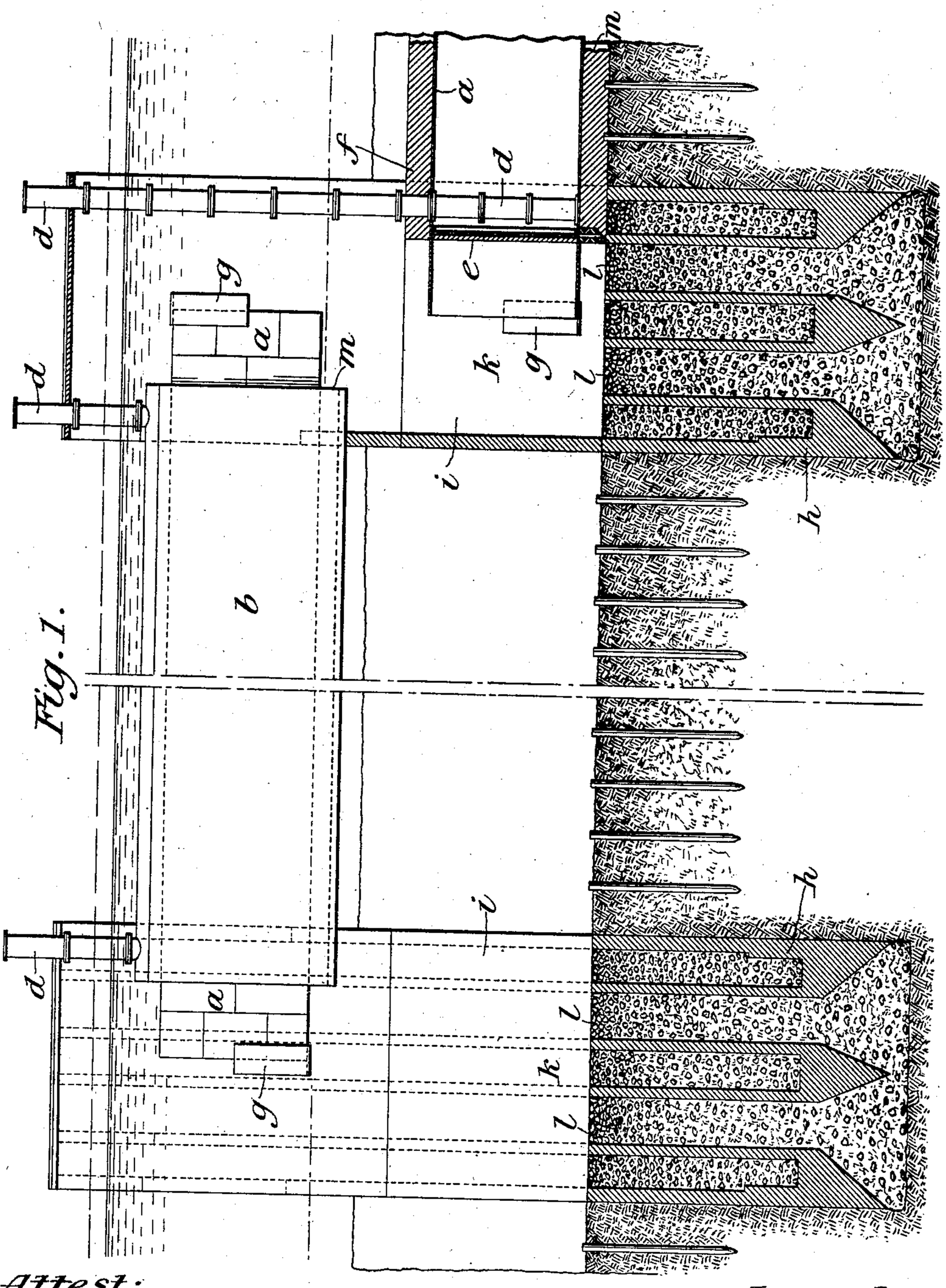
No. 708,249. Patented Sept. 2, 1902.

J. F. O'ROURKE.

SUBAQUEOUS TUNNEL CONSTRUCTION.

(Application filed Apr. 28, 1902.)

(No Model.) 3 Sheets—Sheet 1.



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(No Model.) 3 Sheets—Sheet 2.

Fig. 3.

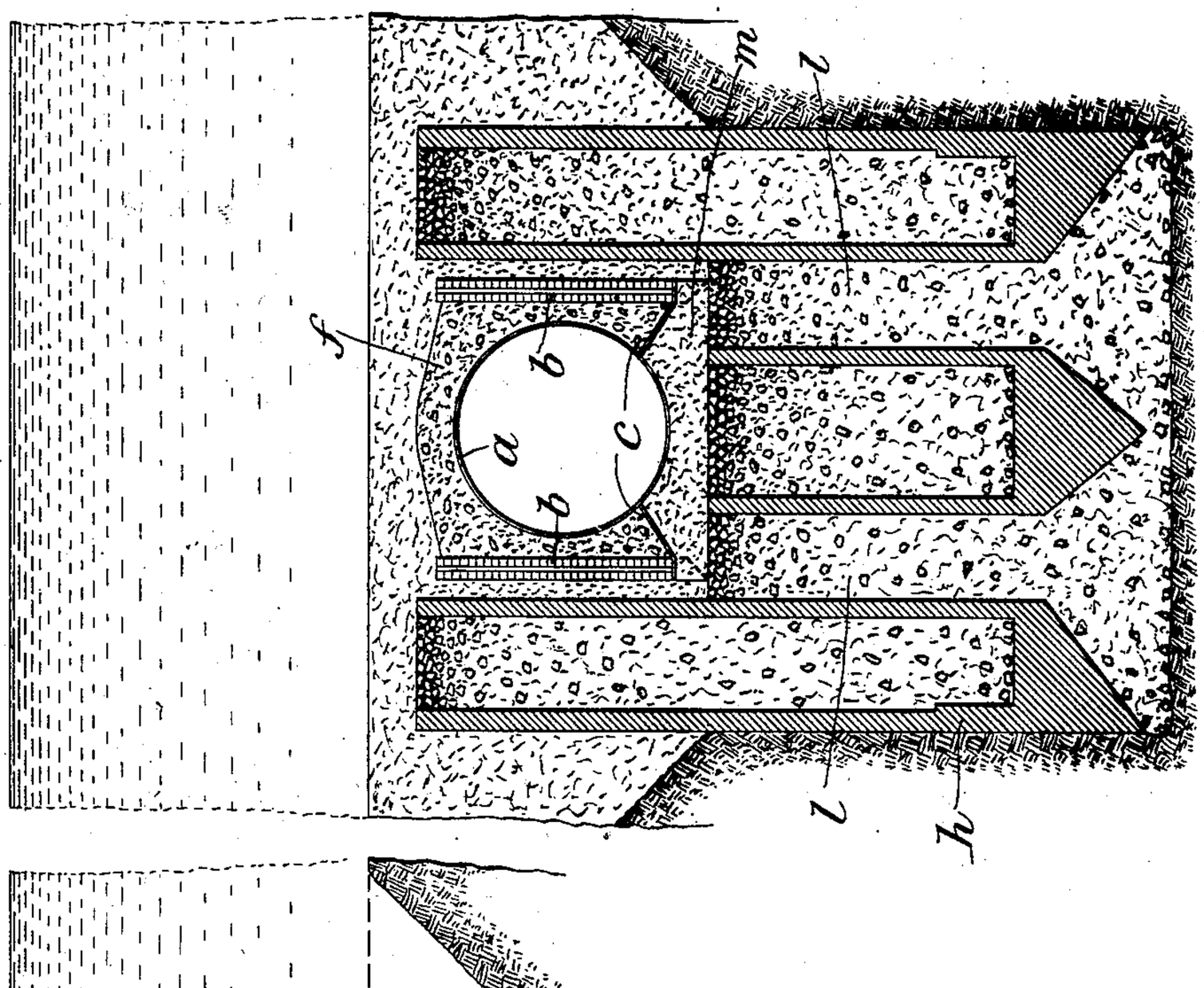
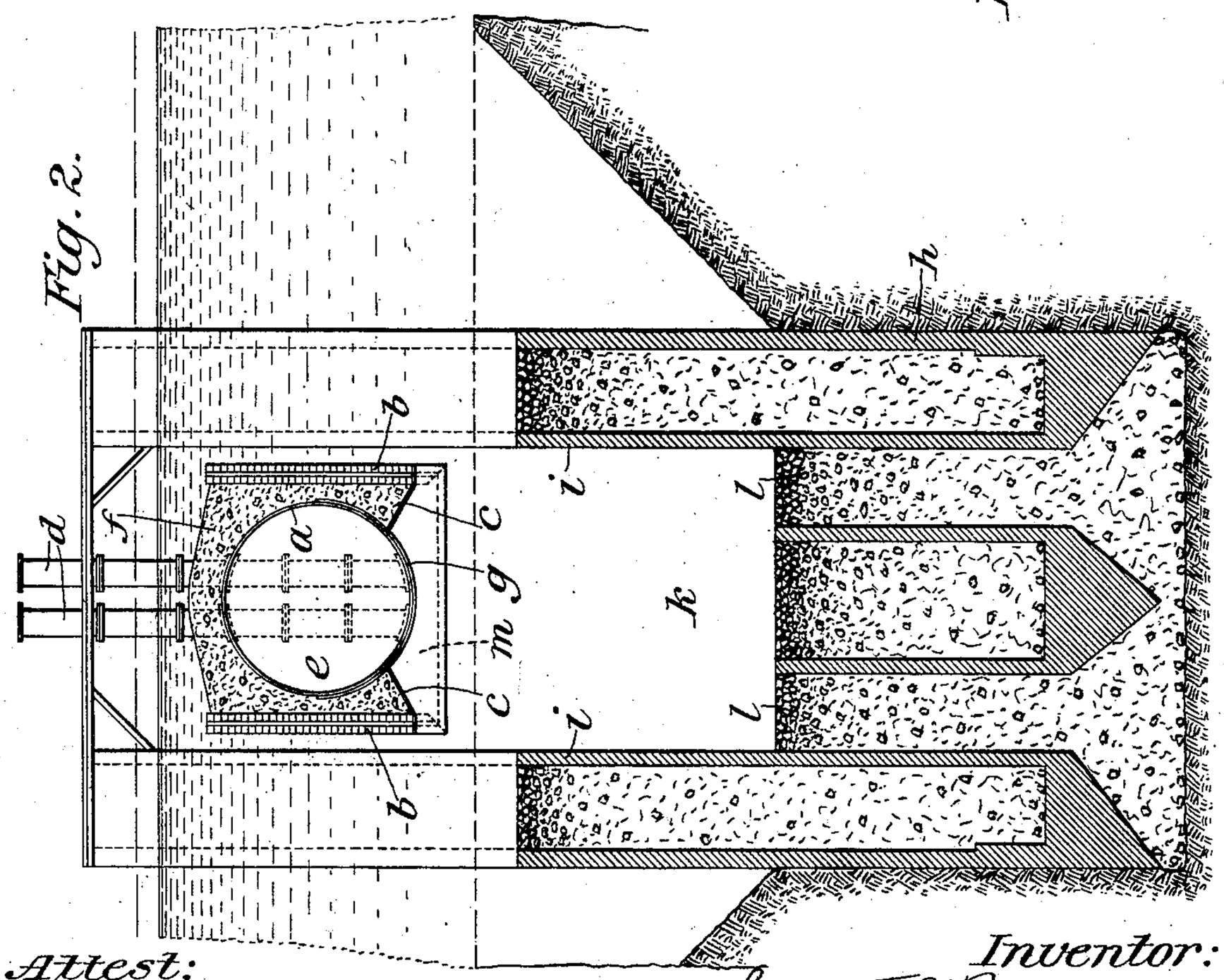


Fig. 2.



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No. 708,249. Patented Sept. 2, 1902.

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SUBAQUEOUS TUNNEL CONSTRUCTION.

(Application filed Apr. 23, 1902.)

(No Model.) 3 Sheets—Sheet 3.

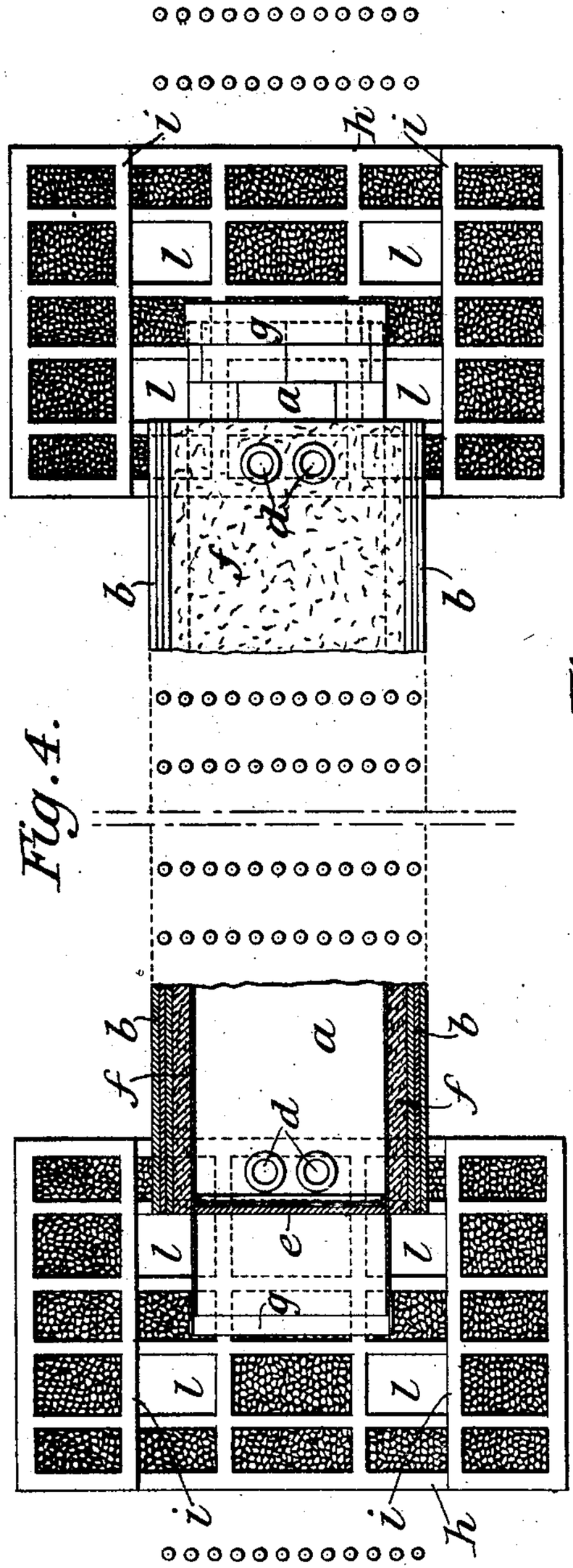

Fig. 4.

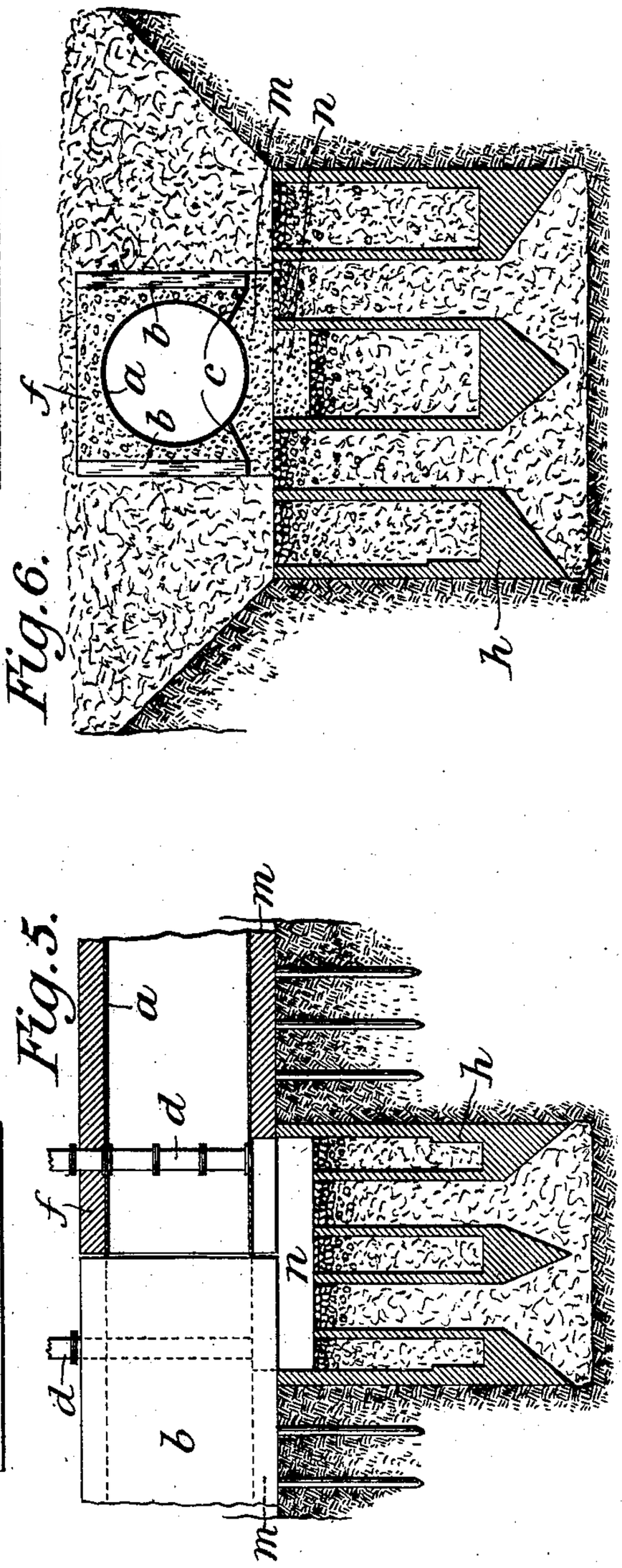

Fig. 6.

Fig. 3.

Fig. 5.

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UNITED STATES PATENT OFFICE.

JOHN F. O'ROURKE, OF NEW YORK, N. Y.

SUBAQUEOUS-TUNNEL CONSTRUCTION.

SPECIFICATION forming part of Letters Patent No. 708,249, dated September 2, 1902.

Application filed April 23, 1902. Serial No. 104,284. (No model.)

To all whom it may concern:

Be it known that I, JOHN F. O'ROURKE, a citizen of the United States, residing in borough of Manhattan, city of New York, State of New York, have invented certain new and useful Improvements in Subaqueous-Tunnel Constructions, of which the following is a specification, reference being had to the accompanying drawings, forming a part hereof.

This invention relates to the construction of tunnels under conditions—such as great depth of water, rapidity of current, thickness or instability of silt, or unsoundness of rock beneath the body of water—which forbid the adoption of the usual methods.

It has been proposed heretofore to construct a tubular steel tunnel and to place it in position in successive sections; but difficulties thus far unsolved have presented themselves in the supporting and in the uniting of the successive sections.

It is the object of this invention, primarily, to overcome these difficulties in a practical and satisfactory manner where either or both are met, although other features relating to the construction of the tunnel are involved therewith.

In accordance with the invention suitable cribs or caissons are constructed and are placed in position at distances apart corresponding to the lengths of the tunnel-sections, and the sections themselves are then placed in position, (with the ends supported on the cribs,) the connection of two adjoining sections being effected on or within the crib.

The invention will be more fully described hereinafter with reference to the accompanying drawings, in which for purposes of illustration and explanation it is represented as embodied in a practical structure, the details of which will be varied more or less according to the varying conditions under which the work is to be performed.

In the drawings, Figure 1 is a view, partly in longitudinal section and partly in elevation, illustrating the construction of a subaqueous tunnel in accordance with the invention. Fig. 2 is a transverse section through one of the cribs shown in Fig. 1, the tunnel-section being shown in end elevation above its position of rest. Fig. 3 is a similar view showing the tunnel-section in its position of rest and the crib removed above the tunnel-section. Fig. 4 is a view, partly in plan and partly in horizontal section, of the parts shown in Fig. 1. Fig. 5 is a view, partly in side elevation and partly in longitudinal section, illustrating the use of a crib without lateral guiding-walls. Fig. 6 is a transverse section of the parts shown in Fig. 5, the tunnel-section being shown in end elevation.

Each tunnel-section, which may be built ashore or afloat, as may be most convenient under the circumstances, comprises a steel tube *a* of suitable diameter and a sustaining vessel therefor, which may be constructed of any suitable material and in any suitable form. As represented in the drawings, the vertical walls *b* of the sustaining vessel may be made of timber, while the bottom of the vessel is formed in part by the tube *a* and in part by plates *c*, which are secured to the tube and to the vertical walls, the tube being preferably supported by the plates, with its lowest point somewhat above the lower edges of the vertical walls, a false bottom, as indicated by dotted lines, being provided, if deemed necessary. The vessel, with the tube therein, may be ballasted by placing concrete (which forms part of the permanent structure) between the tube and the vertical walls, and when it has been brought to the desired position is sunk by adding more concrete or ballast to the vessel. Whatever form of ballast may be employed for this purpose the entire space between the tube and the walls *b* is eventually filled with concrete to make a solid and enduring wall completely surrounding the tube. The ends of the tube are preferably extended somewhat beyond the ends of the vessel, as indicated in Figs. 1 to 4 of the drawings, and near each end one or more air or working shafts *d* are carried through the tube *a* to give access to the space beneath the tube, as hereinafter explained, such shafts being continued upward as the vessel and tube are sunk to place, so that their upper ends shall be always above the surface of the water. A bulkhead *e*, arranged to be subsequently removed, is provided within the tube *a*, near the end and outside of the shafts *d*, and at the ends of the sustaining vessel the filling *f* is carried upward to the top of the vessel to exclude the water during the

placing of the vessel in position. This masonry or concrete filling is carried substantially to the ends of the vessel and is preferably finished exteriorly in such a manner as to facilitate the making of a close union therewith by the concrete, which is subsequently placed around the joint between two adjoining sections when the invention is carried out as illustrated in Figs. 1 to 4. The ends of the tubes to be united may also be provided with suitable means to facilitate the making of a temporary joint when two tubes have been sunk to position and pending the filling in of the space about the two projecting ends of adjoining tube-sections, such means being indicated by the half-flanges *g*.

For the purpose of supporting and joining the ends of the tunnel-sections, which in effect become spans, a crib or caisson *h* is placed at the proper point and is sunk to a depth sufficient to secure stable foundation. This crib may likewise be constructed in any suitable manner and is preferably of cellular construction, as represented in the drawings, being divided by interior vertical walls *i* to form chambers or pockets *k* for the reception of the ballast necessary to sink the crib and a dredging-chamber *l*, through which the material excavated beneath the crib may be removed as the crib is sunk to position, although a pneumatic caisson may be employed when the conditions are such as to render its use desirable. The cribs or caissons having been constructed and the tunnel-sections having been prepared in their sustaining vessels, the cribs or caissons are placed and sunk to the required depth. If necessary, the river-bottom is excavated to the required depth, and piles are driven when necessary to support the tunnel-sections between the cribs. One of the prepared tunnel-sections is then floated into position, the end and interior walls of the two adjacent cribs (if they are carried high enough to make it necessary) being cut out to receive with a close fit the ends of the sustaining vessel. More ballast is then added to the sustaining vessel to sink it, together with the steel tube, the end walls of the two cribs being removed as the tunnel-section sinks, so that such tunnel-section is always held in line and under perfect control, anchors being made fast to the sides of the tunnel-section and if necessary to the cribs to resist lateral pressure. As the tunnel-section sinks a bulkhead may be carried upward at the top of the tunnel-section between the walls of the crib to exclude water-currents from the interior of the crib, or, if conditions permit, such bulkhead may be placed after the tunnel-section has reached its position of rest, if it be deemed necessary, or the ends of the crib may be left open, the concrete filling around the ends of the projecting tubes, hereinafter referred to, being placed through the water. When two adjoining tunnel-sections have been placed as thus described with reference to the structure shown in Figs. 1 to 4, a temporary joint is made between the abutting ends of the steel tubes by the means previously provided, such as the half-flanges *g*, and the space around the abutting ends of the tubes and between the ends of the sustaining vessels is filled with concrete to make good the joint and make continuous the masonry surrounding the tube. Access is given to the air space or chamber *m* between the walls *b* of the sustaining vessel and beneath the tube through the air-shaft *d*, and such chamber is completely filled with concrete or other material after the foundation has been suitably prepared. Access to the interior of the tunnel-tube is also afforded through the air-shafts *d*. The bulkheads *e* within the tubes may be removed and the joint between the abutting ends of the tubes be completed on the inside in any desired manner, it being practicable to make of this tube a second chamber when compressed air is required. When the tunnel-sections have been placed and united as described, the upper portions of the cribs or caissons may be removed to the level of the top of the tunnel-sections. It will be obvious that intermediate cribs or caissons may be placed to aid in holding or supporting the tunnel-sections where necessary.

As represented in Figs. 1 to 4, the side walls of the cribs or caissons are carried upward to guide the ends of the span or tunnel-sections as they are sunk and also to support a suitable platform for convenience in carrying on the operations incident to the uniting of adjoining tunnel-sections; but under some conditions it may be possible to dispense altogether with the walls of the crib or caisson above the level at which the bottom of the tunnel-sections are to rest, as illustrated in Figs. 5 and 6. In such case the crib *h* is sunk to the required depth, and the upper surface is suitably prepared to receive the ends of the tunnel-sections or spans, and the ends of the sustaining vessels of the tunnel-sections are carried out substantially flush with the ends of the steel tubes, so that when the two adjoining sections are brought to position the joint between the two may be calked by divers or otherwise made tight before the interior bulkheads are removed, and thereafter the joint between the ends of the steel tubes may be completed in any suitable manner. As indicated at *n* in Fig. 5, the interior of the crib may be cut out either before or after the tunnel-sections or spans are placed in position to give access from one tunnel-section to the other, the chamber thus formed being subsequently filled with concrete to make a bond between the two tunnel-sections in case such a bond is desirable.

It will be obvious that the details of construction of the tunnel-sections or spans and of the cribs or caissons may be varied to suit different conditions and that the details of

the manner in which the tunnel-sections are placed and united may vary otherwise, as circumstances and convenience may suggest.

I claim as my invention—

1. A subaqueous-tunnel section comprising a tube-section, bulkheads in the ends thereof, a sustaining vessel and filling between the walls of the sustaining vessel and the tube-section, substantially as described.

2. A subaqueous-tunnel section, comprising a tube-section, bulkheads in the ends thereof, a sustaining vessel comprising side walls and plates uniting the tube-section to said walls, and filling supported upon said plates between the tube-section and the side walls, substantially as described.

3. A subaqueous-tunnel section, comprising a tube-section, bulkheads in the ends thereof, a sustaining vessel for said tube-section, and a shaft extended through said tube-section to the bottom thereof, substantially as described.

4. A subaqueous-tunnel section, comprising a tube-section, bulkheads in the ends thereof, a sustaining vessel for said tube-section forming an air-chamber below the tube-section and a shaft extended through said tube-section to said air-chamber, substantially as described.

5. In subaqueous-tunnel construction, the combination of a crib or caisson sunk to the required depth and two tunnel-sections each comprising a tube-section and a sustaining vessel, said tunnel-sections having their ends brought together and supported upon the crib or caisson, and means to unite the ends of the tube-sections, substantially as described.

6. In subaqueous-tunnel construction, the combination of a crib or caisson sunk to the required depth, two tunnel-sections each comprising a tube-section and a sustaining vessel, the ends of the tunnel-sections being brought together within the crib, means to unite the tube-sections within the crib and concrete filling the space around the tube-sections within the crib or caisson, substantially as described.

This specification signed and witnessed this 16th day of April, A. D. 1902.

JOHN F. O'ROURKE.

In presence of—

W. B. GREELEY,

ROSWELL S. NICHOLS.