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METHOD OF AND APPARATUS FOR PROTECTING WATER CHANNELS

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2 Sheets-Sheet 1

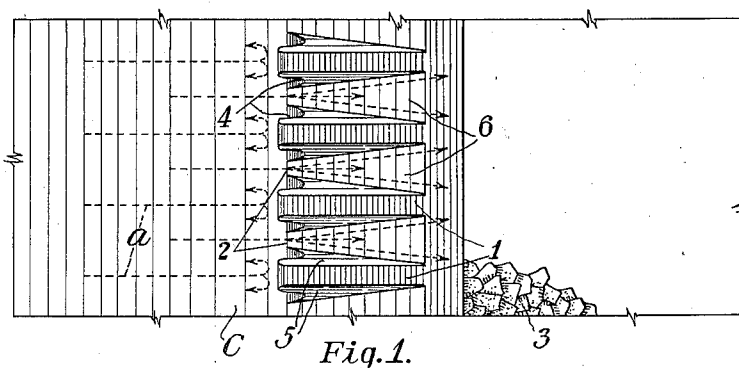


Fig. 1.

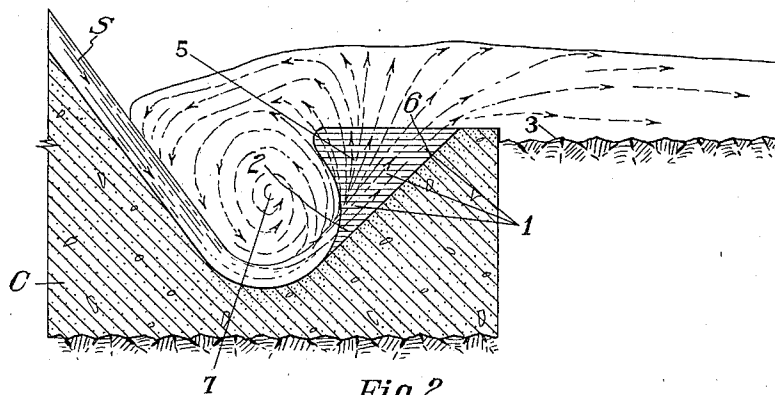


Fig. 2.

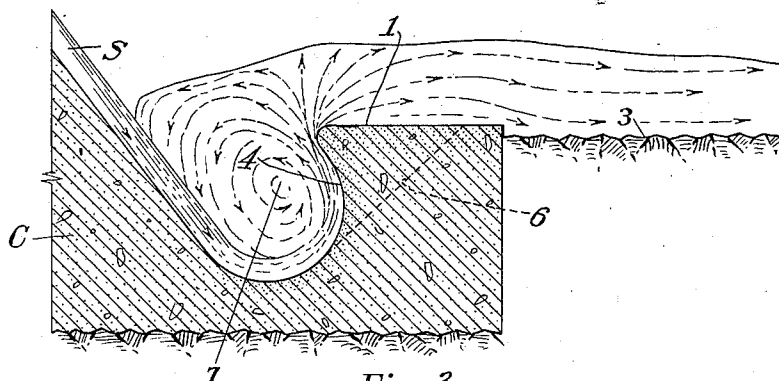


Fig. 3.

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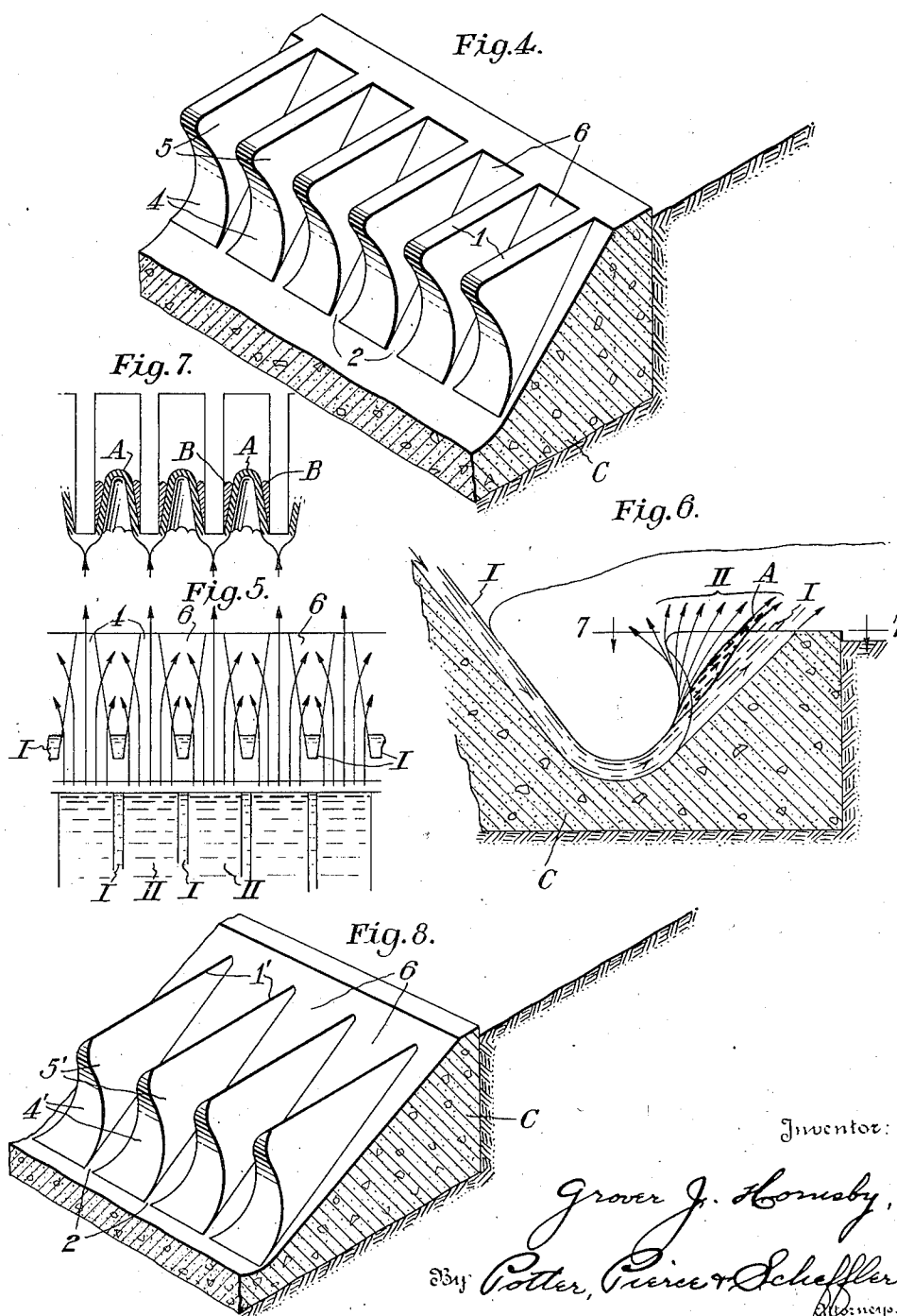
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UNITED STATES PATENT OFFICE

2,080,045

METHOD OF AND APPARATUS FOR PROTECTING WATER CHANNELS

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Application January 19, 1935, Serial No. 2,567

10 Claims. (Cl. 61—18)

This invention relates to methods of and apparatus for protecting water channels, and particularly to methods of and apparatus for reducing the kinetic energy of a high velocity stream of water such as may be present, for example, at the toe of overflow dams, weirs, chutes or other channels of hydraulic structures.

It is well recognized that the velocity of a stream of water flowing down the face of an overflow dam must be substantially reduced to prevent scour and erosion at the toe of the dam, and that a similar problem arises in connection with water flow in various hydraulic structures. The general methods of solving these problems have included the use of structures for reducing the water velocity by impact and/or by "hydraulic jump". The impact methods are not practical in the case of the very high velocities encountered in high overflow dams, and the hydraulic jump method necessitates the construction of paved aprons or stream beds which extend downstream a relatively long distance from the region of maximum velocity. In most instances, a sill or auxiliary dam must be provided at the downstream end of the apron and such constructions are relatively expensive. The operation of the hydraulic jump systems is quite critical under varying flow conditions and, due to the relatively high cost of construction, a proper factor of safety has not been provided in all instances to meet extreme conditions which may arise only once in several years, but such false economy and/or faulty design have resulted in dangerous and costly erosion of the stream bed.

An object of this invention is to provide a novel method of dissipating the high velocity and kinetic energy of a stream of water flowing in a hydraulic channel or analogous structure. An object is to provide a method of dissipating the kinetic energy of high velocity streams of water which does not rely upon impact or hydraulic jump and which may therefore be practiced without the use of extended aprons or other expensive constructions. More particularly, an object of this invention is to provide a method of dissipating the high velocity of a flowing stream by passing spaced portions of the stream along paths of increasing cross-sectional area, and employing the intermediate portions of the stream to form one boundary of the several paths and to create a boil or energy-dissipating eddy at the region of the division of the stream into the several and relatively independent sections thereof.

An object of the invention is to provide novel apparatus for protecting the channel bed of a water stream, which apparatus may dispense with the elongated aprons now commonly employed for the reduction of velocity flow by impact and/or hydraulic jump. An object is to provide velocity dissipating apparatus which may be located directly at the toe of a high overflow dam or at the region of other structures at which the stream flow is of dangerously high velocity. Objects of the invention are to provide velocity dissipating apparatus which is subject to rational design and computation and which is generally applicable whether the high velocity is either slightly or substantially in excess of the critical value or maximum safe velocity of flow in a particular water channel. More particularly, an object of the invention is to provide velocity-dissipating apparatus having the general form of a dentilated or spaced abutment apparatus in which diffusion chambers of expanding cross-section have their inlets at the interspaces between the dentils, and the dentils are so shaped that water flowing along the same spills over to form a wall of the diffusion chambers.

These and other objects of the invention will be apparent from the following specification when taken with the accompanying drawings, in which:

Fig. 1 is a plan view of one embodiment of the invention appropriate for use at the toe of an overflow dam;

Fig. 2 is a longitudinal section taken substantially along the center of a diffusion chamber formed between an adjacent pair of abutments;

Fig. 3 is a similar section taken through one of the abutments;

Fig. 4 is a fragmentary perspective view of a portion of the apparatus;

Figs. 5, 6 and 7 are schematic views illustrating the general paths taken by certain sections of the stream of water in passing through or over the apparatus; Fig. 7 being a section taken on line 7—7 of Fig. 6; and

Fig. 8 is a fragmentary perspective view of another embodiment of the invention.

In the drawings, the invention is illustrated as embodied in apparatus positioned directly at the toe of an overflow dam, but it is to be understood that the velocity-reducing apparatus may be located in any hydraulic channel where the stream velocity may reach dangerous values.

In the drawings, the reference character C identifies a portion of the concrete or other rigid structure at the base of an overflow dam. The

velocity-reducing apparatus takes the form of a series of abutments 1 which are spaced apart, at their upstream edges, to leave a series of openings 2 through which spaced sections I of the water stream enter the "diffusion chambers" which are formed between adjacent abutments. The concrete structure may terminate substantially at the down stream ends of the abutments and diffusion chambers, i. e., an extended apron is not required in advance of the natural bed 3 of the stream.

The end faces 4 of the abutments or dentils 1 are preferably curved to direct a portion of the stream sections II backwardly upon the advancing sheet of water to form a roll, as shown in Fig. 2. The side walls 5 of each abutment incline towards each other and the bottom walls 6 of each diffusion chamber slope upwardly at an angle which may be approximately the same as the slope of the adjacent lower portion of the overflow dam.

When a sheet of water S flows down the face of the dam at high velocity, the lines of water flow are substantially as indicated by the broken line arrows in Figs. 2 and 3, the lines indicated in Fig. 2 having been obtained by painting the walls 5 of the diffusion chamber and passing water over the same before the paint hardened.

The method of operation can best be understood from a consideration of the schematic views, Figs. 5 to 7. The upper portion of Fig. 5 illustrates the spaced faces 4, of wedge form, of the abutments 1 as seen when looking at the same along the plane of the advancing water stream, and the cross-hatching at the lower part of the view indicates the manner in which the water stream is divided in alternating sections I which enter the diffusion chambers and sections II which flow upwardly along the upstream faces 4 of the abutments. The high velocity water sections I enter the diffusion chambers at the inlets 2 and, due to the increasing cross-sectional areas of these chambers, the velocity head of these water sections is reduced at a rate inversely proportional to the cross-sectional area, within certain limits which are defined by the rate at which the velocity can be reduced through diffusion without reaching a point of zero pressure. Each diffusion chamber has approximately the form of a frustum of an inverted pyramid, the bottom wall 6 of the pyramid flaring, in the direction of flow, due to the inclined arrangement of the side walls 5 of the chambers. It will be noted that the diffusion chambers do not have a solid upper wall; the fourth wall of each chamber being a sheet or diaphragm of water A which is formed by the portions of the water stream sections II which flow up the tapered faces 4 of the abutments and spill over into the interspaces between the abutments.

The path of water flow along the faces 4 is shown by the arrows in Fig. 5 and, as the side edges of each stream section II spill over, the sheets of water from adjacent abutments impinge against each other to form the diaphragms A which close the openings between adjacent abutments. These diaphragms of relatively high velocity water sag inwardly due to the impingement of the sheets forming the diaphragm, the greater pressure at the entrance to the abutments and the lowered pressure within the diffusion chambers. As the sag increases, the thickness of the diaphragm is decreased so that, when it reaches the upper edge of the diffusion chamber, the greater part of the energy is dissipated and

the water flows in diverging directions to the surfaces where it develops a non-violent series of boils.

From this series of boils, a part of the water flows downstream and cushions itself upon the low-velocity water I emerging from the diffusion chambers and which flows harmlessly along the bottom of the channel. The remainder flows upstream, as indicated by arrows a in Fig. 1, and falls more or less violently into the approaching sheet S of high-velocity water, thus forming a roll 7 commonly known as a back roller, which is highly beneficial in that it helps to dissipate energy from the time that it strikes the inflowing sheet of water until after it leaves the end of the plane, curved or warped surface, forming the upstream face 4 of the abutments or dividing walls which separate the diffusion chambers.

The central portion of each stream section II flows up the end face 4 to take part in the formation of the boils and back roller. It is to be noted that the end faces 4 of the abutments are not "impact" surfaces designed to effect an abrupt arrest of portions of the water stream. Some impact action may take place and, by appropriate design, an impact action may be purposely provided to cooperate with or modify the described diffusion action but impact action is not an essential feature.

Reverting to Fig. 7, it will be seen that small wedge-shaped zones B lie at each forward edge of the concaved diaphragm walls A. These are regions of relatively low pressure which form portions of the diffusion chambers as some portions of the high velocity stream sections I will turn upwardly through these zones, as is shown by the arrows, Fig. 2, which indicate the path of water flow along the walls 5. The water flowing upwardly through the regions B enters the series of boils and falls either forwardly into the low velocity stream or backwardly into the back roller.

There is considerable latitude in the design and arrangement of the several surfaces which cooperate to form the diffusion chambers into which certain sections of the stream flow and which so direct the other stream sections as to dissipate energy by directing various portions of the stream against each other. By appropriate choice of the design and spacing of the abutments, the relative quantities of water in the sections I and II of the stream may be varied without substantial change in the size or effective length of the structure.

In the modified construction shown in Fig. 8, the abutments 1' do not have a top wall as the side walls 5' slope inwardly to meet at the upper edges of the abutments. The upstream faces 4' are therefore approximately triangular, as viewed from the front, and are appropriately curved or warped to deflect some portions of the stream laterally and other portions upwardly and rearwardly to form a back roller.

In the following claims, the term "water channel" is to be understood as a general term identifying a chute, canal, or other passage in which water may flow.

I claim:

1. The method of protecting the beds of water channels from scour and erosion which comprises passing transversely spaced sections of the flowing water stream into open-topped diffusion chambers, and impacting the portions of the water stream between the said sections against each

other to form moving diaphragms of water which serve as flexible top walls for the diffusion chambers.

2. The method as claimed in claim 1, wherein other portions of the water stream between said sections are directed upwardly and against the direction of water flow, thereby to form a back roller in advance of the entrances to the diffusion chambers.

3. In apparatus for the protection of the beds of water channels, a rigid structure extending transversely of the channel and having an upstream portion whose upper surface aligns with the adjacent bed of the channel, a plurality of dentils at the downstream portion of said structure, said dentils being spaced apart transversely and having inclined side walls defining a plurality of diffusion chambers which increase in cross-sectional area in the direction of water flow.

4. Apparatus as claimed in claim 3 wherein the side edges of the end face of each dentil approach each other in the direction of water flow.

5. Apparatus as claimed in claim 4 wherein the end face of each dentil is a curved surface smoothly merging at its lower edge into the adjacent upstream portion of the rigid structure, and the side edges of the said upstream face slope towards each other in the direction of water flow.

6. A dam having an overflow surface down which a sheet of water may flow, and diffusion chamber means integral with said dam at the toe thereof; said diffusion chamber means having a plurality of transversely spaced end surfaces smoothly merging at their upstream edges into the overflow surface of said dam, and dentils

extending downstream from the said end surfaces, the side walls of said dentils being inclined to each other to define between each pair of dentils a diffusion chamber which increases in cross-sectional area in a down-stream direction.

7. A dam as claimed in claim 6, wherein the bottom walls of said diffusion chambers are upwardly inclined in the direction of water flow.

8. A dam as claimed in claim 6, wherein each of the said end surfaces of the diffusion chamber means decreases in width towards the discharge edge thereof.

9. In apparatus for the protection of the beds of water channels, a rigid structure extending transversely of the channel and having an upstream portion whose upper surface aligns with the adjacent bed of the channel, a plurality of spaced dentils at the downstream portion of said structure, said dentils having end surfaces smoothly merging at their upstream edges into the surface of the adjacent upstream portion of the rigid structure and having side walls defining a plurality of diffusion chambers.

10. A dam having an overflow surface down which a sheet of water may flow, and diffusion chamber means integral with said dam at the toe thereof; said diffusion chamber means having a plurality of transversely spaced end surfaces smoothly merging at their upstream edges into the overflow surface of said dam, and dentils extending downstream from the said end surfaces, the side walls of said dentils defining a diffusion chamber between each pair of dentils.

GROVER J. HORNSBY.

CERTIFICATE OF CORRECTION.

Patent No. 2,080,045.

May 11, 1937.

GROVER J. HORNSBY.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 23, claim 5, for the reference numeral "4" read 3; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of June, A. D. 1937.

Henry Van Arsdale

Acting Commissioner of Patents.

(Seal)