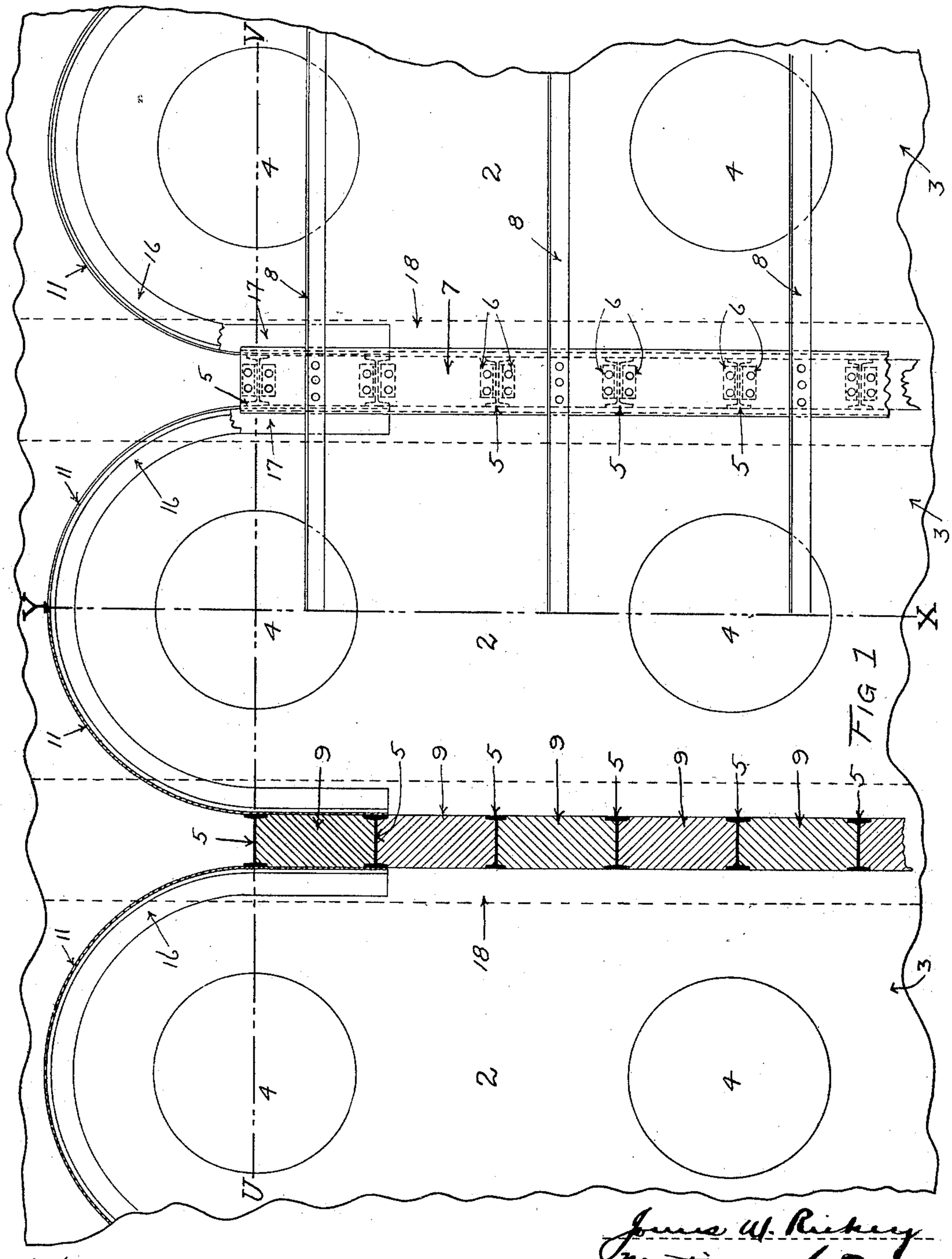
No. 703,216. Patented June 24, 1902.

J. W. RICKEY & M. G. BARNES.

WATER WHEEL PENSTOCK CONSTRUCTION.

(Application filed Mar. 10, 1902.)

(No Model.) 3 Sheets—Sheet 1.



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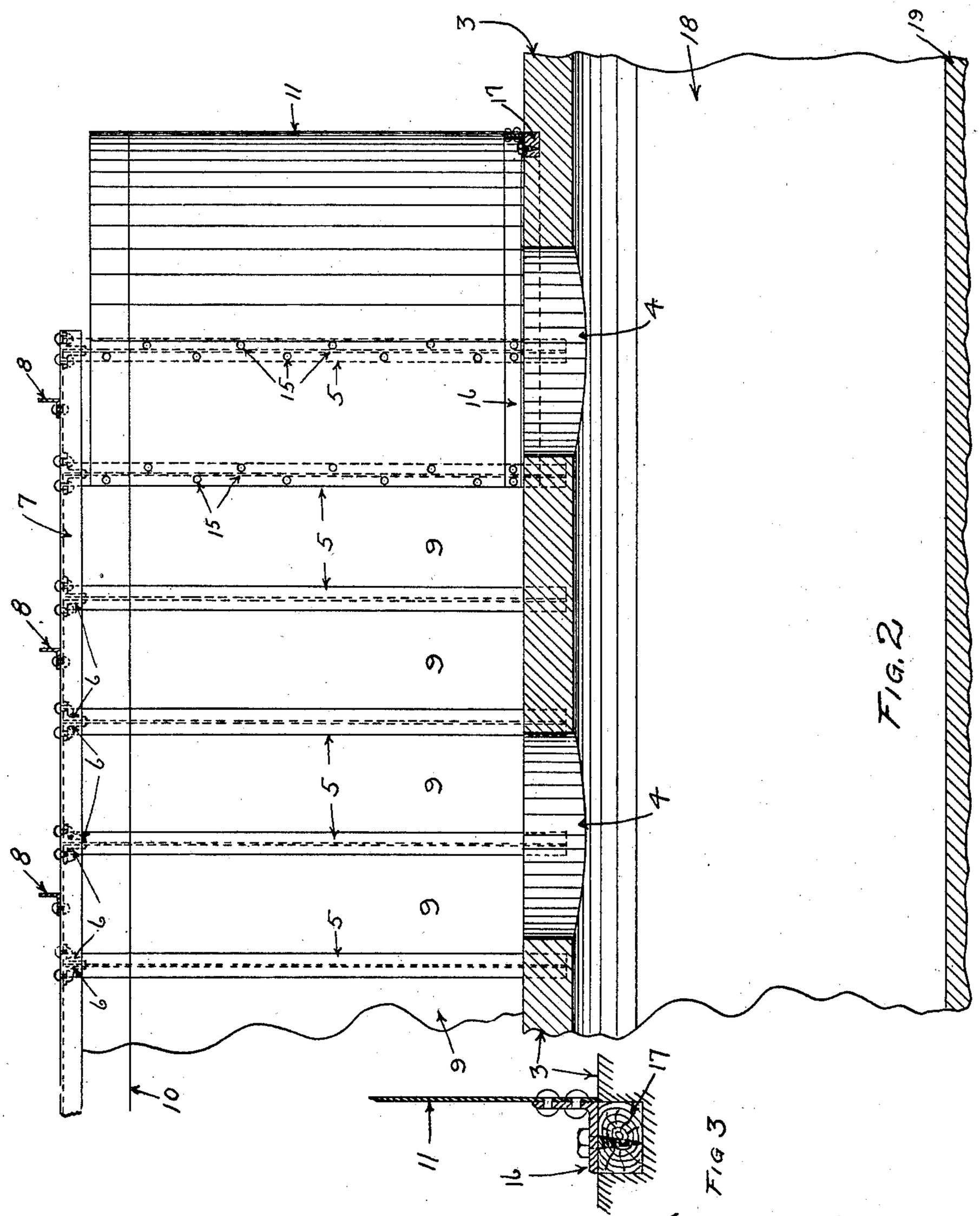

FIG. 2

FIG 3

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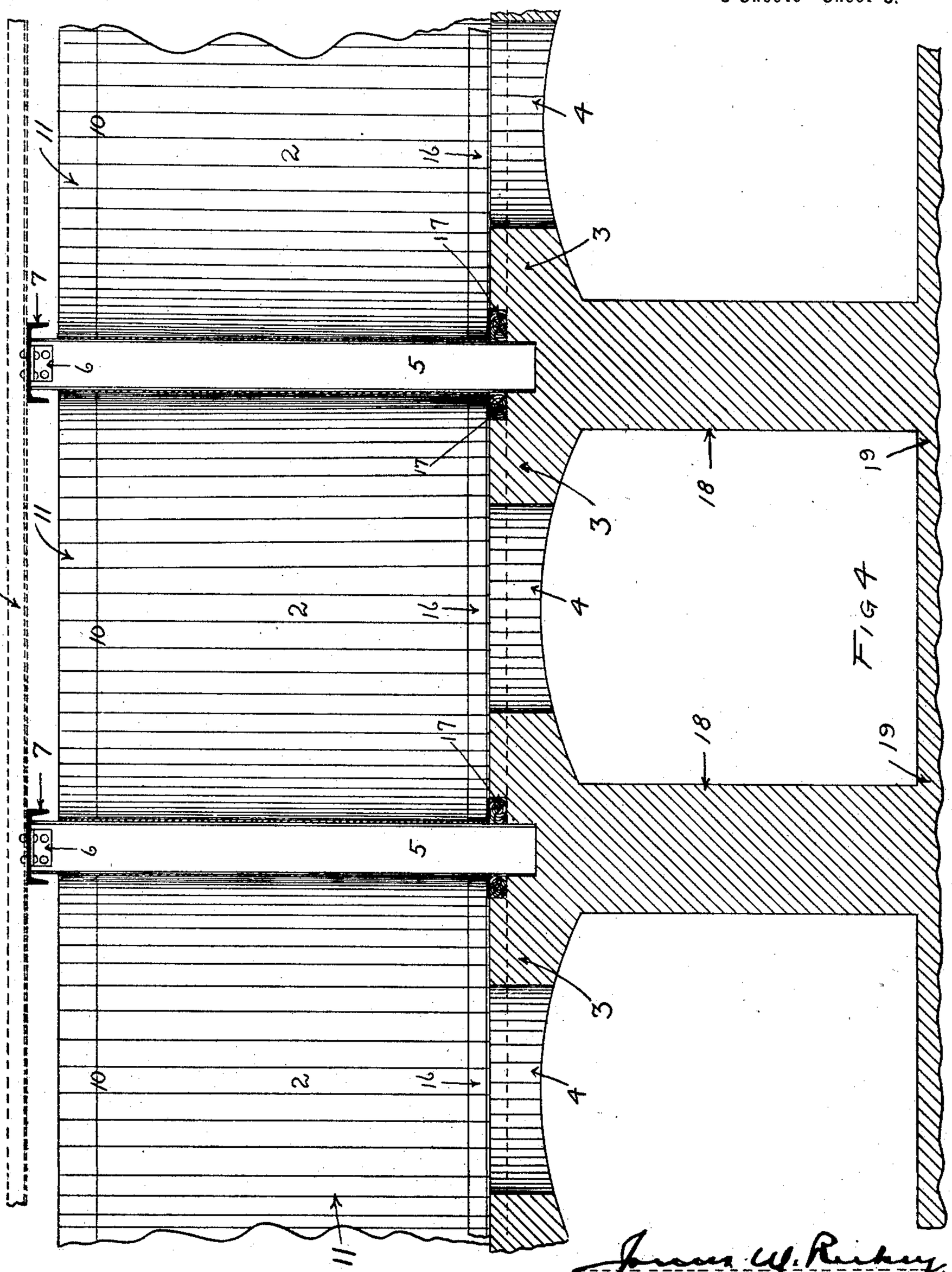

FIG 4

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UNITED STATES PATENT OFFICE.

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WATER-WHEEL-PENSTOCK CONSTRUCTION.

SPECIFICATION forming part of Letters Patent No. 703,216, dated June 24, 1902.

Application filed March 10, 1902. Serial No. 97,481. (No model.)

To all whom it may concern:

Be it known that we, JAMES W. RICKEY, of Minneapolis, Hennepin county, Minnesota, and MORTIMER G. BARNES, of Sterling, Whiteside county, Illinois, have invented certain new and useful Improvements in Water-Wheel-Penstock Constructions, of which the following is a specification.

Our invention relates to improvements in the construction of water-wheel penstocks arranged in series of two or more, and particularly to that class generally known as "open penstocks" or "open wheel-chambers," either expression signifying penstocks wherein the water is not under pressure, the surface of the quiet water therein being on a level with the surface of the water in the mill-pond, head-race, or forebay with which the penstocks are directly connected.

The invention also relates more particularly to penstocks of masonry construction, either stone or concrete, or both.

In constructing a series of open masonry penstocks it has been necessary heretofore to build massive and expensive bulkheads at the closed ends of the penstocks to resist the pressure of water against them, and correspondingly heavy partition-walls between two or more adjoining penstocks to withstand the hydrostatic pressure of the water in a full penstock when an adjoining one was empty, said bulkheads and walls, when made sufficiently thick and heavy to provide properly for these pressures, occupying a considerable portion of the total superficial area covered by a hydraulic-power house. In penstocks of such construction it has been found impossible to compute with any degree of accuracy the way in which the stresses in the partition-walls and bulkheads arising from the hydrostatic pressure of the water in the penstocks will act, and hence it is customary in constructing such bulkheads and walls to provide for an excess of strength, though the cost of construction and the area occupied are thereby increased.

The object, therefore, of our invention is to economize in area covered by reducing the thickness of the partition-walls and bulkheads to a minimum, to effect a large saving in cost of construction, and provide a structure capable of resisting any stress to which it may be subjected, and one in which the stresses and the way in which they will act can be readily computed, and consequently only the actual computed stresses need be provided for in the construction. These two features—namely, the reduction of the gross superficial area occupied by a power-house of a given capacity and the accurate determination of the stresses and their lines of action—constitute a valuable improvement in penstock construction, as both tend to materially lessen the cost of a hydraulic-power development.

The invention consists generally in providing open water-wheel penstocks with partition-walls composed of metallic framework or beams and a concrete or stone arch-filling.

Further, the invention consists in providing comparatively thin semicylindrical metallic bulkheads tangent to and anchored to the partition-walls.

Further, the invention consists in connecting and tying together the tops of the opposite partition-walls to prevent them from being forced outward by the pressure of the water in one penstock when one or both of the adjoining ones are empty.

Further, the invention consists in improved means for anchoring the lower ends of the bulkheads to the floor of the penstock to prevent the water from leaking out between the floor and the bulkheads.

Further the invention consists in various constructions and combinations, all as hereinafter described, and particularly pointed out in the claims.

In the accompanying drawings, forming part of this specification, Figure 1 is a plan view, partially in horizontal section, of a series of three open adjoining water-wheel penstocks. Fig. 2 is a section on the line $x\ y$ of Fig. 1. Fig. 3 is a detail showing the manner of securing or anchoring the lower edges of the bulkheads to the penstock-floor. Fig. 4 is a section on the line $u\ v$ of Fig. 1.

In the drawings, 2 represents a series of

open penstocks, (three in number,) and 3 a floor common to all of them and which we prefer to designate as the "penstock-floor," though it is sometimes referred to as the "wheel-pit arch." For clearness of illustration we have omitted the water-wheels and their shafts or fixtures from the drawings.

4 represents the draft-tube openings through which the water, having passed through the water-wheels, is discharged into the wheel-pit. We have shown two draft-tube openings in each penstock; but any desired number of them may be provided.

5 represents beams, (here shown as I-beams,) which compose the vertical members of the framework forming part of the penstock partition-walls. The lower ends of these beams 5 are firmly embedded and fixed in the masonry of the penstock-floor, while the tops are secured by means of brackets 6 or other suitable connections to the caps 7. (Herein shown as channel-beams.) These caps may be flat or any other suitable shape and are connected by tie rods or bars 8, which preferably extend continuously over all the penstock partition-walls and are secured to said caps at the points of intersection therewith. The function of the cap 7 is to transfer the hydrostatic load which comes on the beams 5 to the tie-rods 8. In each partition-wall the spaces between the beams 5 are filled with concrete 9 from the penstock-floor up to any desired height above the high-water line 10, which represents the surface of the water in the penstocks. The filling 9 may be in the form of flat arches or double-curved arches, or a combination of the two, or any other suitable shape of arch. It is evident that if the two outside penstocks are empty while the middle one is filled up to the high-water line the concrete filling between the beams 5 will act under the normal hydrostatic load as arches and will transfer this load to the beams 5, which in turn will carry part of it to their lower ends, where it is sustained by the penstock-floor, and the remainder of the load will be carried to the tops of the beams 5 and there be transferred by the brackets 6 to the caps 7, which in turn will transfer this part of the load to the tie-rods 8. The hydrostatic loads on each of the two walls of any penstock being equal and acting in opposite directions, the stresses in the tie-rods 8, due to the pressure of the water on the two opposite penstock-walls, must balance each other, and hence there will exist a condition of equilibrium under all conditions, whether both the adjoining penstocks are filled with water or one filled and the other empty.

Between the walls of each penstock is fitted a semicylindrical metallic bulkhead or shell 11, tangential to the flanges of the adjacent beams 5 and securely fastened thereto, preferably by rivets 15. We have shown the bulkhead fastened to the beams, but it may be secured to the concrete filling or to both the beams and the filling. At the bottom of the shell or bulkhead, secured to it by rivets or other suitable means, is an angle-iron or other suitable shaped part 16, having one flange secured to the bulkhead and the other fastened by screws or other suitable means to a curved wooden sill 17, that is embedded in the penstock-floor under the lower edge of the bulkhead. This angle-bar forms a water-tight cut-off and prevents any leakage of water from the penstock between the lower edges of the bulkhead and the floor. When the penstock is filled with water up to the water-line 10, the water presses normally against the semicylindrical bulkhead at all points, and it is evident that all stresses existing in the shell are those of tension only. Consequently if the shell where it is tangent to the penstock-walls at the flanges of the beams 5 be continued backward and secured to one or more flanges of the partition-wall beams the beams to which the shell is connected will take up the full thrust of the water against said shell. By securing the shell to the flanges of the two adjacent beams of the opposite walls or to additional beams, if desired, by rivets or other suitable means the beams and shell form, as it were, a box-girder, and the pressure of the water upon the shell, which tends to push it forward, is transferred by said girder and also by the framework and concrete filling in the penstock partition-walls to the penstock-floor, from whence it is carried into the pit-walls 18 and foundations 19 of the building. By this construction a thin metallic shell will with perfect safety and great economy fulfil the same functions and take the place of a cumbersome, thick, and expensive masonry bulkhead.

We are aware that circular tubes for water-wheel cases have been used heretofore, but only in connection with closed penstocks where the water in the wheel case or tube is under pressure. We make no claim to this application of the invention, but confine ourselves to open penstocks, as above described, and particularly in connection with concrete, stone, or masonry construction.

We claim as our invention—

1. A series of two or more open water-wheel penstocks having partition-walls between them, said walls being composed of upright beams having their lower ends anchored to the penstock-floor, a suitable filling material between the beams of each wall and tie rods or bars connecting the tops of said walls.

2. A series of two or more open water-wheel penstocks having partition-walls between them, said walls being composed of upright beams having their lower ends embedded or set into the penstock-floor, a suitable filling material between the beams of each wall, caps horizontally arranged upon the top of each wall and secured to the beams thereof, and tie rods or bars extending over said walls and connecting and tying the walls and the caps thereon together.

3. A series of two or more open water-wheel penstocks having partition-walls between them, said walls being composed of upright I-beams having their lower ends embedded or set into the penstock-floor, a concrete filling material between the beams of each wall and forming arches, channel-bars upon the top of each wall and secured to said I-beams, and angle tie bars or rods secured to said channel-bars and connecting and tying the tops of said walls together.

4. In a series of two or more adjoining water-wheel penstocks, the combination, of partition-walls separating the adjoining penstocks, with semicylindrical metallic bulkheads closing the ends of said penstocks, respectively, and tangential to and secured to said walls.

5. In a series of two or more adjoining water-wheel penstocks, the combination, of a series of partition-walls separating the adjoining penstocks, said walls being composed of upright beams having their lower ends embedded in the penstock-floor and a suitable filling material between them, with semicylindrical metallic bulkheads closing one end of said penstocks and secured to said partition-walls, and tie rods or bars connecting the tops of said beams and walls and tying them together.

6. In a series of two or more adjoining water-wheel penstocks, the combination, of a series of partitions separating the adjoining penstocks, with semicylindrical metallic bulkheads anchored at their ends to said walls and closing the open end of said penstocks, and means for forming a close water-tight joint between the lower edges of said bulkheads and the floor of said penstocks.

7. A series of open water-wheel penstocks, comprising a suitable floor provided with draft-tube openings, partition-walls between adjoining penstocks and consisting of metal beams having their lower ends anchored to said floor and a suitable filling material between said beams, means connecting or tying the tops of said walls together, semicylindrical metallic bulkheads anchored at their ends to said walls and tangential with respect thereto, beams embedded in said floor at the bottom of said bulkheads, and angle-bars secured to said embedded beams and to said bulkheads.

8. In a series of two or more open water-wheel penstocks, the combination, of a series of partitions separating the adjoining penstocks and composed of metallic frames embedded at their lower ends in the penstock-floor and having a suitable concrete filling, with semicylindrical bulkheads having their ends riveted to the frames of said partition-walls and tangential thereto, and tie rods or bars extending across said walls and secured to said frames and tying them and said walls together.

9. In an open water-wheel penstock, a semicylindrical metallic bulkhead closing one end of the penstock, and walls whereto said bulkhead is anchored.

10. In an open water-wheel penstock, walls composed of beams having their lower ends anchored to the penstock-floor, a suitable filling material between the beams of each wall, and means for tying the upper portions of said walls together.

In witness whereof we have hereunto set our hands, JAMES W. RICKEY at Minneapolis, on the 27th day of February, 1902, and MORTIMER G. BARNES at Sterling, Illinois, on the 1st day of March, 1902.

JAMES W. RICKEY.
MORTIMER G. BARNES.

Witnesses to signature of Rickey:
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M. C. NOONAN.

Witnesses to signature of Barnes:
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