

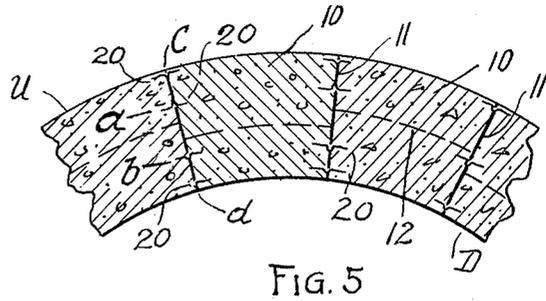
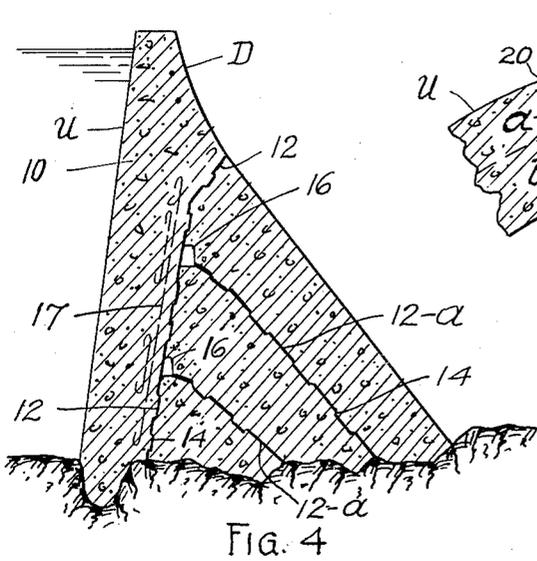
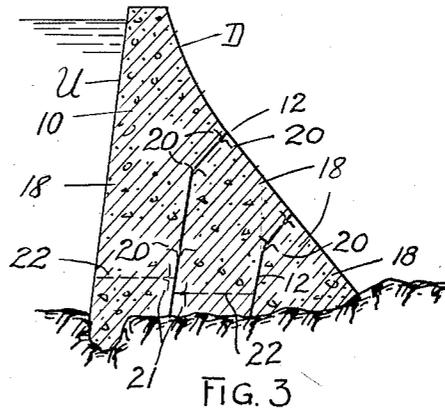
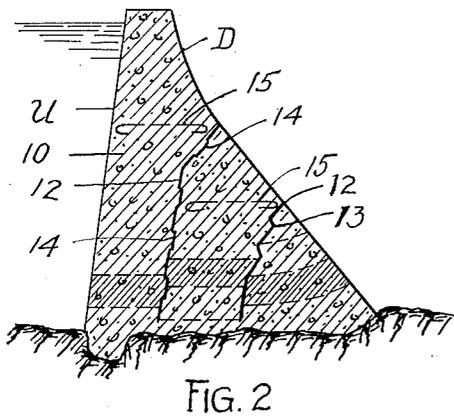
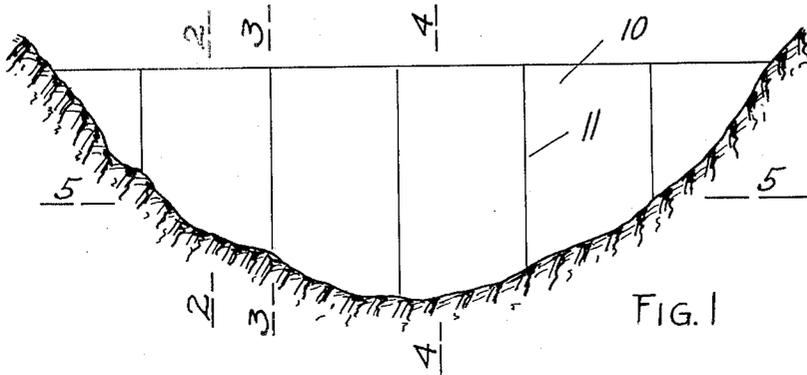
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DAM

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UNITED STATES PATENT OFFICE

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DAM

Application filed January 19, 1932. Serial No. 587,515.

This invention relates to dams, and the primary object of the invention is to provide a dam of the straight gravity or curved type which will be less expensive and at the same time safer than similar dams as heretofore constructed.

Another object of this invention is to provide a construction for dams of the gravity or arch type which employ long expanses of concrete wherein joints are established at intervals to permit shrinkage and temperature changes without weakening the dam.

Unless shrinkage and temperature stresses are taken care of at intervals of about 50 feet, cracks develop which are irregular and which weaken the structure. This feature has been recognized in my co-pending applications Serial No. 319,205, filed Nov. 14, 1928, and Serial No. 390,870, filed Sept. 7, 1929, over which the construction disclosed in this application may be considered as an improvement.

A further object of the invention is to provide a novel construction for concrete dams with joints, by widening the joints temporarily by forcing water under pressure into certain sections of the area of a joint thus widening it by a small amount, and then forcing cement grout into certain other sections of the area of the widened joint. Subsequently, the area of the joint is filled completely with cement grout.

Other objects of the invention are to provide improved methods of construction to reduce the danger of sliding in horizontal construction joints.

With the foregoing and other objects in view which will be made manifest in the following detailed description and specifically pointed out in the appended claims, reference is had to the accompanying drawing for an illustrative embodiment of the invention, wherein:

Figure 1 is an elevation of the dam embodying the invention.

Figures 2, 3 and 4 are typical vertical sections through the dam and may be considered as having been taken upon the lines 2—2, 3—3 and 4—4, respectively, upon Fig. 1.

Figure 5 is a partial view in horizontal section through a dam curved in plan and may

be considered as having been taken upon the line 5—5 of Fig. 1.

Referring to the accompanying drawing wherein similar reference characters designate similar parts throughout, the dam shown in Fig. 1 consists of concrete or masonry and in general is designed to withstand water pressure in the reservoir by virtue of its weight and of the weight of the water overlying the upstream face of the dam. The dam may be straight or curved in plan. In the latter case at least a portion of the water pressure may be transmitted by arch action to the side hills. The dam may be solid or it may be built of a series of structurally independent walls joined or connected near the upstream face, similarly as disclosed in my co-pending application Serial No. 498,078, filed November 30, 1930.

The dam comprises vertical walls or units. These walls or units extend substantially transversely to the direction of the dam and they are usually joined by vertical transverse joints 11 or connected in some other way so as to provide a contiguous upstream face for the dam. Concrete walls of long expanses are apt to crack due to shrinkage or change of temperature and moisture content. Novel and advantageous types of contraction joints 12 extending longitudinally to the dam and across the walls or units 10 are disclosed in Figures 2, 3 and 4. The joints 12 near the foundation are preferably either approximately vertical or roughly parallel to the upstream face U of the dam and are inclined rearwardly in the upper part such as to intersect the downstream face D of the dam at an angle approaching 90°. The joints 12 do not necessarily extend along planes or lines of zero shear, and in order to prevent excessive movements of portions of the dam on opposite sides of the joints 12 I provide steps 13 or key and groove connections 14 in these joints such as shown in Fig. 2. The individual steps 13 are preferably arranged in planes of zero shear. The key and groove connections 14 must be at least strong enough to take care of the shear stresses in the plane of the joints 12 for any state of loading of the dam so as to prevent slippage in the joints 12.

While ordinarily the joints 12 are spaced roughly 50 feet apart so as to provide for the shrinkage of the concrete, the distance between two joints in the upper portion of the dam may be materially greater than 50 feet. In these portions of the dam I may provide reinforcing bars 15 to prevent cracks.

I also may divide the walls 10 into portions by one joint 12 extending upwardly and roughly parallel or asymptotic to the upstream face of the dam, as shown in Fig. 4, and by one or more joints 12—*a* extending upwardly and forwardly roughly parallel or asymptotic to the downstream face of the dam. The joint or joints 12—*a* intersect the joint 12, and the points of intersection are preferably made to coincide with inspection tunnels or openings 16. Special reinforcing bars 17 may be placed along the joint 12 either continuously for the entire length of the joint 12, or at least across the plane of intersection of the joints 12 and 12—*a* as shown in Fig. 4. The bars 17 will prevent the extension of the joints 12—*a* to the upstream face of the dam. The joints 12 and 12—*a* are preferably provided with key and groove connections 14 which will permit a slight movement of the portions of the dam on opposite sides of the joints but which will prevent large movements or settling.

In constructing the dam I build it in units or walls 10 extending substantially transversely to the direction of the dam. I divide these units into elements or columns 18 as shown in Fig. 3, by upwardly extending joints 12. Due to the shrinkage of the concrete or by reason of artificial cooling, the joints 12 will open up a small amount. It is desirable to fill the joint space with cement grout thus improving monolithic action of the dam. If the cement grout is forced into the joint space under pressure, the elements or columns 18 are bent due to the pressure of the grout. The water pressure in the reservoir tends to bend the dam downstream. The distribution of the stresses upon horizontal planes in the dam due to water pressure is generally such that the stresses increase in a downstream direction. In some cases there may even be tension in the upstream face. I improve the stress distribution in the dam by grouting successively the joints 12, in a unit beginning at the joint farthest downstream and end at the joint farthest upstream. By the pressure of the grout in the joints the columns 18 are bent successively in an upstream direction. By this process a certain initial compression is put into the upstream face of each column except the one farthest downstream, for which this feature is of small importance.

In a concrete dam curved or arched in plan such as shown in Fig. 5 I may divide the dam into units 10 by transversely extending joints 11 and place across some or all of the joints

upwardly extending water seals 20 dividing the joints into sections closed on all sides, then I force water under pressure into some of the sections, preferably over about the middle half *a—b* of the vertical cross sectional area of the dam. This produces axial pressure in the curved dam and tends to deflect the arch upstream. While the dam is in this position I fill the remaining sections *a—c* and *b—d* of the joint or joints 11 with cement grout. After the grout has set I remove the water from the section *a—b* and fill the corresponding joint space also with grout. I may apply this process to one joint at a time, or preferably simultaneously to several or all of the transversely extending joints whereby arch action may be improved considerably in the dam. In order to avoid up-lift pressure in horizontal construction joints due to the temporary pressure of the water in the transverse joints 11 I may provide water stops 21 across the horizontal construction joints 22 in the vicinity of the joints 12.

I claim:

1. In a concrete dam a wall extending transversely to the direction of the dam, a first joint in said wall extending upwardly and roughly parallel to the upstream face of the dam, and at least one other joint in said wall extending upwardly and roughly parallel to the downstream face of the dam to the intersection with said first joint.
2. A concrete dam as described in claim 1, there being a special tie of reinforcing steel bars embedded in said wall substantially parallel to and upstream of said joint.
3. A concrete dam as described in claim 1 and being provided with an opening at the intersection between said joints.
4. A concrete dam comprising a wall extending transversely to the direction of the dam and being divided into sections by at least one upwardly extending expansion joint, said sections being made up of layers of concrete, said layers on opposite sides of the expansion joint being offset vertically relative to each other.
5. A concrete dam comprising a wall extending transversely to the direction of the dam and being divided into sections by an upwardly extending expansion joint, said sections being made up of layers of concrete joined by substantially horizontal construction joints, and water stops extending across at least some of said construction joints and adjacent to and alongside said expansion joints.
6. A concrete dam comprising a wall extending transversely to the direction of the dam, said wall being divided by joints into sections, one first of said joints extending near the upstream face of the dam from near the foundation upwardly and rearwardly to the downstream face, at least one other of

said joints extending from near the foundation upwardly and forwardly to the intersection with said first joint, said wall being provided with an opening at the intersection between said joints, said opening tending to minimize the concentration of stresses in the wall in the vicinity of said intersection.

7. A concrete dam comprising units extending substantially transversely to the direction of the dam, said units being divided by joints into sections to provide for shrinkage of the concrete, one first of said joints extending near the upstream face of the dam from near the foundation upwardly and rearwardly, at least one other of said joints extending from near the foundation upwardly to the intersection with said first joint.

8. A concrete dam comprising a plurality of vertical units extending substantially transversely to the direction of the dam, at least some of said units being divided into portions by upwardly extending contraction joints so as to provide for shrinkage of the concrete, said joints being provided with steps to prevent excessive movements relatively to each other of the portions of the units on opposite sides of said joints, the surface areas of at least some of said steps being arranged approximately in planes of zero shear stress in the dam when it is fully loaded.

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