the overflowing water by ensuring that the overflow stream conditions are different for the various portions of the gate. The theoretical considerations of the invention will be explained herein together with the experimental results that have been noted.

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The various objects, features and attendant advantages of the present invention will become more apparent from the following detailed description of preferred exemplary embodiments for practicing the invention, when considered in conjunction with the accompanying drawings, wherein—

FIG. 1 is a schematic side view of a conventional overflow-type watergate showing the usual overflow phenomena;

FIGS. 2a through 2f are somewhat perspective illustrations of a number of exemplary overflow-type gates according to the invention, to be described in detail;

FIG. 3 represents the experimental results obtained with the watergate as shown in FIG. 1, also shown here in a schematic front view; and

FIGS. 4 and 5 represent similar experimental results obtained with the gates according to the invention as shown in partial FIGURES 2a and 2f (types A₁ and C, respectively).

FIG. 1 shows the overflow phenomena in an overflow-type watergate, with a body generally designated 1. The water handled by the gate arrives from the direction shown by the arrow and has there an over-flow-water level H above the top edge of the gate. The water depth h, in the dominant cross-section X—X, of the overflow water 2 is determined by the minimum energy law. The depth h influences the stream conditions of the upper as well as the lower stream sides of the gate against said cross-section. The depth h can be termed the critical depth; it constitutes a point of minimum energy for the overflow water, and any change of the critical depth, due to certain disturbances from the outside, produces some stabilizing force, to keep the overflow water in an equilibrium.

The stabilizing force and the inertial force induced by the former act as oscillating forces, repeatedly one after the other, which leads first to a cyclic oscillation of the overflow water, and then to that of the gate itself. This phenomenon is similar to that of a pendulum of a clock which continues a cyclic oscillation by the aid of a stabilizing force and the inertial force induced thereby.

As the external forces which are influential to the critical depth h, one can mention an air-engulfing effect in the space 3 formed behind the gate 1 and the overflow water 2, a change in the water level H in the upper stream, wind and wave forces, as well as some other external forces acting on the gate proper. Owing to the continuous natural forces as above-mentioned, the oscillation of the overflow water continues regularly. This oscillation acts directly on the top of the gate as an up-and-down oscillating force, and besides, it acts as a front-and-rear force against the gate through the cyclic pressure fluctuation, due to the striking phenomenon on the water surface of the lower stream side.

In order to keep the afore-said oscillations as small as possible, it is considered to be important that the regularity of the oscillations should be broken. For that purpose, it is considered to be the most suitable way that the overflowing water 2, along the entire length of the gate width, might impart different oscillation characteristics to each section of the gate top.

FIGS. 2a through 2f are, in oblique illustrations schematic views of several kinds of overflow-type watergates having various shapes, based on the aforesaid theory, and serving as examples of the present invention (as against the illustrations of FIGS. 1 and 3, particularly the latter which is taken from the same angle as FIGS. 2a through 2f).

FIG. 2a shows a gate A₁ according to the invention, having a saddle-shaped top edge of gently concave slope on its top, and along the entire gate width. The depth of the saddle surface becomes bigger as the gate width in-

creases, when the surface has a constant radius. Therefore, this type is usually used for gates of relatively short width.

FIG. 2b shows a gate A_2 similar to the previous one, being constituted by two (or more) saddle-shaped surfaces, arranged consecutively at the top of the gate. This structure can of course be used for wider gates, with three, four or more portions therein.

FIG. 2c shows a gate B_1 with a concave of trapezoidal cross-section constituted by at least two folded planes (three in this exemplary embodiment). FIG. 2d and 2e with gates B_2 and B_3 , respectively, are similar types composed of two or more folded-plane concave surfaces at their tops, as illustrated.

The gates of the B type, shown in FIGS. 2c through 2e wherein the concave surfaces are composed of at least partially flat, folded surfaces or planes, are easier to manufacture than the gates of type A, of FIGS. 2a and 2b, or any similar structure having true concave surfaces. FIGS. 2c through 2e are considered to have effects equivalent for oscillation prevention to those of FIGS. 2a and 2b although they have not yet been confirmed by experiments.

The gates explained so far and shown in FIGS. 2a through 2e are representative illustrations of gates having tops which are specially shaped in vertical or up-down direction over the entire gate width. In gates of these types, the critical depth h of the water flowing over the tops of the gates are different for each section of the tops; therefore, the oscillation characteristics are not only due to the depth but also to the water striking against the water surface at the lower stream side.

Finally, in FIG. 2f, a C-type gate is shown which is constructed so that the gate proper includes a convex surface facing the upper stream side. In this case, the water flowing over the top of the gate falls down approximately perpendicularly to the gate on the water surface of the lower stream side. Consequently, the critical depth h differs at every point of the gate and the oscillation characteristics vary from section to section, in the same way as in the A- and B-type gates shown in the previous FIGS. 2a through 2e.

When the oscillation characteristics of the overflow water differs regionally or sectionally according to the particular point of the gate, then these oscillations of different characteristics confuse each other and interfere mutually to weaken the magnitude of the oscillation as a whole.

IN FIGS. 3 to 5 to be described hereafter, the relation between the overflow water depth and the corresponding pressure fluctuation is shown in various overflow-type gates, including the conventional and the inventive types. In addition to the diagrams, these figures also include schematic front views of the gates, similar to those of FIGS. 2a through 2f. As a matter of example, each of these views includes exemplary, preferred measurements (in millimeters), and it will be seen from the drawing that each of these figures has a curve identified as ΔP_1 and one marked ΔP_2 , plotting values of the magnitude of pressure fluctuation at the respective locations, as appearing on the small auxiliary views. Similar measurements have been considered in the three illustrations. In the inventive gates shown in FIGS. 4 and 5, respective top and bottom radii are identified.

In these diagrams, the abscissa always shows the overflow water depth (in millimeters), and the ordinate, the pressure fluctuation (in mm AQ that is, water column). FIG. 3 is for a conventional gate as shown also in FIG. 1; FIG. 4 is for the A_1 type as shown in FIG. 2a, and FIG. 5 is for the C-type gate as illustrated in FIG. 2f.

As clearly noticeable from the plotted experimental results, in conventional gates, as shown in FIG. 3, the magnitude of the pressure fluctuation acting on the gate increases in proportion to the increase of the overflow water depth H . Thus, the increased pressure fluctuation

acts as an influential oscillating force for a vertical oscillation in the gate. In the inventive gates, as shown in FIGS. 4 and 5, on the other hand, the magnitude of the pressure fluctuations is very small, and they are noticed to be almost completely independent from the overflow water depth or level H .

As explained in the foregoing, the inventive method of and means for preventing oscillations in overflow-type watergates is based on the deduction that in a gate of this sort the oscillating force due to the overflowing water striking against the water surface on the lower stream side is regarded as the cause of the gate oscillations, in addition to the air-engulfing phenomenon produced at the rear side space of the water gate.

According to the illustrated, preferred embodiments of the invention, the top of the gate is shaped so that a concave surface is formed, or the gate may itself be so constructed as to deflect in the direction of the water stream, in order to give different oscillation characteristics for the overflowing water for each section of the gate. The effectiveness of these expedients has been confirmed by experiments.

The method and means therefor according to the present invention are quite different from any conventional spoilers, both as to their purpose and their effect, and have a superior oscillation preventing effect which is unobtainable with spoilers.

In addition to the afore-described experiments, the invention has been put into practical use by which it was confirmed that the magnitude of oscillation of a gate provided in accordance with this invention is approximately $\frac{1}{5}$ to $\frac{1}{10}$ as compared to that of the conventional gates, and that oscillation troubles are perfectly eliminated. Consequently, it can be said that the oscillation of an overflow-type gate of this kind can easily be prevented by virtue of the inventive method.

The foregoing disclosure relates only to preferred, exemplary embodiments according to the invention, which is intended to include all changes and modifications of the examples described, within the scope of the invention as set forth in the appended claims.

It will thus be understood by those skilled in the art that the claims are meant to cover embodiments which are not illustrated in the submitted drawings but have been fully described. Also, combinations of the exemplary features may be used in gates of this kind so as to arrive at the same novel and useful results.

What I claim is:

1. A gate for preventing untoward oscillations in overflow-type watergates, comprising a gate body having an upright planar upstream side for damming water and a planar downstream side parallel to said upstream side; said body terminating in an uppermost water overflow face extending along the top of the sides for guiding the water over the gate; said overflow face defining with said sides an upstream edge and a downstream edge spaced apart uniformly for the entire width of the gate; said overflow face being divided into two sections converging upwardly from said edges for the width of the gate; said sections meeting in a plane parallel to said sides and defining a ridge for the width of the gate; and each section having at least two adjoining surface portions diverging from each other along said ridge and with said surface portions being bounded by similarly diverging segments of the respective edge and of said ridge, whereby said sections ensure that the stream conditions and water depths over said overflow face are different therealong and thereby control the oscillation characteristics of the overflow of water.

2. The gate as defined in claim 1, wherein said sections are in the form of a saddle and, are slightly concave, facing the downstream side.

3. The gate as defined in claim 1, wherein said sections are in the form of at least two saddle-like slopes.

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4. The gate as defined in claim 1, wherein said ridge is slightly convex, facing the upstream side.

5. The gate as defined in claim 1, wherein each said section is in the form of at least two angularly disposed planar sections.

6. The gate as defined in claim 5, wherein said planar sections diverge upwardly to define an angle therebetween.

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