April 12, 1932. E. H. BURROUGHS 1,853,545

DAM

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Fig. 1.

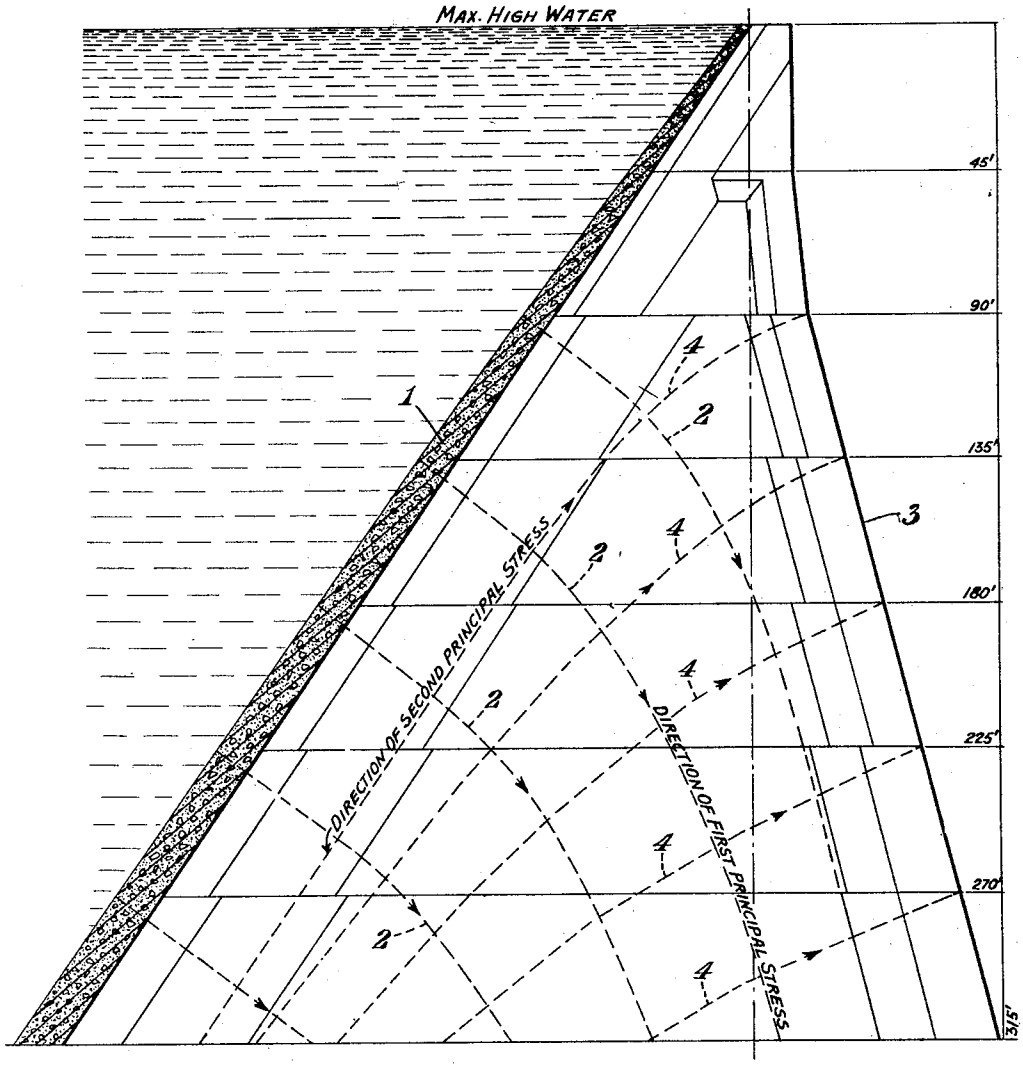

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Fig. 2.

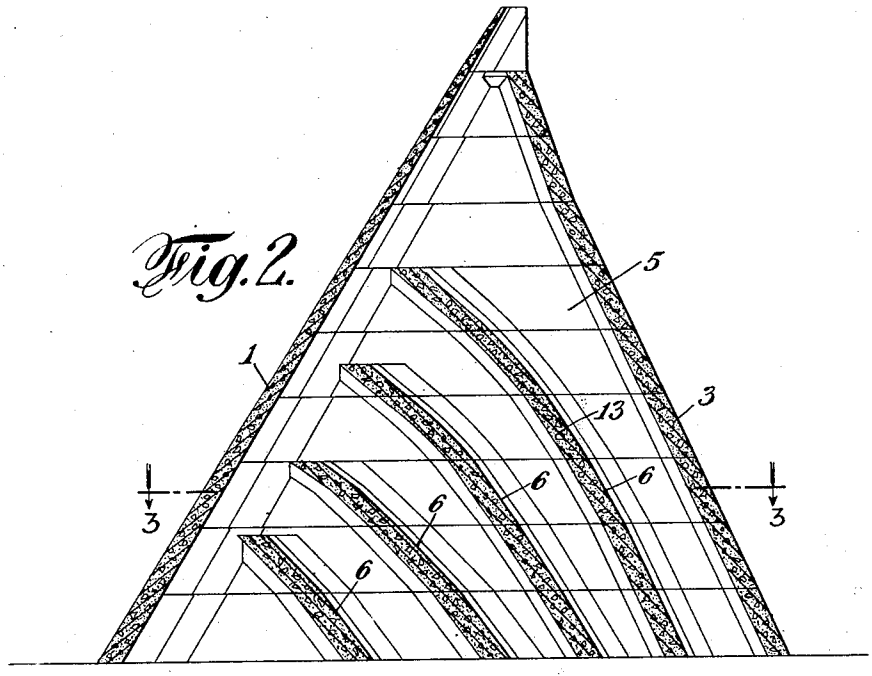

Fig. 3.

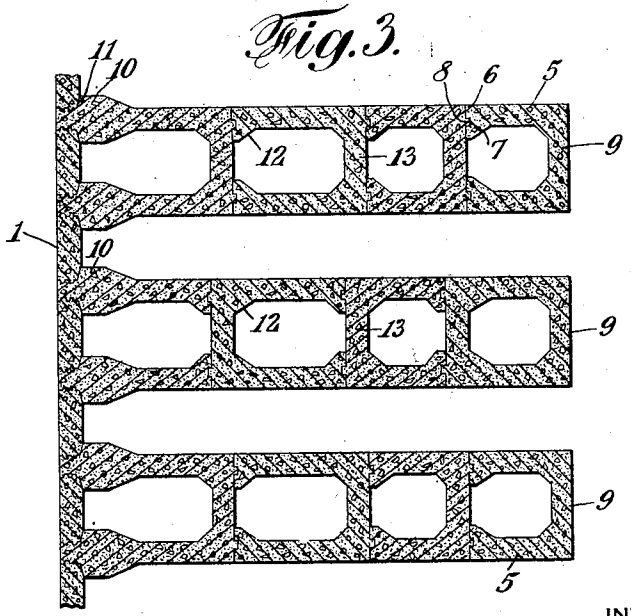

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Fig. 4.

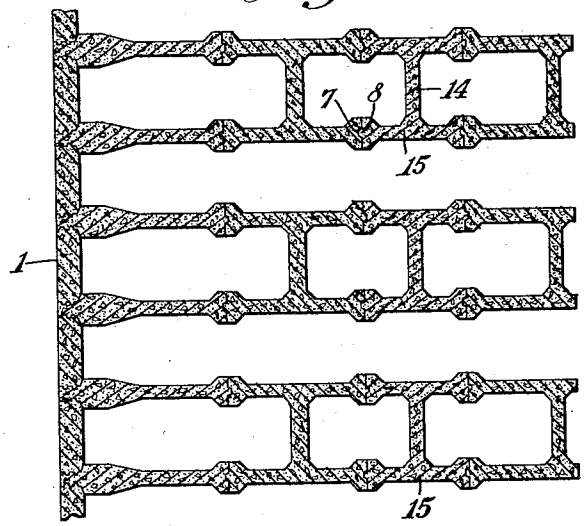

Fig. 5.

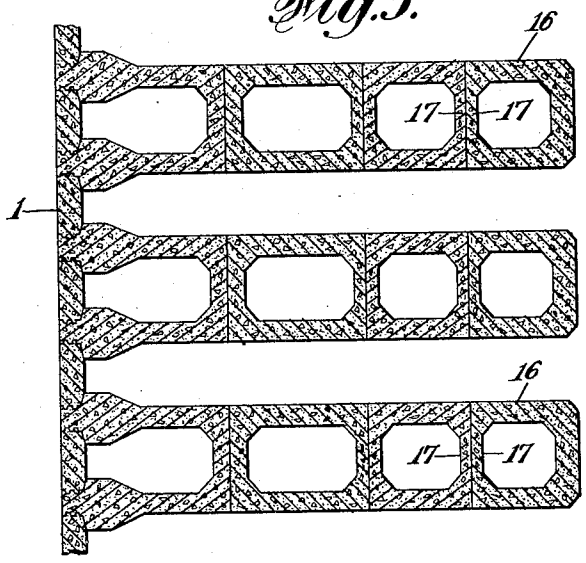

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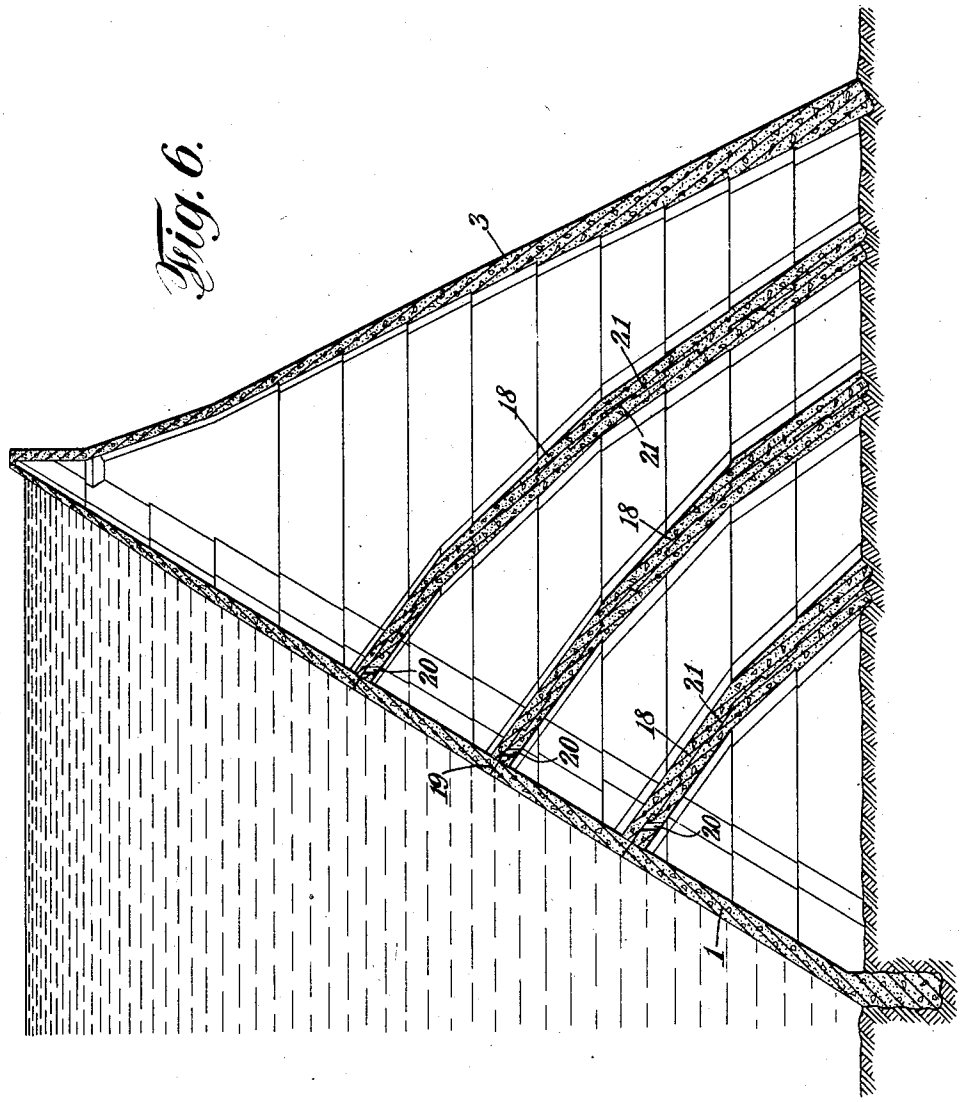
Fig. 6.



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Patented Apr. 12, 1932 1,853,545

UNITED STATES PATENT OFFICE

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DAM

Application filed April 30, 1930. Serial No. 448,506.

This invention relates to a novel and improved form of dam, the novel features of which will be best understood from the following description and the annexed drawings, in which are shown selected embodiments of the invention, and in which:—

Fig. 1 is a vertical sectional view taken on a plane extending up stream and down stream through a dam and illustrating the direction of certain stresses;

Fig. 2 is a view on the same plane as Fig. 1 and showing one form which the invention may take;

Fig. 3 is a section on the line 3—3 of Fig. 2;

Figs. 4 and 5 are views similar to Fig. 3, but showing different forms which the invention may take;

Fig. 6 is a view similar to Fig. 2, but illustrating another embodiment of the invention.

The type of dam covered by this application is that in which there is provided an up-stream water-bearing deck 1 carried by a plurality of supports beneath it. For the purpose of illustration, I have shown the deck as being of the flat slab type but it is to be understood that when I use the term "deck" I intend as well to cover other forms of water-bearing surfaces, such as arches and domes, as the invention is not limited to any particular type of such surface.

In the past it has been customary to support the deck on buttresses of generally triangular form. While this type of support for a deck has become practically standard, nevertheless there are certain disadvantages in its use, particularly caused by the uneven distribution of stresses. It is to overcome these objections that I have devised this invention.

Referring now to Fig. 1, I have indicated thereon certain lines 2 indicating the directions taken by the first principal stresses, at spaced intervals along the foundation, or along the water-bearing deck. These stresses and their directions may be calculated by known methods, and it is known that these directions are substantially normal to the water-bearing surface and are so curved as to be asymptotic with relation to the down-stream face 3 of the dam. It is also known that the surfaces represented by the lines 2 are surfaces of zero shear.

I have also shown in Fig. 1 other lines 4 which indicate the directions of second principal stresses at spaced intervals, and it will be seen that these lines cross the lines 4 substantially at right angles.

Referring now to Figs. 2 and 3, I have shown a way in which the above principles can be employed to obtain a dam in which the stresses will be better distributed, which can be more economically and rapidly built, and which will have higher factors of safety than the dams of the prior art.

In Figs. 2 and 3, I have shown each support as comprising a plurality of structural bents 5. By the term "bent" I mean a plurality of structural elements rigidly secured together to act as one member and designed as a column to support a load placed on one end thereof. The bents 5 are separated by joints 6, these joints being arranged approximately on surfaces parallel to the direction of first principal stress at that location and, therefore, on surfaces which have approximately zero shear. Each bent 5 is preferably designed so as to be laterally stable independently of other bents, and in Fig. 3, I have shown this as being accomplished by making the bent of U-form and having grooves 7 receiving keys 8 on adjoining bents. The arms of the U may extend up stream, as shown in the upper and lower bents of Fig. 3, or may extend down stream, as shown in the middle bent of this figure. The bent adjacent the face of the dam is shown as closed at 9 and the bents adjacent the deck are shown as provided with flared portions 10 to form seats 11 for the slabs here shown as forming the deck. This up-stream portion of the bent will, of course, vary according to the particular type of deck which is used. Lateral stability may also be increased by the use of fillets 12 and, of course, the transverse portions 13 forming the bottoms of the U's add greatly to this lateral stability.

The result then is a plurality of bents separated by surfaces of zero shear and which

are substantially normal to the deck and asymptotic to the down-stream face of the dam. These bents, structurally speaking, are independent of each other when completed, although each bent is prevented from downward movement by the one below it. This is of substantial importance because in a high buttress dam trouble has been experienced with individual buttresses which, of course, have to be designed to act as columns and expensive bracing systems have been used, the effectiveness of which at best was unknown. With this invention, however, the inclined or curved bents not only are monolithic in character but may be designed to be of such proportions that their lateral stability is assured.

Moreover, in the prior art constructions the resultant of all the loads on the dam falls some distance down stream from the center of gravity of the dam, thus giving a higher normal pressure on the horizontal plane at the down-stream face or toe of the dam than at the up-stream face or heel. With this invention, however, there is a better distribution of stresses because the center of gravity upon each horizontal section is drawn further down stream, or nearer the point of application of the resultant force, thus providing more nearly uniform distribution of the pressures on each horizontal plane. With this construction again the span between supports may be increased, thus cutting down the number of supports for the deck and saving a substantial amount of masonry.

While I have illustrated the dam as formed of concrete alone, it is to be understood that reinforcing steel may be employed where found necessary.

In Fig. 4, is shown another form which the invention may take, in this case the bents being formed of H-sections and comprising cross pieces 14 connecting legs 15 and these legs 15 being provided with grooves and keys 7 and 8 forming the joints between adjacent bents. It is to be understood that these joints are disposed on surfaces following the directions of first principal stresses, as in Figs. 2 and 3.

In Fig. 5, is shown another form which the bents may take. In this case they are formed as boxes 16 having transverse portions 17 in contact with each other. In this form the keys and grooves have been omitted although they may be employed, if found desirable.

In Fig. 2 the joints between bents terminate beneath the deck, which is shown as being continuous. In Fig. 6, however, is shown an embodiment in which the joints 18 are extended through the deck, as shown at 19, thus a section of the deck between consecutive joints acts as a part of the bent between these same joints. By this arrangement internal stresses in the superstructure are reduced. Each bent is supported by the one beneath it, while there is no tendency for the shrinkage in one part of the deck to affect another part, beyond one of the joints 19.

The water tightness of the joints 19 in the deck may be provided for by the use of flashing or other suitable means. Preferably, I provide drains 20 leading from the joints 18 beneath the deck, to take care of any water that may leak through the joints 19, and to prevent this water from building up a pressure between adjacent bents.

While the bents are designed to act independently, and while the joints between bents are disposed on surfaces of approximately zero shear, nevertheless with varying loads a condition may obtain in which some shear will be developed along these surfaces, although probably not a very great amount. In order to take care of this shear, however, I provide the adjacent surfaces of adjoining bents with overlapping elements in the form of projections 21, which resist relative movement between the bents in a direction lengthwise of the joint.

I claim:

1. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports being formed of a plurality of bents separated from each other by joints substantially parallel to the direction of first principal stress.

2. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports being formed of a plurality of bents extending from the deck to foundation material and each constructed to transmit its load from the deck to the foundation independently of the other bents.

3. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports being formed of a plurality of bents having their upper ends substantially normal to the deck and their lower ends substantially asymptotic to the down-stream face of the dam.

4. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports comprising bents disposed substantially parallel to the direction of first principal stress.

5. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports comprising bents disposed substantially parallel to the direction of first principal stress and each constructed to transmit its load from the deck to the foundation independently of the other bents.

6. A dam comprising an inclined up-stream

water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports comprising a plurality of separate bents separated from each other by curved surfaces substantially normal to the deck and asymptotic to the down-stream face of the dam.

7. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports comprising a plurality of separate bents separated from each other by curved surfaces substantially normal to the deck and asymptotic to the down-stream face of the dam, and keyed connections between adjacent bents permitting relative longitudinal movement but resisting relative lateral movement therebetween.

8. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports being formed of a plurality of bents separated from each other by joints substantially parallel to the direction of first principal stress, and means resisting relative movement between said bents along said joints.

9. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports being formed of a plurality of bents separated from each other by joints substantially parallel to the direction of first principal stress, and overlapping elements on adjacent bents to transmit part of any excess of load on one to the other, to prevent relative movement therebetween.

10. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports being formed of a plurality of bents separated from each other by joints substantially parallel to the direction of first principal stress and extending through said deck.

11. A dam comprising an inclined up-stream water-bearing deck and a plurality of supports beneath said deck and extending down stream therefrom, each of said supports being formed of a plurality of bents separated from each other by joints substantially parallel to the direction of first principal stress and extending through said deck, and drains leading from said joints adjacent the deck.

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