No. 864,383. PATENTED AUG. 27, 1907.

D. E. MORAN & J. W. DOTY.

MEANS FOR RESISTING LATERAL HYDRAULIC PRESSURES ON POWER HOUSES AND SIMILAR STRUCTURES.

APPLICATION FILED JAN. 22, 1907.

7 SHEETS—SHEET 1.

FIG. 1.

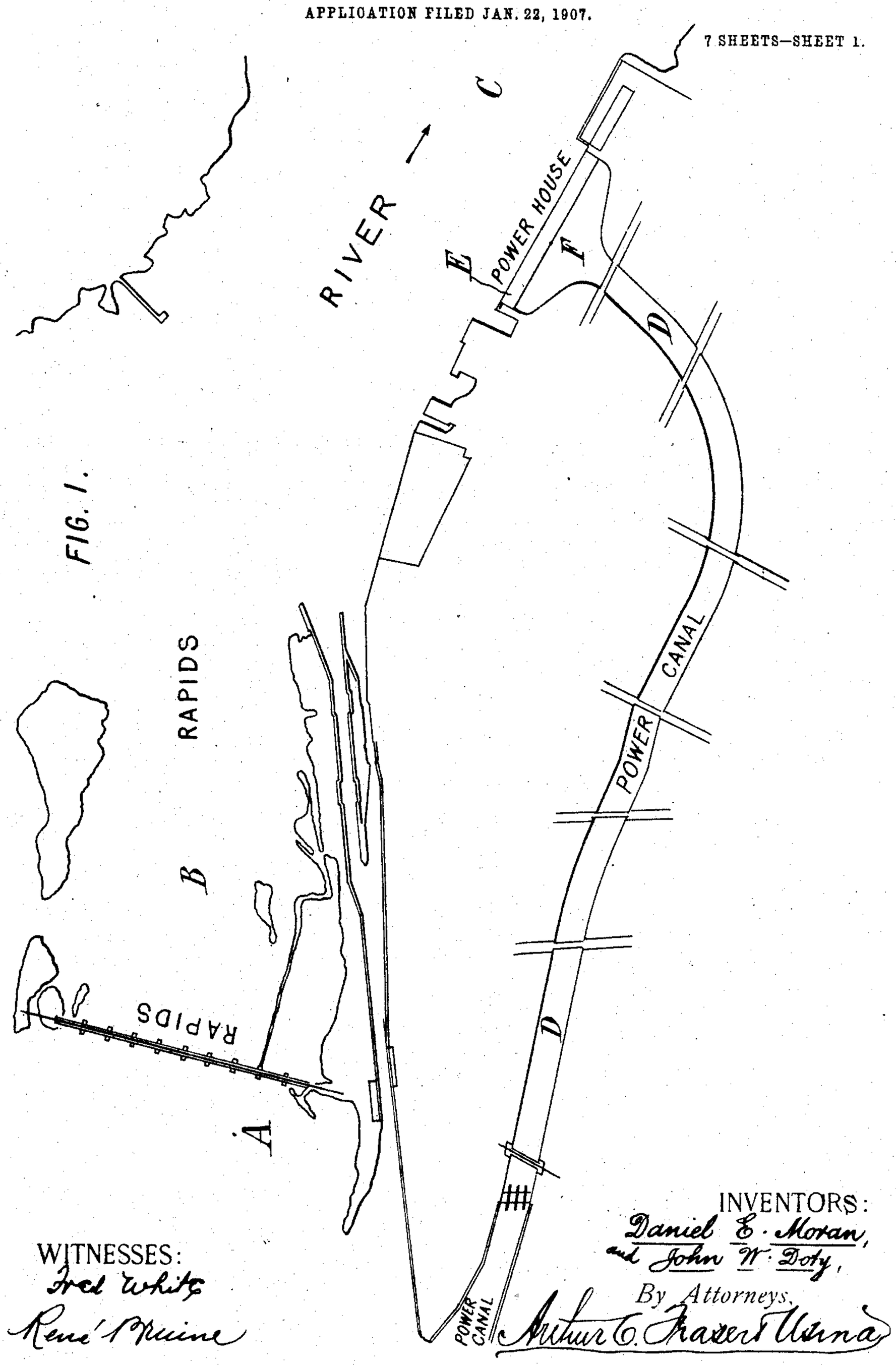

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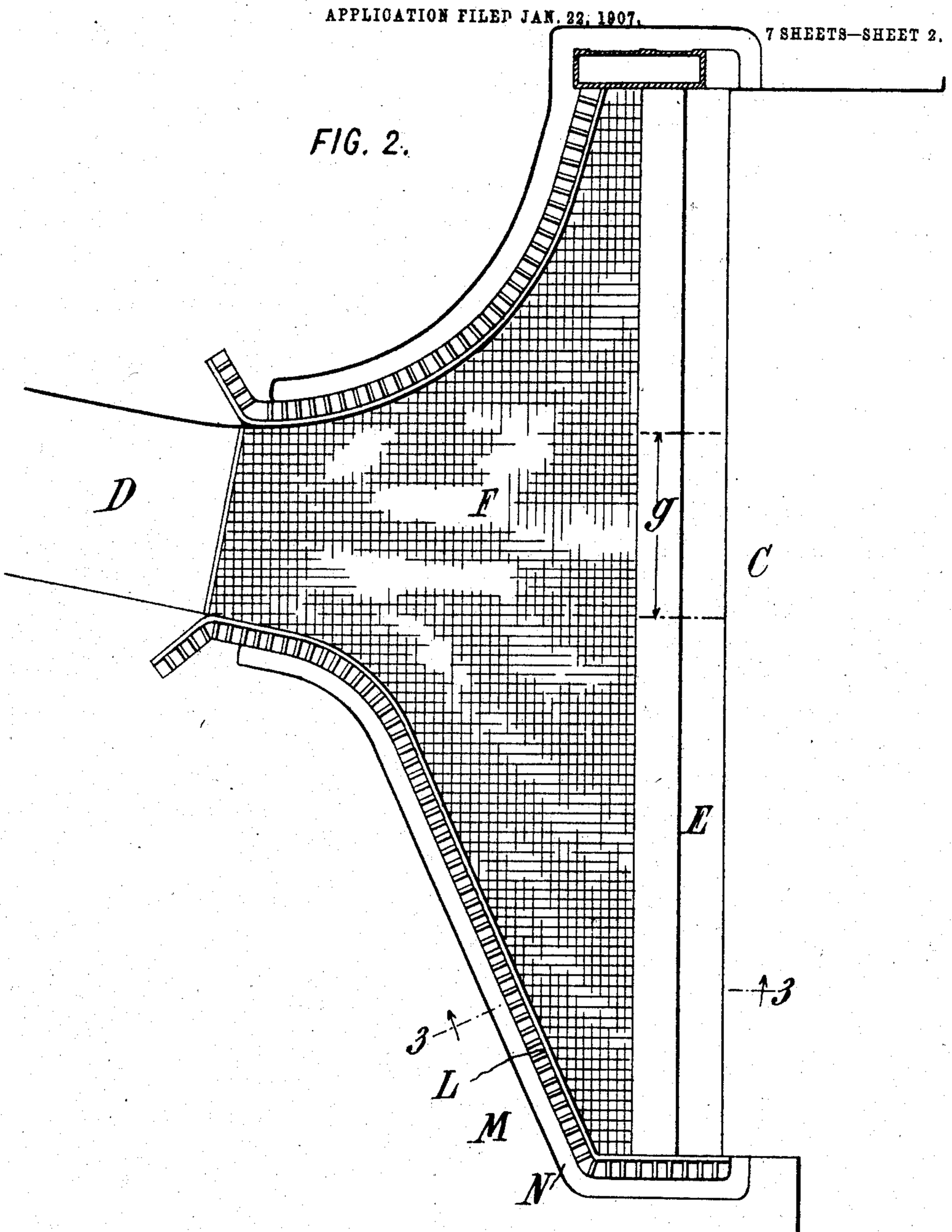
FIG. 2.



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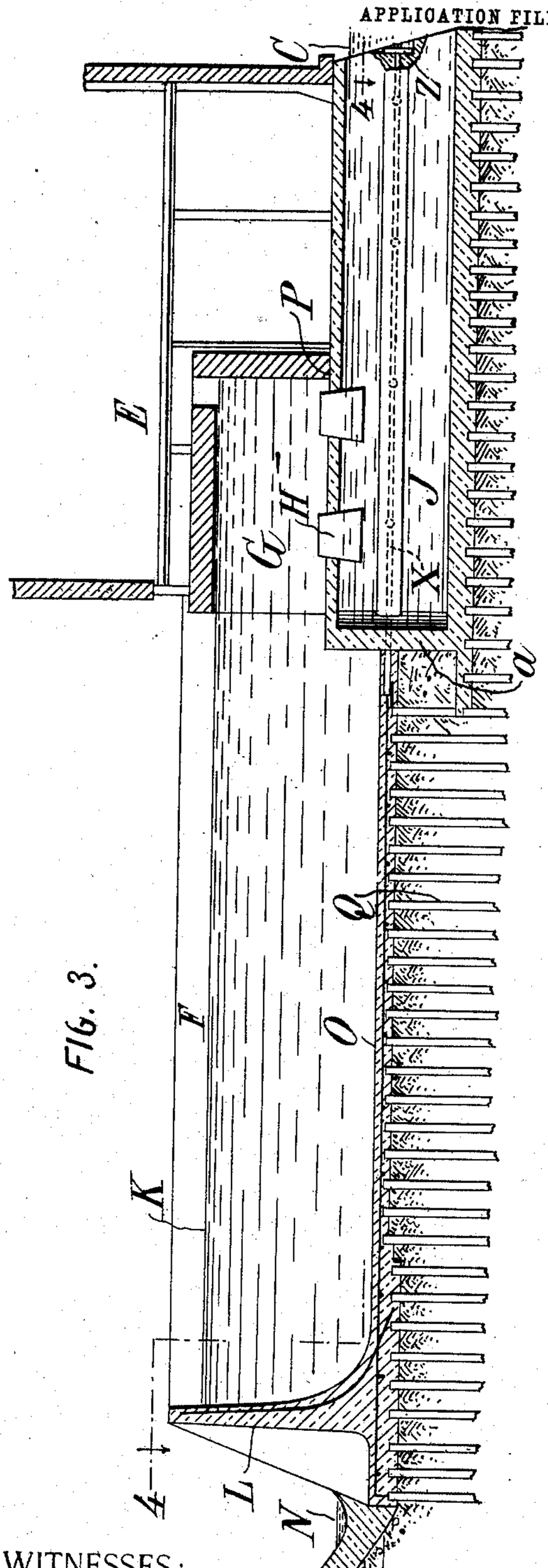

FIG. 3.

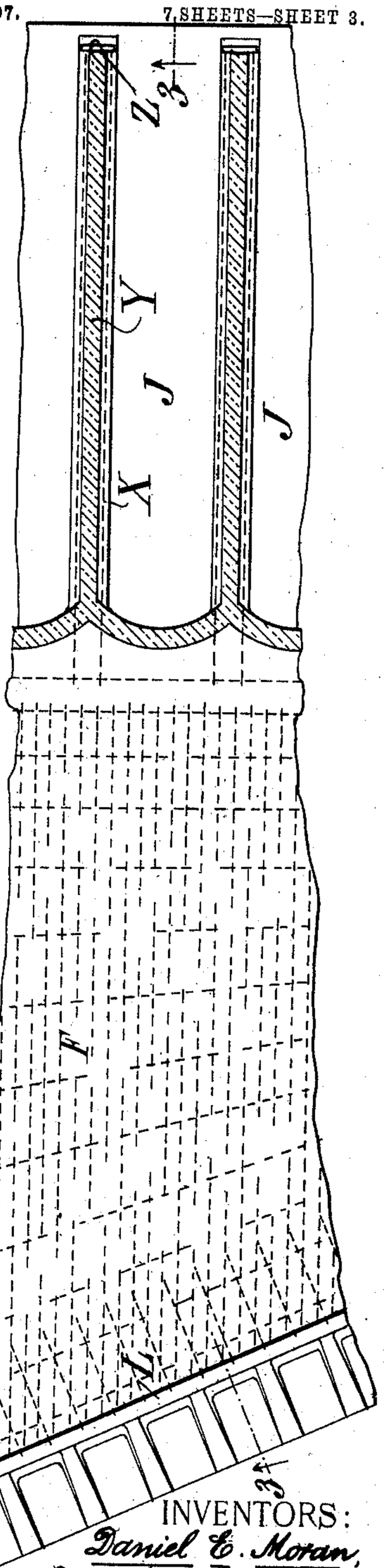

FIG. 4.

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7 SHEETS—SHEET 4.

FIG. 5.

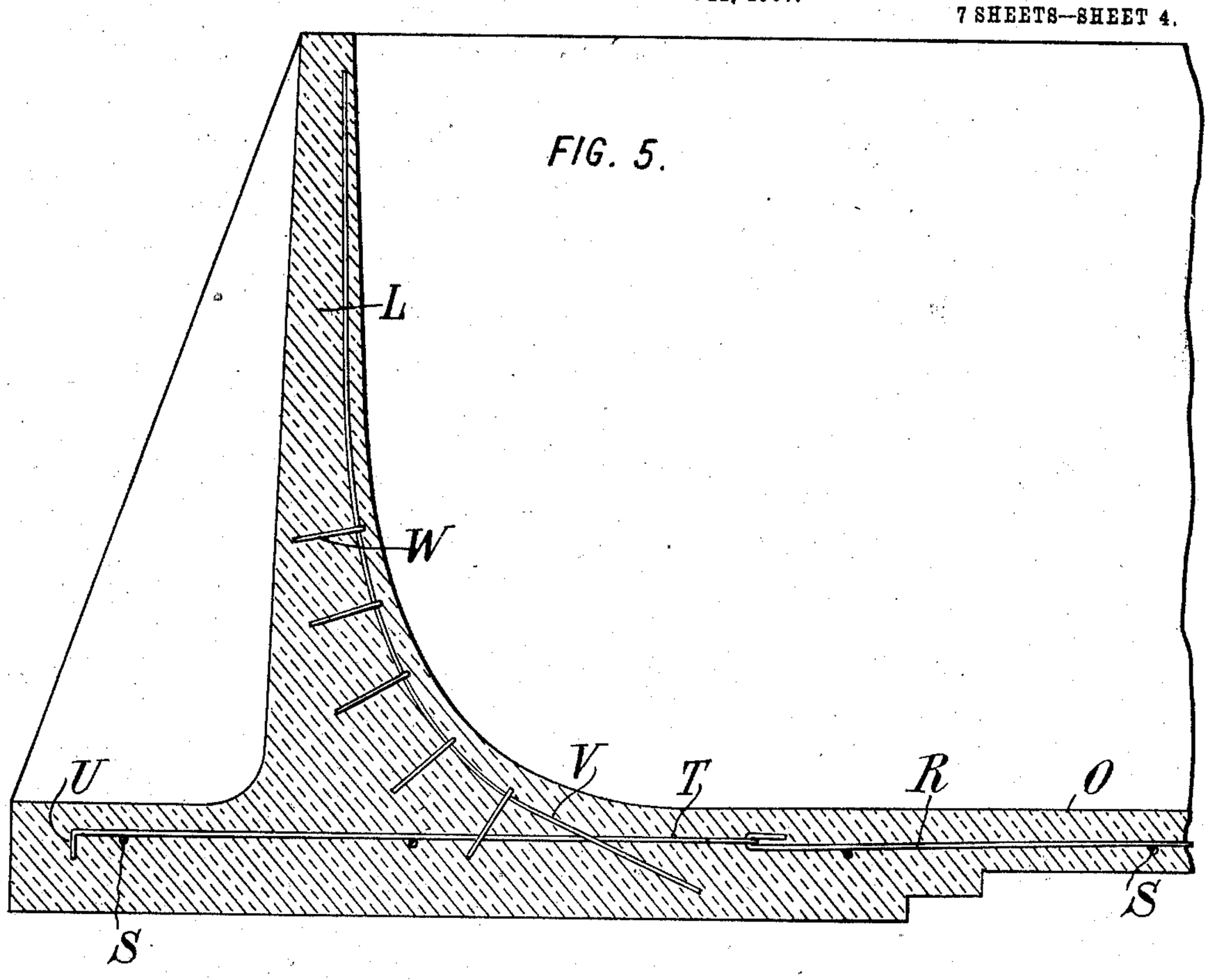
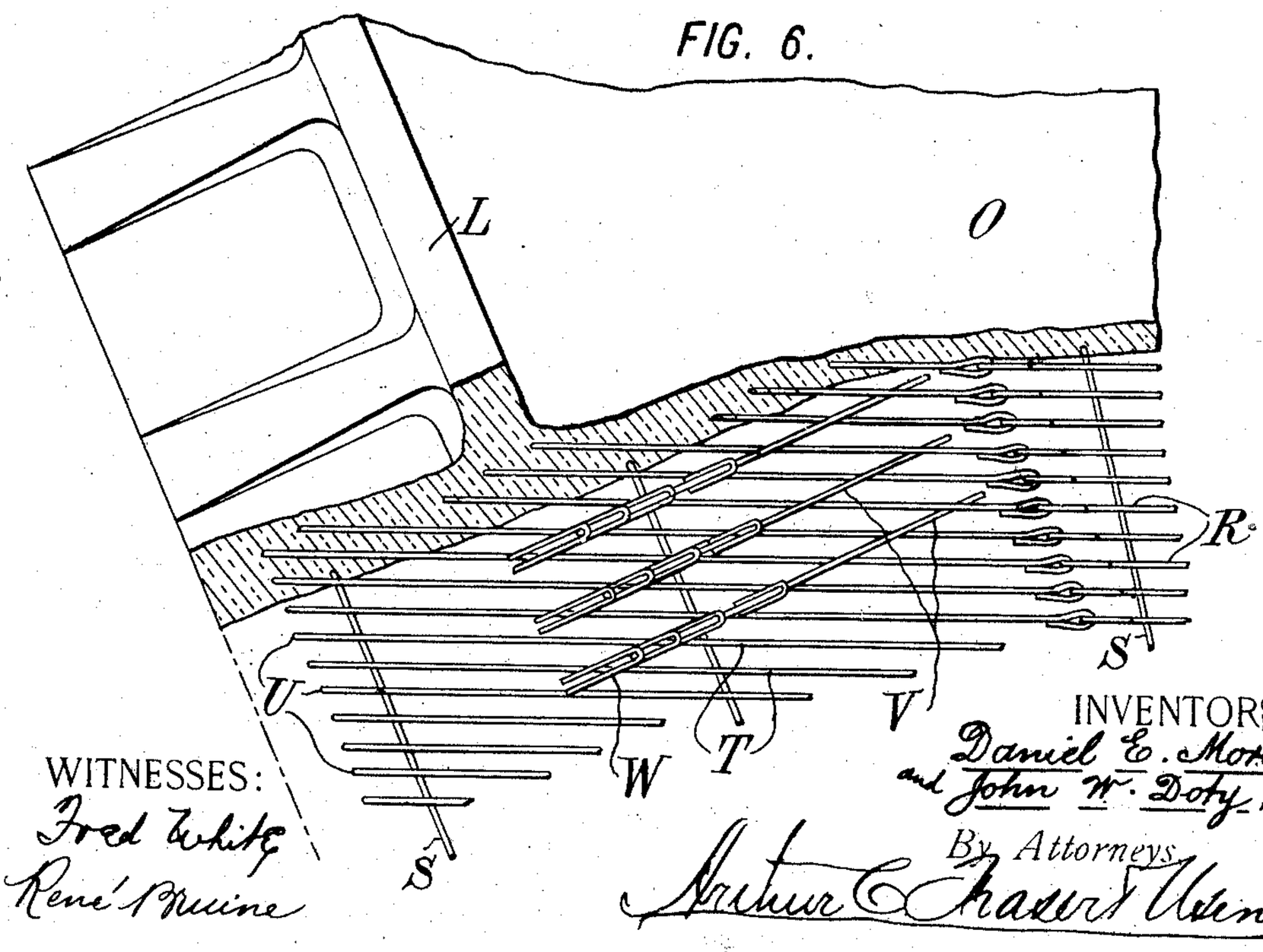


FIG. 6.



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7 SHEETS—SHEET 5.

FIG. 7.

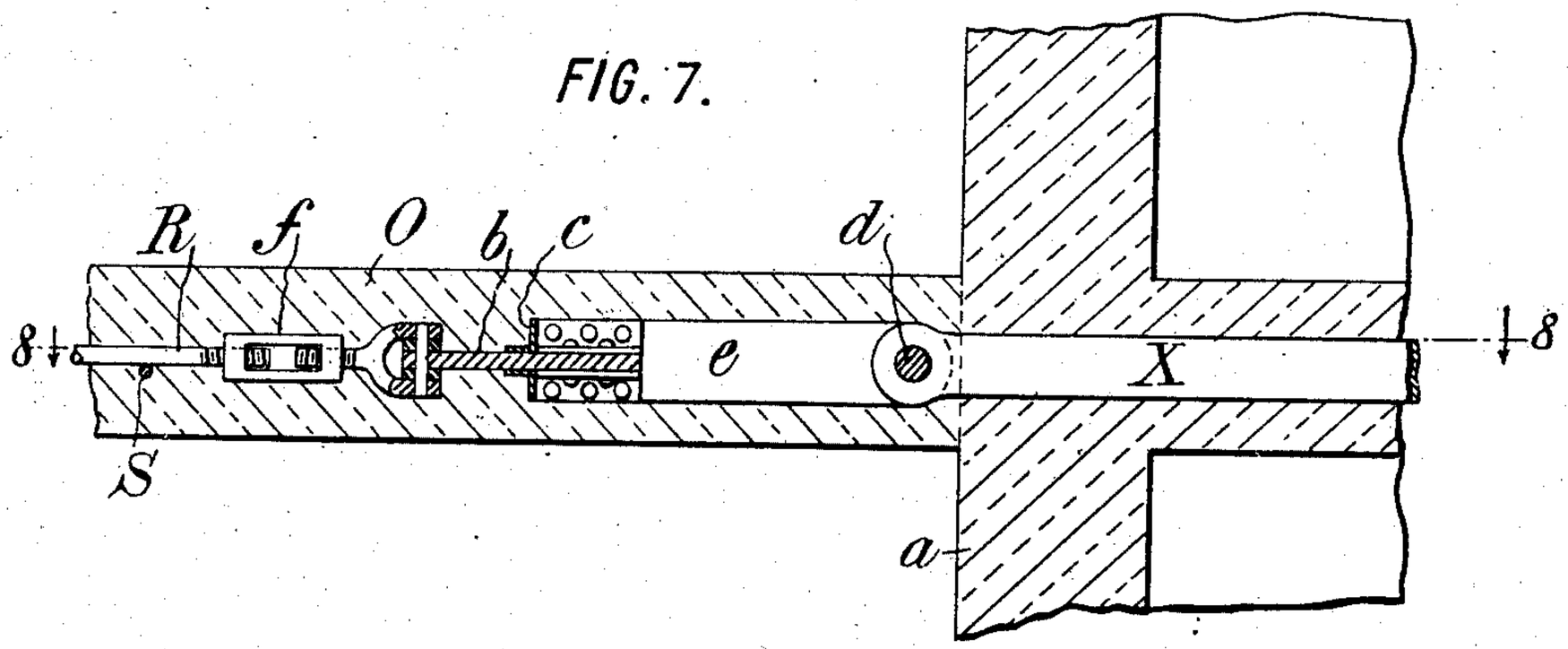
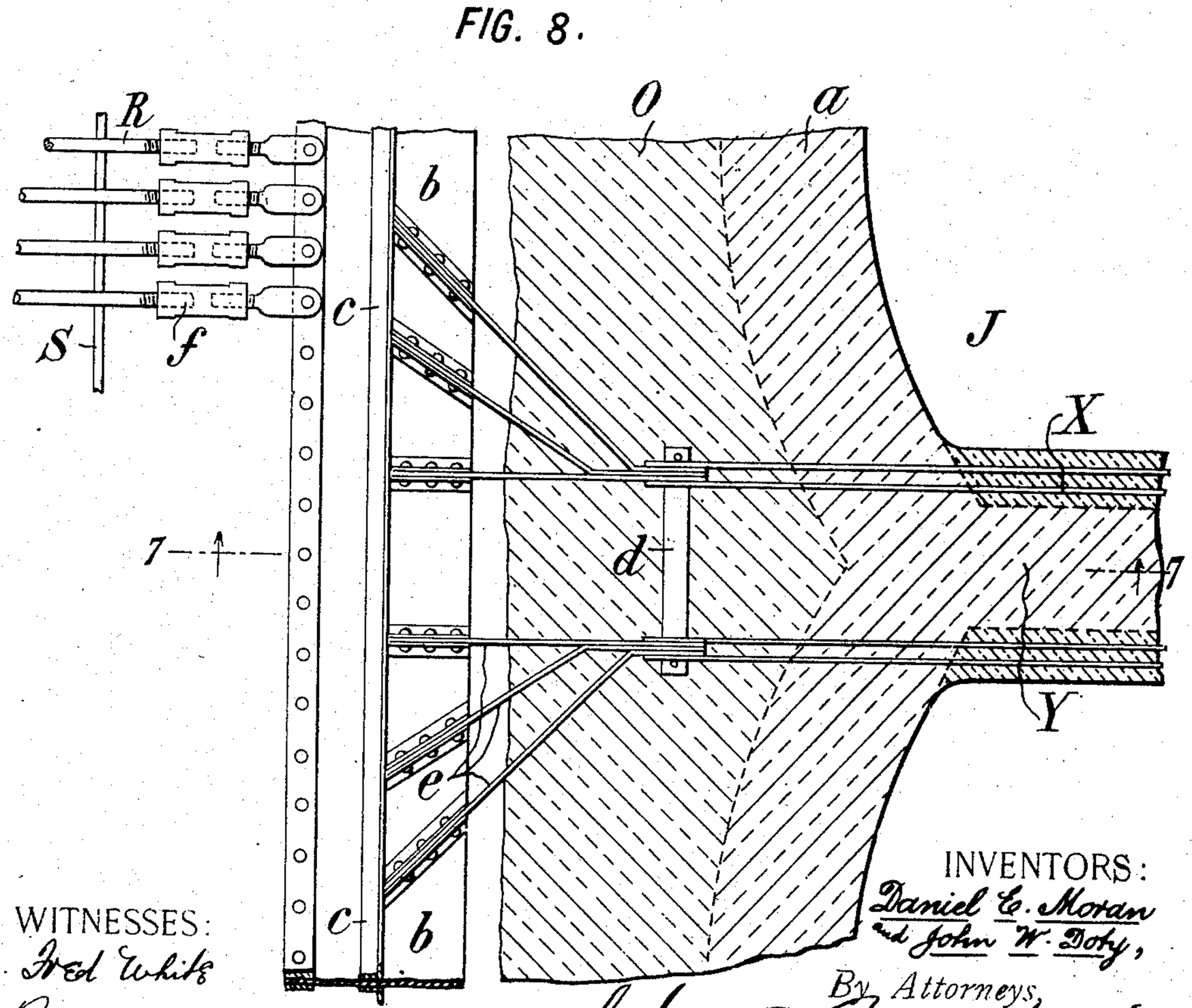


FIG. 8.



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7 SHEETS—SHEET 6.

FIG. 9.

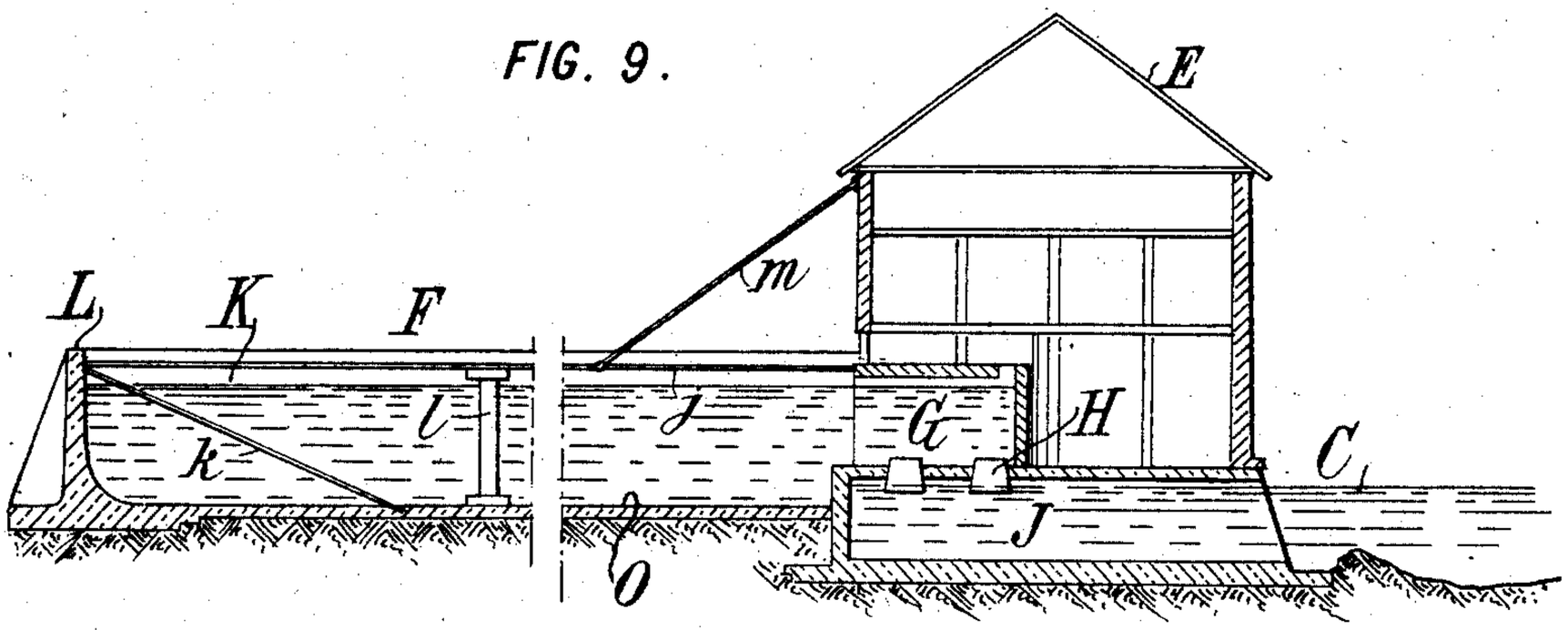
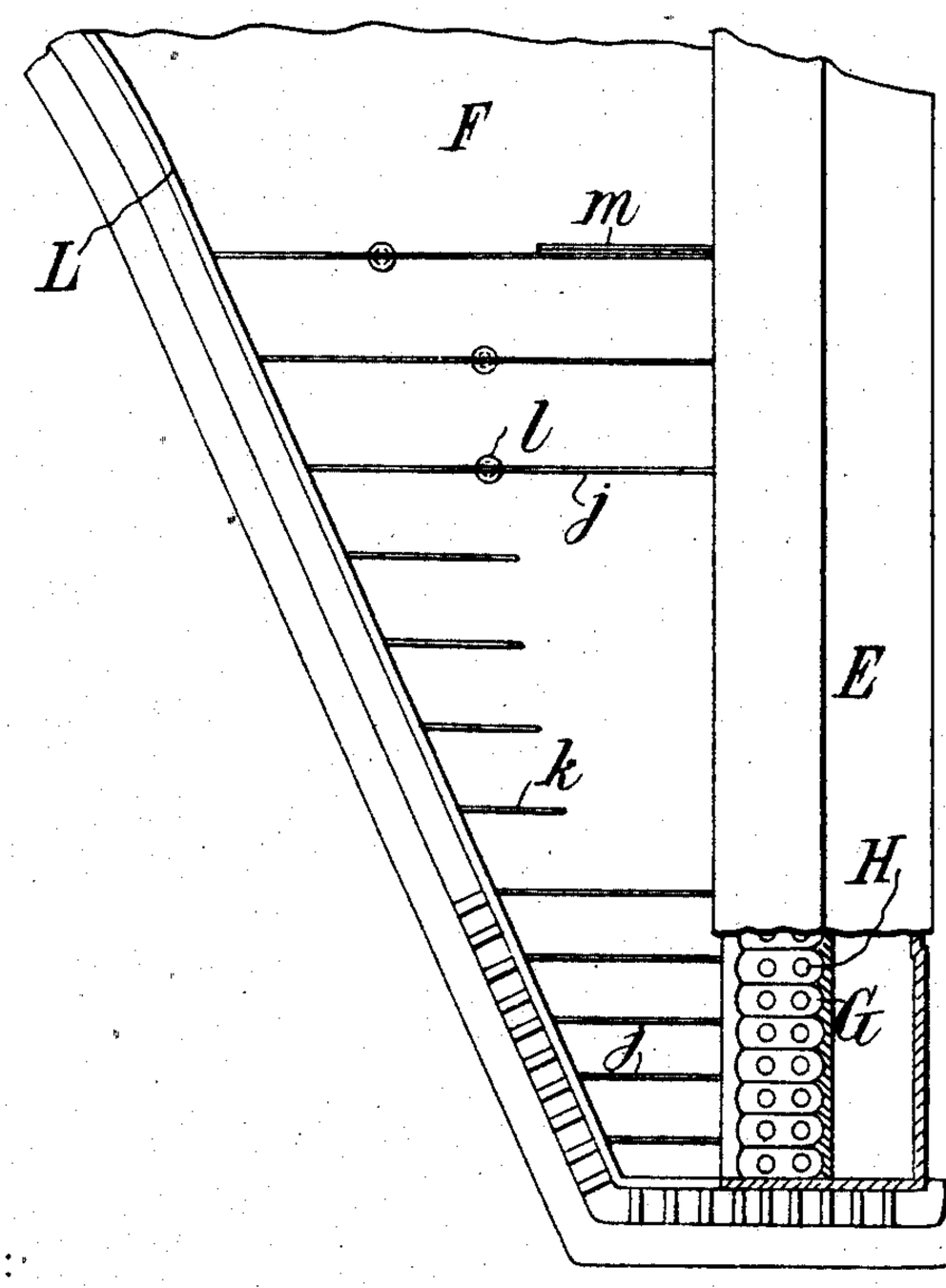


FIG. 10.



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7 SHEETS—SHEET 7.

FIG. 11.

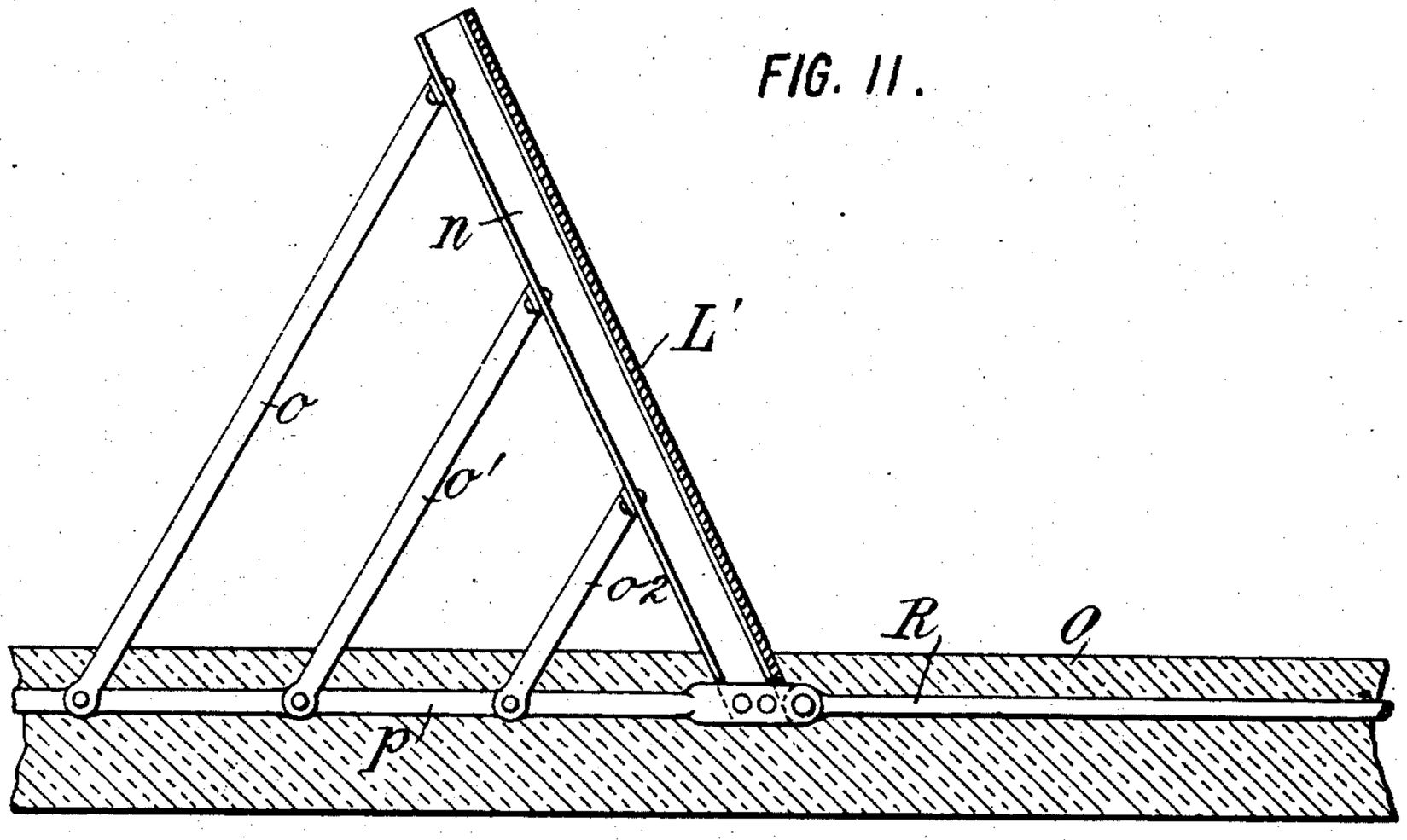
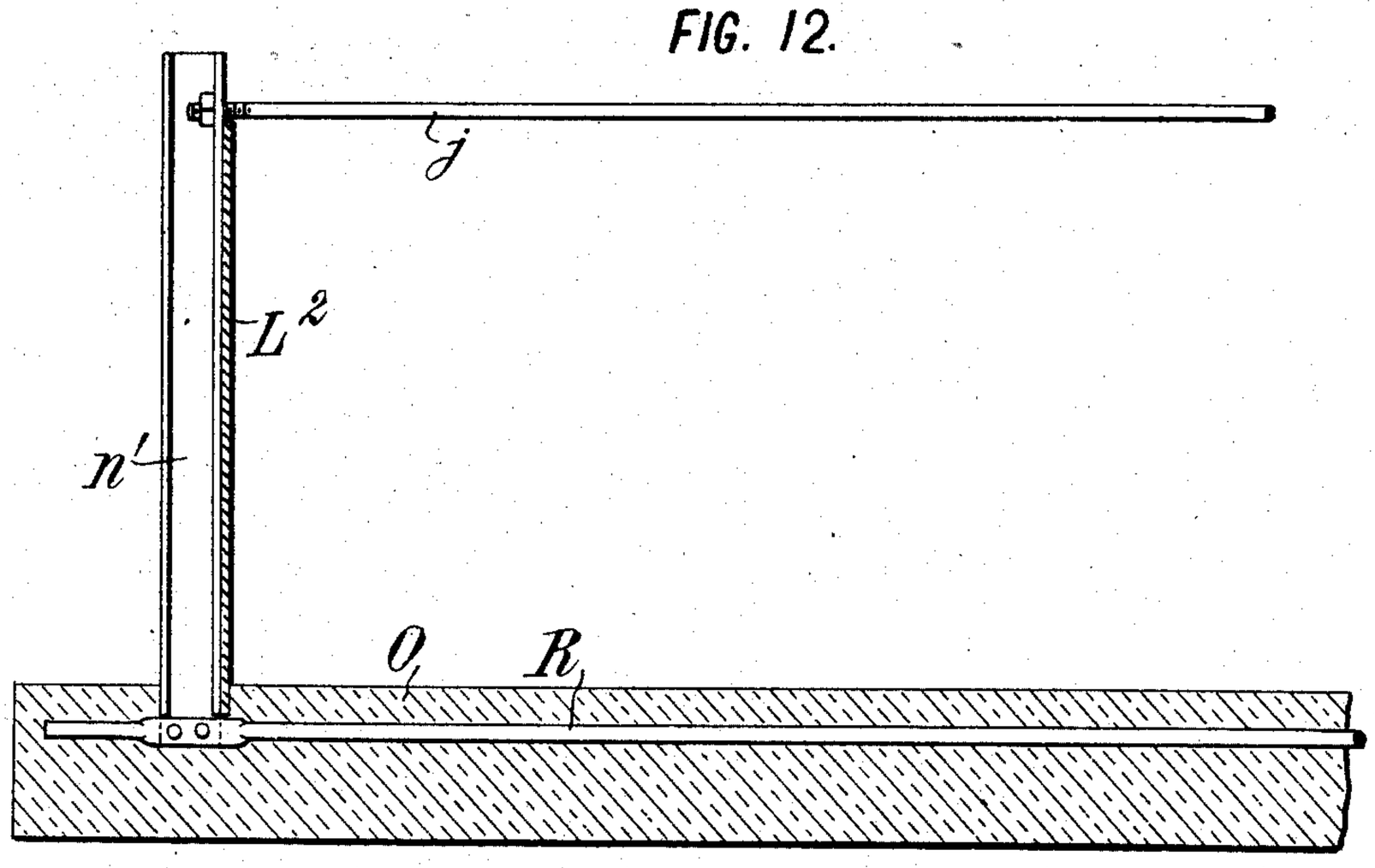


FIG. 12.



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UNITED STATES PATENT OFFICE.

DANIEL E. MORAN, OF MENDHAM, NEW JERSEY, AND JOHN W. DOTY, OF NEW YORK, N. Y.

MEANS FOR RESISTING LATERAL HYDRAULIC PRESSURES ON POWER-HOUSES AND SIMILAR STRUCTURES.

No. 864,383. Specification of Letters Patent. Patented Aug. 27, 1907.

Application filed January 22, 1907. Serial No. 353,545.

To all whom it may concern:

Be it known that we, DANIEL E. MORAN, a citizen of the United States, residing at Mendham, in the county of Morris and State of New Jersey, and JOHN W. DOTY, a subject of the King of Great Britain, residing in the borough of Brooklyn, county of Kings, city and State of New York, have jointly invented certain new and useful Improvements in Means for Resisting Lateral Hydraulic Pressures on Power-Houses and Similar Structures, of which the following is a specification.

Hydraulic power houses are usually situated in such a way as to receive at the side where the water enters a lateral hydraulic pressure which is not balanced, the water level of course being lower at the side where the water discharges. This lateral pressure is so great as to exert a severe strain, tending to overturn the house or to give it a bodily lateral displacement and in the course of time to force it into the river into which it discharges. Or a break being made in the forebay floor or between this floor and the power house, there will be a resulting flow below the power house causing a waste of water and endangering the power house. This tendency is most marked in the type of power house which extends for a considerable length along the shore of the stream into which it discharges, carrying a number of water wheels, and receiving the incoming water from a canal or forebay extending along the entire length of the building or a great part of such length. Similar conditions exist in connection with dams and various other hydraulic engineering structures, and such structures are considered equivalents of the power houses referred to for the purposes of this invention. It has been proposed to stay the movement of such power houses by various expedients more or less costly and difficult to put into practice. Our invention provides a very simple means for attaining this end by the use of a tension connection extending back from said power house or other building, and subjected to hydraulic pressure in a direction opposite to the pressure upon the building, and of sufficient magnitude to prevent, in connection with the other resistances occurring, any lateral movement of the power house. In the preferred arrangement the water in the forebay is held between two walls which are tied to each other, and one of which is composed in whole or in part of the power house, each of the two walls thus supporting the other against the outward pressure due to the pressure of the water. In such an arrangement the connection between the two opposite walls may be made through the floor or at points above the floor; being a tension connection, it should be of metal which may be well protected from the water or from the atmosphere by embedding it in a concrete floor.

Other features of the invention are referred to in detail hereinafter.

The accompanying drawings illustrate the application of the invention to a particular case.

Figure 1 is a plan or map showing the arrangement of the power house and adjacent water courses, including the power canal; Fig. 2 is a plan on a larger scale showing the power house and forebay; Fig. 3 is a transverse vertical section on the line 3—3 of Fig. 2 and of Fig. 4; Fig. 4 is a horizontal section on the line 4—4 of Fig. 3; Figs. 5 and 6 are enlarged views of the left hand portion of Figs. 3 and 4 respectively; Figs. 7 and 8 are similar views of the right hand portions of Figs. 3 and 4; the former being taken on the line 7—7 of Fig. 8, and the latter on the line 8—8 of Fig. 7; Figs. 9 and 10 are respectively a vertical transverse section and a plan partly in horizontal section showing an arrangement of ties above the floor of the forebay and designed for a forebay of varying widths. Figs. 11 and 12 are sectional views similar to Fig. 5 showing the wall opposite the power house of steel.

Referring now to the embodiment of the invention illustrated, and especially to Fig. 1, the river passes from a higher level at A over a fall or rapids B to a lower level C. From the upper level of this river water is drawn through a power canal D into a power house E, where after passing through the turbines or other water wheels, it is discharged into the lower level of the river C. The power house extends for a substantial distance along the shore, and in order that the water from the power canal shall be conveyed freely to all the points at which it enters the power house, a forebay F is provided at the back of the power house and into which the power canal D debouches either at an intermediate point as shown in the figure, or at one end of the bay.

The water from the forebay enters the several penstocks G (Fig. 3) and passes through the turbines H into the tail races J, from which it runs to the lower level of the river. The water in the forebay may be assumed to stand at substantially the level K, and exerts a lateral pressure tending to push the power house into the river, and measured by the head of water between the levels K and C, (disregarding back pressures of the water at C upon the portion of the power house which is below the bottom of the forebay, and which back pressure is more or less neutralized by earth and water pressures exerted upon the power house by the material immediately beneath the bottom of the forebay).

Ordinarily the sides of the forebay are merely paved with riprap or the like sufficiently to prevent erosion, and the bottom of the forebay is supported on piles or in any other suitable way and is designed to avoid erosion, and usually to resist the vertical pressure of the water. We propose however to provide a wall L or equivalent structure at the opposite side of the forebay from the power house E, and adapted not only to

resist erosion but to withstand the lateral pressure coming upon it by reason of the outward pressure of water in the forebay, and we tie this wall to the power house so that the two opposite pressures shall be exerted upon a practically unitary structure, and shall counterbalance each other either perfectly or to a sufficient extent to reduce to a comparatively small amount the tendency of the power house to shift laterally. With such an arrangement the foundations of the power house may be designed merely for supporting the vertical strains due to the weight supplied, and may be of the driven pile type shown or of any other suitable type. In connection with the use of the wall L as a lateral support for the power house, it is important that the outer face of the wall be relieved as far as possible of pressure, preferably by sloping the earth back therefrom as shown at M, and by providing a drainage channel N built of concrete, stonework, or any other suitable material, from which water may be carried off by underground drains, or by way of the ends of the power house as indicated in Fig. 2.

The connection between the power house and the supporting wall L may be made in any one or more of a number of ways. For example the floor O may be used for this purpose, where the wall L and the power house are sufficiently stiff to resist moments tending to overturn their upper portions. In the construction shown in Figs. 3 to 8 inclusive, the specific means for tying the wall and power house together is a steel connection, or a combination of steel with the concrete of the floor in which it is embedded for a great portion of its length. The floor O of the forebay is of concrete arranged at a level below that of the main floor P of the power house, and is supported upon piles Q the heads of which are embedded in the concrete. Slightly above the heads of the piles run steel rods or wires or the like constituting the metallic tension connection. At one side these rods extend clear to the outer edge of the floor, the tensile strain thereon being preferably transmitted upward through the wall by means of similar rods. At the other side these floor-embedded rods are connected to the power house.

A proper arrangement for a distribution of the strains and for convenience in making connections, is shown on a comparatively large scale in Figs. 5 to 8. The main tension rods R in the floor extend from front to back of the forebay at suitably close intervals, having regard to the thorough distribution of the strains and the avoiding of too close an arrangement which might form horizontal cleavage planes in the floor. These main tension rods are connected by crossing tie-rods S which serve to equalize the strains upon the several main rods R, and which may be tied thereto laterally by wires or other means at their crossing points, or merely by their common engagement in the concrete. These two systems of rods may serve the purpose of reinforcing the floor against the vertical strains at points between the heads of the piles. At approximately the line where the floor O joins the wall L, the rods R terminate, being connected however to extension rods T extending in the same direction to the outer edge of the wall, and preferably anchored by having bent outer ends U near the outer edge of the structure. Crossing the extension rods T in a direction inclined to the horizontal, is a series of rods V which follows approximately the curved inner face of the wall L and extends nearly up to the top of the wall, and which serves to form a tension connection between the wall and the floor or the tension rods T. The rods V may carry a series of anchors or other devices projecting laterally therefrom, such as the looped wires or rods W designed to resist internal shearing stresses within the wall.

The arranging of the tie rods in the concrete has the great advantage of protecting the rods against corrosion, and also of keeping the forebay and other water passages clear, an especially important matter in countries where ice forms. It is desirable to preserve the same advantages in the portions of the tie which are connected directly to the house. For this purpose the connection is preferably made by means of bars X extending along the side faces of the walls Y between the adjacent tail races J, and attached to anchor plates Z upon the faces of the walls Y, or embedded in such walls at some point inside of the exposed face. The use of tie bars X arranged in the situation shown, is particularly convenient for the supporting of power houses already built and in position. It is a comparatively easy matter to apply the anchor plate Z and to run the tie bars X along the exposed faces of the walls or partitions Y, afterwards embedding them in concrete or not as desired.

In the plane of section shown in Fig. 8, the rear wall *a* of the tail race joins directly the floor O of the forebay to which the various tension members previously described run, this floor, however, being broken away to show the arrangement of the tension members more clearly. The strain is carried from the members X by a distributing connection to the main tension rods R of the floor. For example these several rods may be fastened to a plate *b* running along parallel with the wall of the power house, and provided with a longitudinal stiffening angle *c* at the center.

The rods X at opposite sides of each partition Y engage a pin *d* carrying diverging straps *e* riveted by means of suitable angle irons to the plate *b*. This provides a very simple connection of the requisite great strength. For taking up any slack in the tie between the house and the opposite wall and putting the tie under tension before embedding it in the concrete, a number of turn-buckles *f* may be provided for the various tension rods R of the floor. Expansion joints to make up for the temperature changes, may be introduced wherever necessary.

The above system for a canal entering the forebay at a central point as in Fig. 2, provides a lateral support for the power house throughout its length, with the exception of a space immediately opposite the mouth of the canal where there is no lateral back pressure tied to the power house. While there may be such a back pressure farther up the power canal (and is so in fact in the map shown in Fig. 1), it cannot be utilized by tying it to the power house. The unsupported distance for large plants will be comparatively slight, and may be reduced to a minimum by a proper width or direction of the canal. And the portion not thus directly supported, say the portion *g* (Fig. 2), is connected indirectly to the adjacent portions of the supporting wall, as shown by the cross rods S which will have the effect of distributing the weakness.

Furthermore it is to be observed that the floor or bottom O of the forebay is widest just at this point, and is tied throughout to the power house, and therefore by its weight and lateral resistance, will give a very substantial degree of lateral support to the power house, and this lateral support will be by far the greatest at the point where the direct lateral support from the wall L is missing.

In place of the particular tension connection described, we may substitute other constructions better adapted for particular conditions. For example as shown in Figs. 9 and 10, we may use at the short end of the forebay tension connections which are designated as a whole by the letter *j* extending directly from the house to the opposite wall, either within the concrete floor or at a suitable point above; and where the forebay widens we may, while maintaining the floor connections, use oblique ties *k* transmitting the strain to the top of the wall (or conversely to an upper point of the house); and as the forebay continues to widen we may have the ties *j* supported at intermediate points either by columns *l* or by diagonal stays *m* running toward a higher point of the house. Any or all of these principles may be applied to the tying of the opposite walls of the forebay together, or any other suitable principle.

Instead of using a continuous plate *b* for distributing the strains from the rods X to the rods R, various other arrangements may be used, such for example as separate plates extending each the width of one tail race and connected at its ends to the rods X at opposite sides of the same tail race so as to act as a simple beam in which the strains can be easily computed.

The various parts of the structure are not necessarily of the materials shown. For example the wall opposite the power house may be conveniently constructed of other materials than concrete. Figs. 11 and 12 show examples in which steel is used for this purpose.

Referring to Fig. 11, the wall L′ consists of a steel plate inclined outward and supported at intervals by beams *n*, which in turn are supported by struts *o*, *o′*, *o²* connected at their lower ends to a series of rods *p*, the inner ends of which are connected in turn to the beams *n*, the whole being connected to the tension rods R in the floor O. Or as in Fig. 12 a vertical wall L² may be formed of steel plates backed by vertical beams *n′*, the lower ends of which are connected to the rods R in the floor O; the upper ends being connected to tie rods *j* such as are shown in Figs. 9 and 10. Therefore though we have described with great particularity of detail certain specific embodiments of the invention, yet it is not to be understood therefrom that the invention is restricted to the particular embodiments disclosed. Various modifications thereof in detail, and in the arrangement and combination of the parts, may be made by those skilled in the art, without departure from the invention.

What we claim is:—

1. The combination with a power house sustaining a horizontal pressure of water in one direction, of a wall sustaining a horizontal water pressure in the opposite direction and tied to said power house.

2. A power house sustaining a lateral pressure, in combination with a tension member transmitting to said building a hydraulic pressure in the opposite direction.

3. Means for supporting a power house having a head of water bearing horizontally against it, comprising a wall sustaining an opposing pressure and tied to said power house.

4. A bay having a power house on one side and a wall at the other side tied to the power house.

5. The combination with a power house subjected to lateral pressure of water in a forebay alongside of it, of a wall at the opposite side of the forebay and subjected to the pressure of the water in the opposite direction, and a tension connection between said power house and said wall and extending through the floor of the forebay.

6. The combination with a power house subjected to lateral pressure of water in a forebay alongside of it, of a wall at the opposite side of the forebay and subjected to the pressure of the water in the opposite direction, a strain-distributing member connected to the power house, and a series of tension members connecting said strain-distributing member to said wall.

7. The combination with a power house subjected to lateral pressure of water in a forebay alongside of it, of a wall at the opposite side of the forebay and subjected to the pressure of the water in the opposite direction, and a tension connection between said power house and said wall and extending through the floor of the forebay, and a series of substantially or approximately vertical rods embedded in said wall and transmitting the strains thereon to the floor.

8. The combination with a power house sustaining a horizontal pressure of water in one direction, of a wall sustaining a horizontal pressure in the opposite direction and tied to said power house, the wall being substantially free from pressure upon the side opposite the water.

9. The combination with a power house sustaining a horizontal pressure of water in one direction, of a wall sustaining a horizontal pressure in the opposite direction and tied to said power house, and means for draining the water from the outer face of the wall.

In witness whereof, we have hereunto signed our names in the presence of two subscribing witnesses.

DANIEL E. MORAN.
JOHN W. DOTY.

Witnesses:
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AUSTIN FINEGAN.