F. E. ROFF.

DAM.

APPLICATION FILED AUG. 19, 1909.

985,841.

Patented Mar. 7, 1911.

Fig. 1.

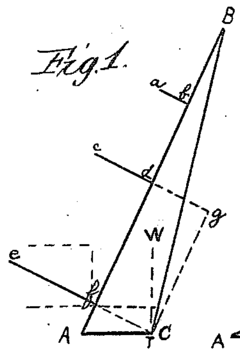


Fig. 2.

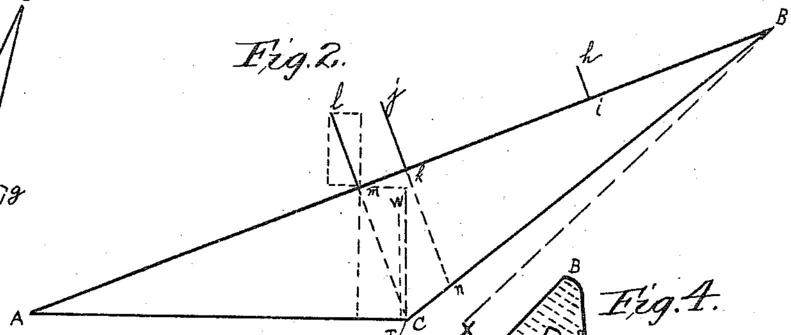


Fig. 4.

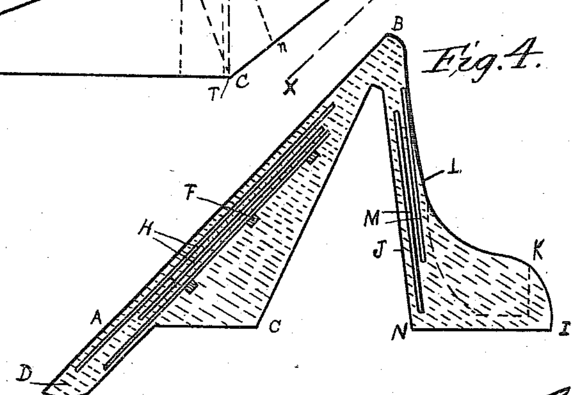


Fig. 3.

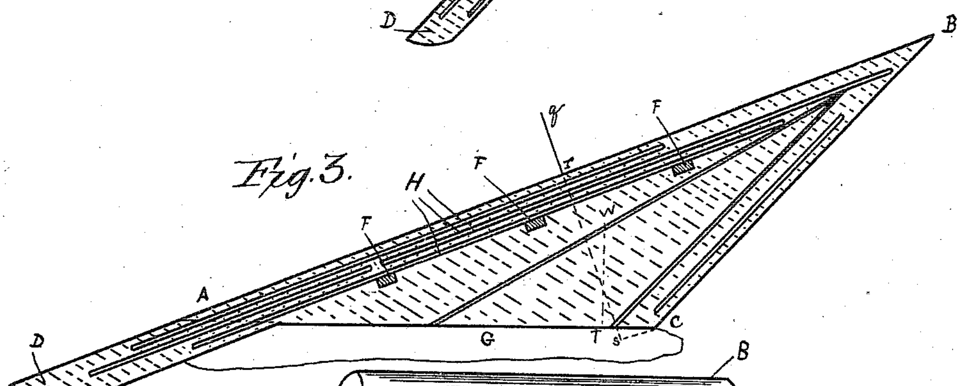
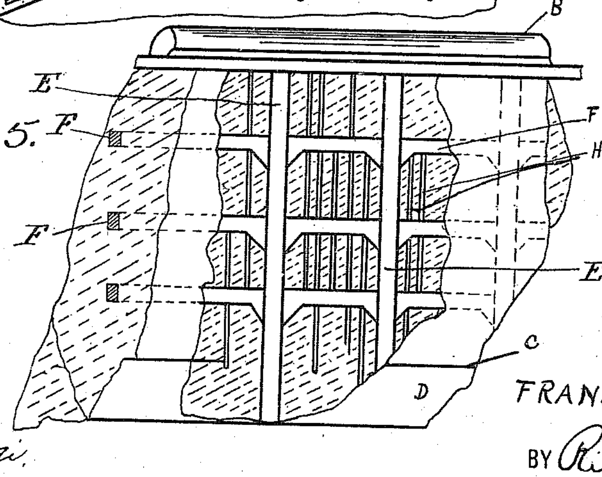


Fig. 5.



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DAM.

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To all whom it may concern:

Be it known that I, FRANK E. ROFF, a citizen of the United States, residing at Richfield Springs, in the county of Otsego and State of New York, have invented certain new and useful Improvements in Dams, of which the following is a specification, reference being had therein to the accompanying drawing.

My invention relates to an improved dam, and I declare that the following is a full, clear, concise and exact description thereof, sufficient to enable one skilled in the art to make and use the same, reference being had to the accompanying drawings in which like reference characters refer to like parts throughout.

The invention relates particularly to a cantaliver dam, as I term it because of the principles upon which it is constructed, as will be set forth.

One purpose of the invention is to produce such a structure at a minimum of cost consistent with ample strength. It is well known that in building a solid dam, of masonry or the like, the cost of construction is excessive in proportion to the safety secured, as compared with certain other kinds of construction.

Many plans have been suggested for reducing the cost while still maintaining strength and stability, such as building hollow dams with arch construction from deck to apron, or building a dam with an apron extended down the bed of the stream to provide resistance to tipping, or by building a deck supported by sub-structure which extends down stream beyond the perpendicular from the crest of the dam. In general cases the deck of the dam, which receives the hydrostatic pressure, is perpendicular, or nearly so, little or no use being made of the weight of the impounded water.

Another purpose is to utilize this weight of water to the greatest advantage in gaining stability of the dam, whereby a less mass of masonry to hold the dam in place is needed, at the same time negativing the crushing effect of such weight, as far as possible.

The principle upon which I purpose to construct the dam is shown by two triangles which are extreme types, for the purpose of illustration. Such triangles are shown in Figures 1 and 2 of the drawings, illustrative of the advantage of the principle of my construction. Fig. 3 is a cross-sectional view of a dam embodying the cantaliver principle. Fig. 4 is a cross-sectional view of a dam, with apron, showing certain particulars of the invention. Fig. 5 is a rear view of the deck of the dam parts being broken away and sectioned.

In the first instance, Fig. 1, a triangle A, B, C, is shown to represent a cross-section of a dam, the lines A, B, representing the deck, which approaches a vertical position, and A, C, the base. It is assumed and shown that the structure shown by this triangle is of barely stable equilibrium, as will be noted from the line of direction, W, T.

The hydrostatic pressure against the deck at different points is shown by the lines *a*, *b*; *c*, *d*, and *e*, *f*. The point *d* being at the center of the line representing the deck, the line *c*, *d* represents the average pressure of the water, acting in the direction of the line, its value being represented by the length of the line. As the point C is about at the base of the line of direction, the weight of the structure is negligible in determining its stability and the effect of the pressure is represented by line *c*, *d* acting with leverage of *g*, C. In the other form, Fig. 2, certain lines of pressure are shown by *h*, *i*; *j*, *k* and *l*, *m*.

The point *k* represents the point of average water pressure, in the line and with the force represented by *j*, *k*, which has a more vertical direction and the effect of the pressure is represented by line *j*, *k* acting with leverage of *n*, C. The force of the water pressure being the same in each case and the leverage by which it acts to overturn the structure being less in the second case than in the first, the advantage of applying the downward pressure of the water is seen in the greater tendency to stability in the latter form.

The structure is spoken of as a cantaliver dam and the principle may be stated in a different way. Suppose the triangle A, B, C in Figs. 1 and 2 to represent a lever with fulcrum C. Project a line through C and perpendicular to the deck line, as e, f and l, m, and showing in each triangle where the effect of the resolved forces balances, or the resultant acts directly against the fulcrum, and it is seen that in the first case the effect of the force is strongly to overturn the structure, while a much lesser proportion has that effect in the second case. If the base A, C and the back B, C were to be made equal, C being as at x in Fig. 2, the balance point of pressures would be the same as the mean pressure point and the weight of the structure would be all applied to keeping it stable. Or, the deck of the dam being disposed to receive the weight of water, if it be made stiff enough to avoid disruption by the distribution of such weight on its face, almost the entire hydrostatic pressure is utilized to hold the dam in place.

Stability may be secured or increased in one of three ways, as by placing the fulcrum C nearer a perpendicular dropped from the crest B, by extending the deck forwardly to receive more downward pressure, or by anchoring the base to provide resistance.

Referring to Fig. 3, where A, B represents the deck-line and A, C the base, and fulcrum C is differently placed, it will be found that the average load pressure at half the height of the deck represented by line q, r acts on leverage of s, C to support the structure, while the weight, with a value equal to W x T, C assists to hold it. While the form of the dam shown in Fig. 3 is perhaps an extreme type, it illustrates certain features of my invention. Though built of solid masonry, concrete or steel-concrete, the cost of such construction does not exceed that of a dam with vertical deck where the stretch or footing extends down stream to brace against the lateral thrust of the impounded water, considering the advantage I secure by utilizing the weight of water as a factor for stability, it being of course understood that the structure is so compact and knit as to preserve the effect of the lever principle. The deck is preferably of wall construction suitably reinforced to withstand the downward pressure of the water. Such reinforcing I propose to effect by embedding in the deck a number of strain irons, of suitable and varied length, supported by girders, as will be described. Such irons will be arranged to provide greater resistance and weight at the lower part of the deck, thus increasing the stability. I have spoken of different means of increasing stability, one of which was by anchoring the base. It will of course be understood that the dam rests on a suitable sub-base, as G, represented in Fig. 3 as of indefinite proportions variable according to circumstances. In Fig. 3, a toe D is formed at the base of the deck, and certain of the reinforcing bars or strain irons H or beams E may be extended downwardly, the toe reaching a given distance into the ground and serving to increase the anchorage of the structure. Where this toe extends in the line of the deck it also receives the pressure of the water in the soil. The deck of the dam is preferably built up in a structure of cantaliver form with beams E and F suitably jointed to provide a stiffening gridiron within the deck, to resist the load of the impounded water. Upon this gridiron or frame are supported iron or steel reinforcing rods, H, arranged up and down in the deck to resist the load pressure and give strength to the deck, these rods being, with the frame or gridiron embedded in the masonry of the dam and the several members of the construction being disposed according to conditions to withstand the strains peculiar to these conditions, which are to be met.

A dam constructed on the principles stated and illustrated is seen to be quite opposite to the older type wherein the deck of the dam is substantially vertical, wherein no application was made of the downward pressure, or weight, of the water to assist in the stability of the structure. On the contrary, my invention seeks to make the utmost use of this force, other considerations being given due weight. I am aware that it is not new, simply to make use of this weight, as it has been considered and applied, but chiefly, and quite solely, to press the structure more firmly on its base, the base of the structure extending beyond a perpendicular dropped from the crest to effect the stability so that the pressure has not been utilized to maintain it stable but simply to make up for loss of weight in a hollow structure. My invention is essentially different since I employ the vertical downward thrust simply to maintain the dam upright, not carrying the base so far to the rear as in the cases mentioned where the dam is essentially a partially hollowed block of heavy material resting on its longest face and with so wide a base that it cannot be overturned, and having its deck or water face constructed to support the dead and unnecessary weight of a large mass of water, while my invention is like a triangular block resting on its shortest face with its fulcrum between extreme perpendiculars, its deck being placed at an angle to apply the maximum of downward thrust and the least possible strain from such thrust. The most desirable angle for the deck and the length of the short arm of the cantaliver are matters of judgment under different conditions, consideration being given also to the possible overload. Thus it will be seen that the invention is complete, if it go no further since the several factors to be considered may be so proportioned as to produce a perfectly stable structure.

However, I show in Fig. 4 a dam having a lesser slant of deck but not such inherent stability as in Fig. 3. It has an apron which, while providing for the flow from the dam also adds an element of strength without any material addition to the cost above the requirements of the apron proper. Applying the same general principle of the cantaliver, I make a structure having a base N, I J, K, from which rises, at an angle the apron L, its top being joined to the crest of the dam and preferably integral therewith. The outer face of the apron is given a curvature for the flow of water and the base of the structure is made hollow to retain a volume of water and by its weight give stability to the structure. In other words, the base is provided with sides extending above the bottom and is walled up at the outer edge. The apron is stiffened with rods M as the deck. The apron structure has the same character of stability as the first described portion and is maintained by weight of the water at the base so that the completed structure represents two upwardly projected walls, with their tops joined, each adapted to be maintained in stable equilibrium by hydrostatic pressure of a volume of water.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. A dam constructed of cantaliver form in vertical cross-section, having the deck extending obliquely to receive the water load.

2. A dam constructed of cantaliver form in vertical cross-section having its deck disposed at an angle to apply the greater proportion of water pressure to maintain the cantaliver upright.

3. A dam having its deck at an angle to receive the downward hydrostatic pressure and apply the same to maintain the dam upright and having a back support lying between verticals bounding the deck.

4. A dam having its deck at an angle to receive the downward pressure of the hydrostatic load in greater proportion to the entire pressure than the horizontal pressure of such load whereby the effect of such pressure is to maintain the dam and having its base within the verticals which bound the deck of the dam.

5. A dam having its deck at an angle to the base whereby the downward pressure of the hydrostatic load exceeds the horizontal pressure and having a sub-structure extending substantially along the line of the deck.

6. A dam formed of a plurality of cantaliver constructions, maintained in place by the hydrostatic load on each.

7. A dam formed of a plurality of cantaliver constructions, maintained in place by the hydrostatic load on each, the said constructions being in reversed position as to each other and united at the crest in one integral construction.

8. A dam formed of a plurality of cantaliver constructions arranged with their apexes adjoining, one of said constructions being formed with a hollow at its base whereby to impound water to assist in maintaining its stability, substantially as described.

9. A dam formed of cantaliver constructions united at the crest, each formed at its base with additional construction to receive water pressure whereby to maintain the stability of the dam, substantially as described.

10. A dam formed of a cantaliver in vertical constructions having at its base an extended portion to receive water load pressure whereby to assist in maintaining the stability of the dam, substantially as described.

11. A dam formed with a deck and a base lying within the limits formed by verticals drawn from the bottom and top of the deck, the said deck being formed with a gridiron or frame having steel reinforcing rods supported thereon, the whole supporting a face of masonry to receive the water pressure, substantially as described.

12. A dam formed with a deck disposed at an angle to receive the downward pressure of the water, the said deck being formed of a framework and having reinforcing rods supported thereon, the rods being arranged in number and position proportionate to the water pressure at different points on the deck, substantially as described.

13. A dam formed of a cantaliver construction having its deck extended in a toe beneath the bottom of the dam in substantially the same line as the deck whereby to receive the pressure of the soil and the water in the soil, substantially as described.

14. A dam constructed of cantaliver form in cross-section, comprising a frame work

of beams, severally positioned and secured, whereby to afford resistance to the water pressure, substantially as described.

15. A dam constructed of cantaliver form in cross-section, comprising a plurality of frames disposed in given positions with regard to the lines of pressure of the impounded water whereby to withstand such pressure, substantially as described.

16. A dam comprising a mass of cantaliver form in cross-section, the same being built up of brace constructions and reinforcing members variously disposed whereby to resist such strains on the dam, substantially as described.

In testimony whereof I hereunto affix my signature in the presence of two witnesses.

FRANK E. ROFF.

Witnesses:
HENRY M. LOVE,
T. L. WILDER.