No. 745,457. PATENTED DEC. 1, 1903.

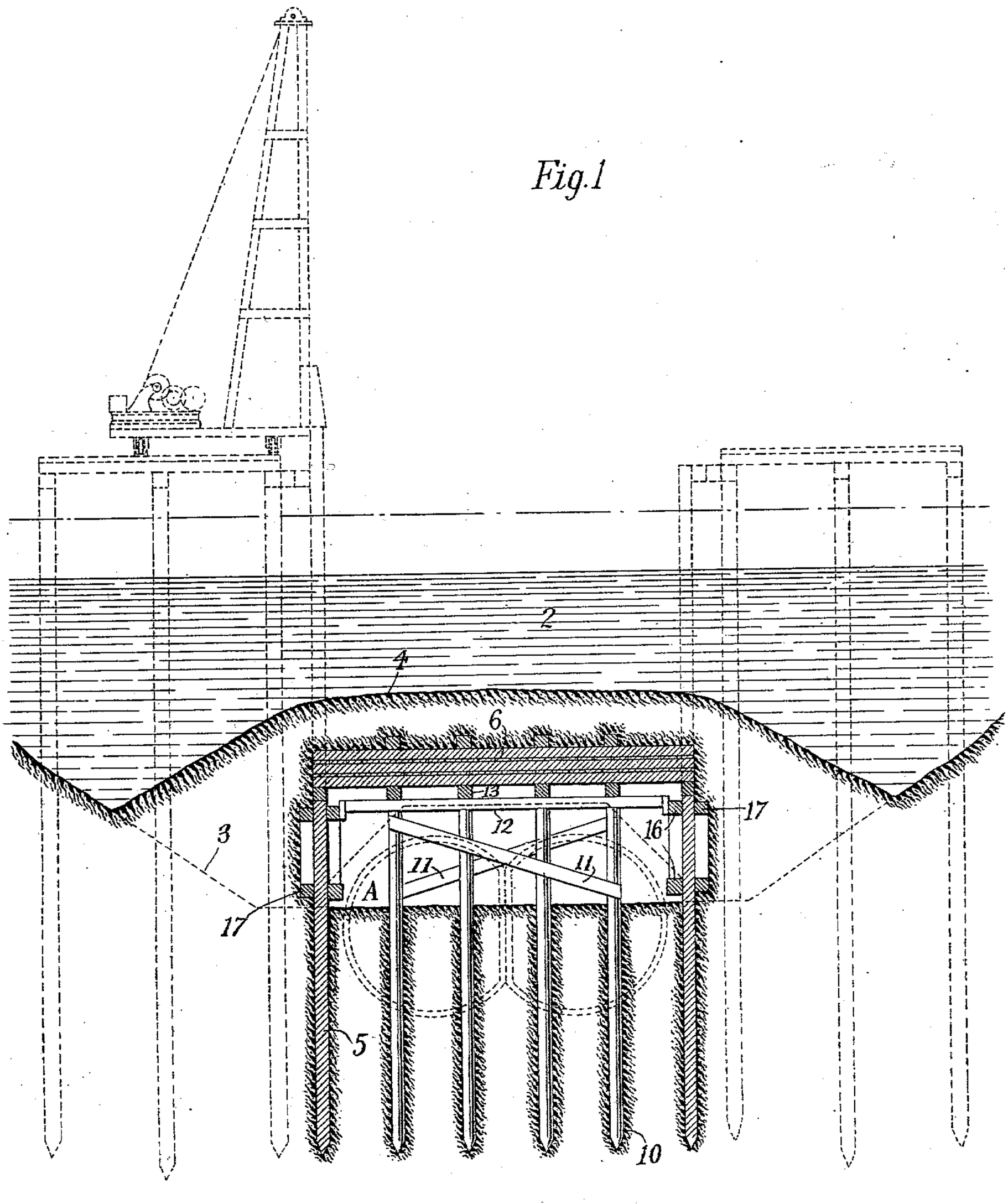
D. D. McBEAN.

SUBAQUEOUS TUNNEL.

APPLICATION FILED OCT. 28, 1903.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 1



Witnesses:
Raphael Netter
Pierce J. Powers.

Duncan D. McBean Inventor
by J. D. Marwin Atty

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NO MODEL. 3 SHEETS—SHEET 2.

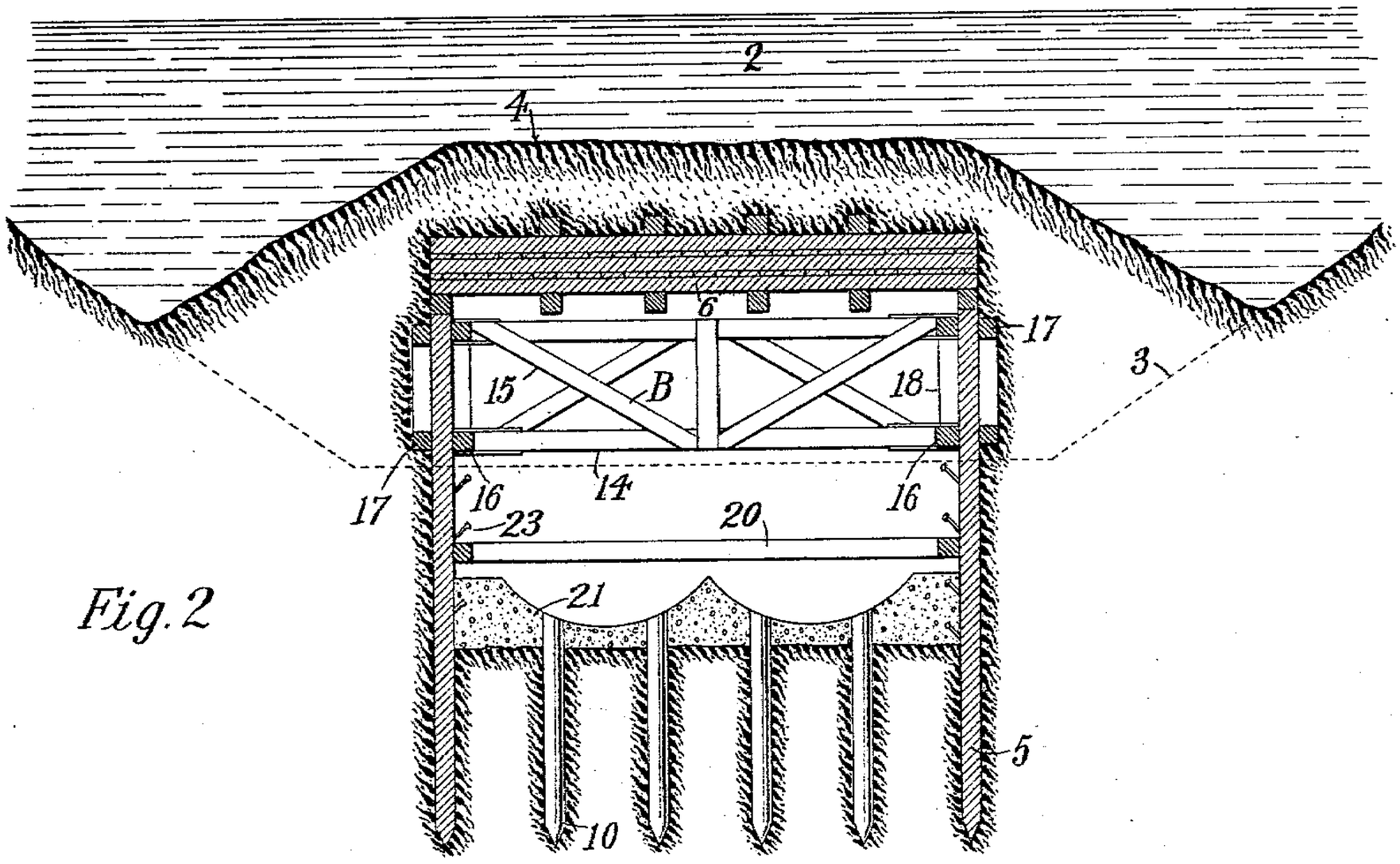

Fig. 2

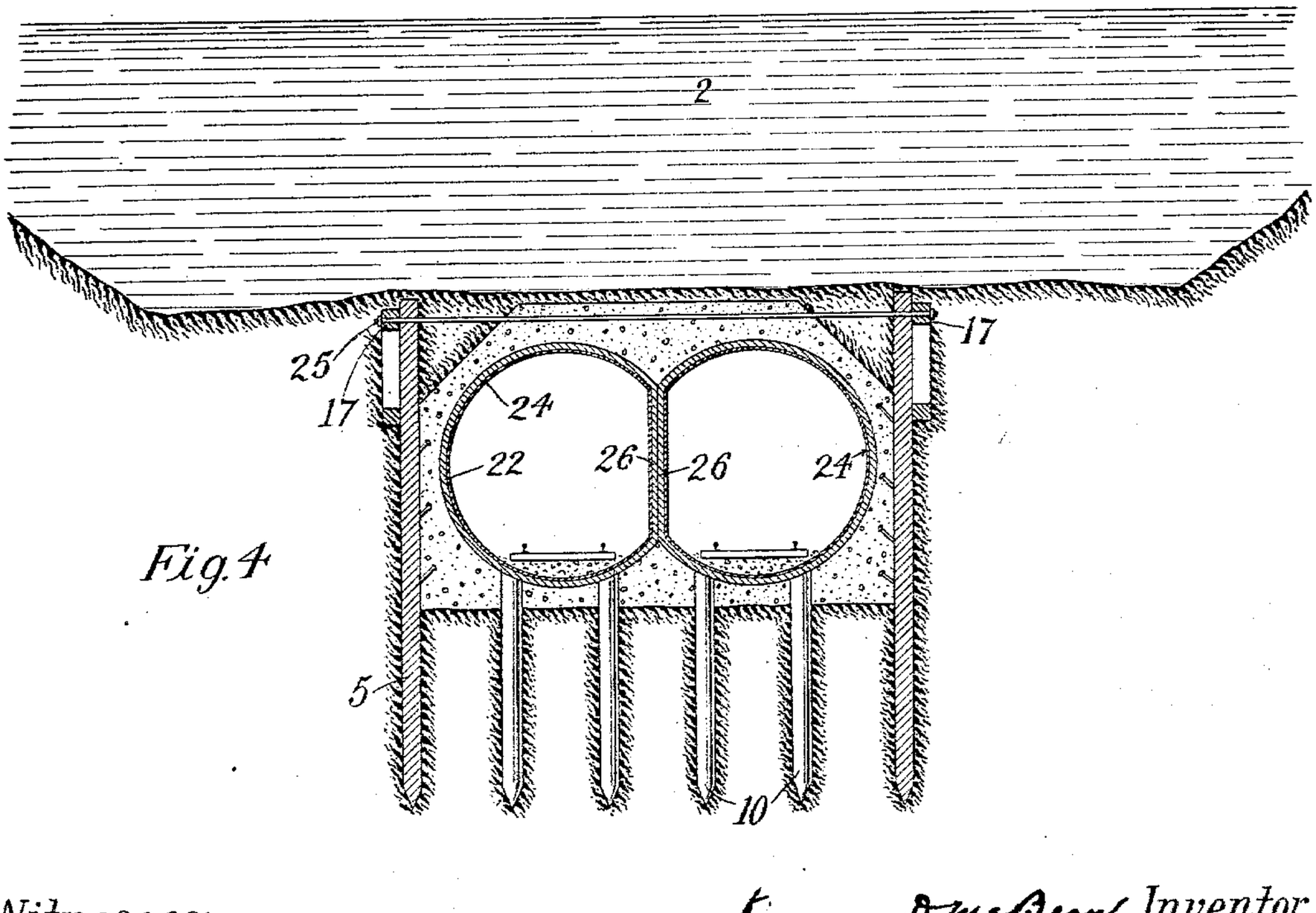

Fig. 4

Witnesses:
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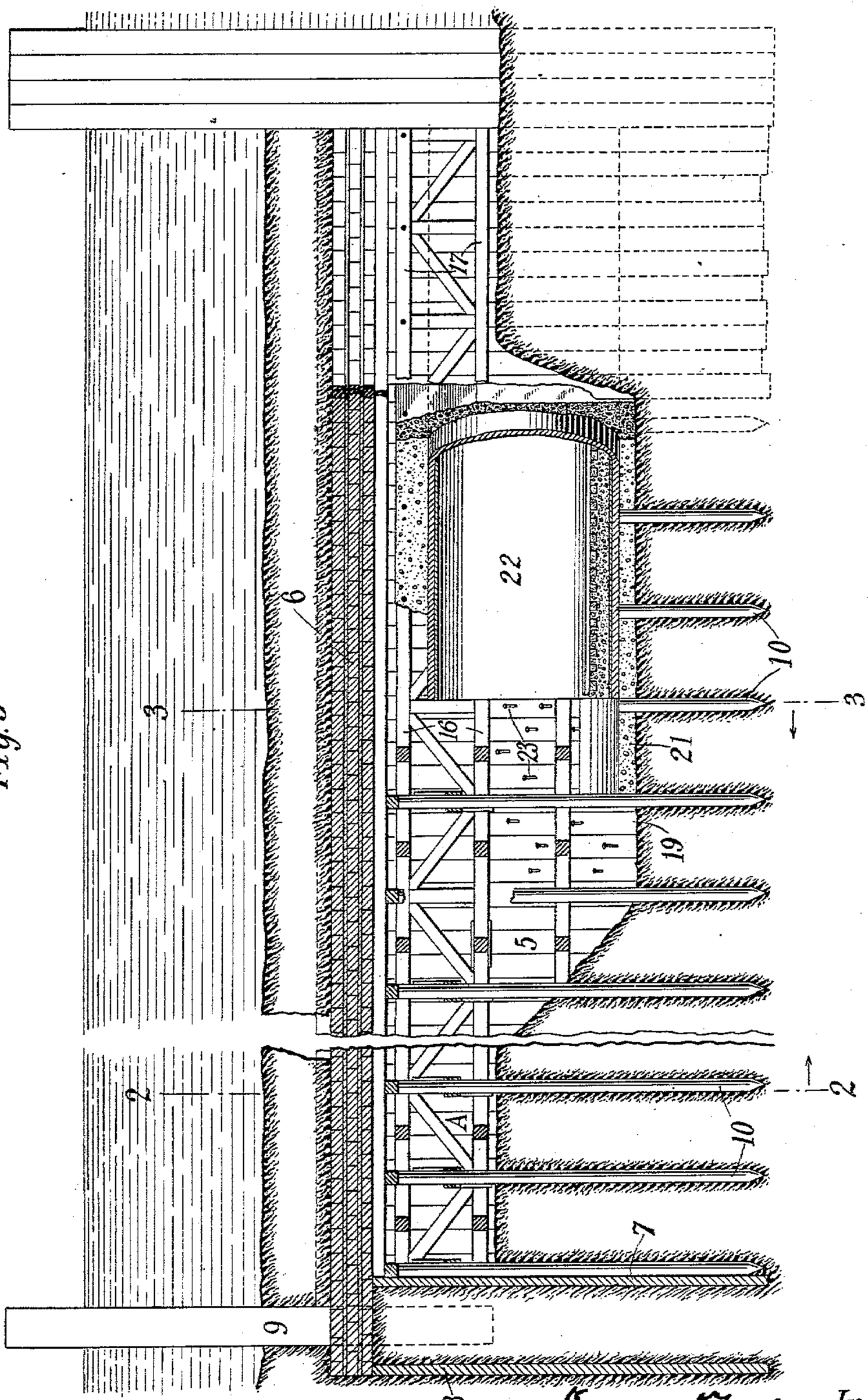
NO MODEL. 3 SHEETS—SHEET 3.

Fig. 3



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by T. D. Merwin Atty

No. 745,457. Patented December 1, 1903.

UNITED STATES PATENT OFFICE.

DUNCAN D. McBEAN, OF NEW YORK, N. Y.

SUBAQUEOUS TUNNEL.

SPECIFICATION forming part of Letters Patent No. 745,457, dated December 1, 1903.

Application filed October 28, 1903. Serial No. 178,950. (No model.)

To all whom it may concern:

Be it known that I, DUNCAN D. McBEAN, of the city, county, and State of New York, have invented a new and useful Improvement in Subaqueous Tunnels, of which the following is a specification.

My invention relates to improvements in subaqueous tunnels and other masonry structures, especially such as are constructed at great depths or under navigable waters; and it consists in the features of construction hereinafter set forth. Where work of this character has to be done in the bed of a navigable stream or other body of water, the great depth precludes the employment of the usual appliances and methods. It is also highly important in view not only of the original cost of construction, but more especially on account of future operating expenses, that such a tunnel be constructed with the least grade or depression possible which will avoid interference with navigation. This requirement oftentimes renders impracticable other and common types of structure because of the lack of adequate foundation-support. In my improved structure the desired results are attained at a minimum of cost and a maximum of strength and durability.

The building of my structure involves the use of a subaqueous working-chamber built in place over and around the tunnel-site, which working-chamber and the appliances and methods employed in connection therewith are covered by pending patent applications. By employing these improved means and methods I am able to construct a tunnel supported throughout its entire width upon piles penetrating to bed-rock or to any desired depth in other material. It is also supported by walls of piles, either round or rectangular sawed timbers called "sheeting," driven to like depth on each side of the structure and anchored thereto. With such support it is unnecessary to carry the tunnel to a greater depth than is requisite to avoid interference with navigation so long as adequate anchorage for the piles is secured in the bed of the body of water.

In the accompanying drawings, forming part of this specification, which illustrate my improved tunnel structure and the manner in which it is constructed, Figure 1 is a cross-sectional elevation of the working-chamber before the work of excavation has been commenced. Fig. 2 is a similar view showing the condition after excavation and after the laying of the concrete tunnel-foundation. Fig. 3 is a longitudinal sectional elevation illustrating the appearance and conditions shown in Figs. 1 and 2 and also a portion of the tunnel completed and ready for the removal of the roof of the chamber; and Fig. 4 is a view similar to those of Figs. 1 and 2, showing the finished tunnel with the roof of the working-chamber removed and the tunnel ready for occupancy and use.

In the drawings, 2 represents the body of water, 3 the line of preliminary excavation by dredging along the site of the proposed tunnel, and 4 the temporary bed of the stream formed by the covering of the working-chamber A. The dotted lines in this figure indicate the piles driven on each side of the preliminary excavation, the platforms supported thereon, the guides for directing the course of the sawed piles or sheeting when driven, and a driver located upon one of the platforms in the position in which it stands while driving the sheeting. These various features are shown, described, and claimed in my other pending applications and need no further illustration herein.

The chamber A is formed by the walls of sheeting 5 and the roof 6, seated thereon, both substantially impervious to water. In the construction of this chamber the several sheetings are driven down to bed-rock or to the lowest required depth and are then cut off in a plane beneath the surface of the water sufficiently above the top of the proposed tunnel structure to admit of convenient access and preliminary working in the chamber. After the roof has been seated in place in order to assist in the sealing of the structure against the admission of water I preferably cover the chamber with earth in the manner shown in Fig. 1. For the end walls or bulkheads of the chamber I prefer to employ a double bulkhead, as illustrated in Fig. 3, although a single wall of sheeting of the same character as the side walls may be employed. With this construction of bulkhead the space between its inner wall 7 and its outer wall 8 I fill with earth to assist in

the sealing of the chamber, providing, if desired, a shaft 9 within the bulkhead for access to the sheeting wall or entrance to the working-chamber. While it is not always necessary, I regard it as a provision for safety in the construction of the working-chamber to drive into the bed of the preliminary channel series of piles 10 to serve, first, as supports for the chamber-roof and for the framework hereinafter described and, finally, as the foundation for the tunnel. These piles are cut off at a suitable level, preferably a little below that of the top of the side walls of the chamber, and stayed and strengthened by braces 11 and their tops connected by cross-beams 12. The cross-beams 12 are on a level with the top of the sheeting walls, and these walls and cross-beams receive the beams 13 of the roof 6. The piles 10 also serve as supports for the framework B, which is made up preferably of cross-beams 14, braces 15, and the inner walings 16 and outer walings 17, interspaced the thickness of the sheeting wall and serving as guides for the sheeting while being driven, the walings being vertically interspaced and supported by studs 18. For convenience in understanding the drawings this framework B is omitted in Fig. 1.

The chamber being completed, air is forced thereinto under sufficient pressure preferably to counterbalance the weight of the superposed waters and transmit the pressure of the same to the bed of the preliminary excavation, the contained water being pumped out. If quicksand or water is encountered in the excavating, the air-pressure may be increased to counterbalance the water-pressure down to the level of the bed of the excavation, thus preventing the inflow of the quicksand or water. The bed of the channel between the sheeting walls is then excavated, as illustrated in Fig. 3, down to the level 19 required for the foundation of the tunnel structure, additional bracing-framework, as illustrated by a single cross-beam 20 in Fig. 2, being added to the original framework B to laterally support the sheeting walls. A foundation 21 of masonry is then laid in the bottom of the excavation around the piles 10, which are then cut off, as illustrated in Fig. 2, even with the top surface of the tunnel foundation or bed. The iron tubes 22 are then erected upon the foundation and the space around and above the same filled in with masonry, as shown in Figs. 3 and 4. As this work of filling in proceeds I prefer to secure in the sheeting walls inclined-headed bolts or spikes 23, which serve as efficient anchors in the masonry, as illustrated in Figs. 2, 3, and 4. The tubes may be given a lining 24 of masonry of any desired thickness to strengthen the structure and to cover the flanges of the sections of the tube. As the masonry filling over the tubes is progressing I prefer to strengthen the structure by means of tie-rods 25, extending through the walings 17 and sheeting walls, as shown in Fig. 4. This work being accomplished, the roof 6 may be removed and the surface of the bed of the stream over the tunnel leveled off, as illustrated in Fig. 4. While cylindrical tubes are preferably employed for single-track structures, where there are two or more tracks I prefer to employ, for the sake of strength and economy, tubes having a vertical intermediate wall or diaphragm 26, as shown in Fig. 4, the tubes being otherwise cylindrical. The structure is thus stronger, more compact, and requires much less excavation and masonry filling than if the tubes were independent and separated.

While I have shown the supporting-piles for the tunnel widely interspaced, it is evident that where the character of the soil or other reasons require a more solid support or foundation any desired number of piles may be driven, even to the filling of the entire space with piles in contact with each other. It is also evident that instead of sawed sheeting for the inclosing walls of the structure series of piles may be used, other means being employed to make the walls of the chamber in which the work of excavation and construction can be carried on practically impervious to water, the finished structure being of the same general character and embodying the idea of my invention as fully as where sheeting walls are employed. It is also evident that it is within the scope of my invention by like methods and appliances to erect other kinds of masonry subaqueous structures.

I claim—

1. A subaqueous tunnel structure, having foundation and side walls of piles.

2. A subaqueous tunnel structure, having foundation and side walls of piles, embedded in or anchored thereto.

3. A subaqueous tunnel structure having partially-inclosing side walls secured or anchored thereto and seated on bed-rock or penetrating other material to a depth below the tunnel structure.

4. A subaqueous masonry structure, having foundation and side walls of piles embedded therein or anchored thereto.

5. A tunnel or other subaqueous masonry structure, having supporting-piles with their tops penetrating or embedded therein and side walls of piles anchored thereto.

6. A subaqueous tunnel, comprising a metallic tube, supporting side walls therefor, a pile foundation and a mass of masonry serving as a bed for said tube, said walls and piles being anchored to said masonry.

7. A subaqueous tunnel, consisting of masonry walls surrounding the tunnel-passage, supporting-piles therefor having their tops embedded in or extended into said masonry, and vertical walls adjacent the sides of said tunnel and penetrating the earth below the same.

8. A subaqueous masonry structure formed in place between vertical sectional walls ex-

tending below said structure, and supported upon and embedding the tops of series of piles, and anchoring devices connecting said walls with said structure.

9. A subaqueous tunnel structure, comprising a mass of masonry, a tunnel-tube seated therein, and series of piles penetrating the earth beneath and extending into and alongside of said masonry and anchored thereto.

10. A subaqueous tunnel structure, comprising a mass of masonry inclosing the tunnel-passage, foundation-piles embedded in said masonry, sheeting side walls anchored to the masonry, and tie-rods connecting the sheeting on opposite sides.

11. A subaqueous tunnel, comprising a metallic tube, supporting side walls therefor, a pile foundation and a mass of masonry serving as a bed for said tube and anchorage for said walls and piles.

Signed at New York city this 19th day of October, 1903.

DUNCAN D. McBEAN.

In presence of—
J. T. CRANE,
T. D. MERWIN.