

T. K. THOMSON.  
SUBAQUEOUS TUNNEL CONSTRUCTION.

APPLICATION FILED AUG. 21, 1902.

NO MODEL.

2 SHEETS—SHEET 1.

Fig. 1.

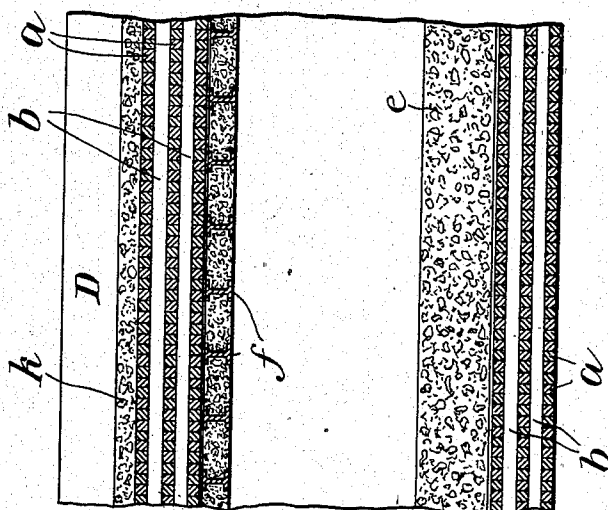
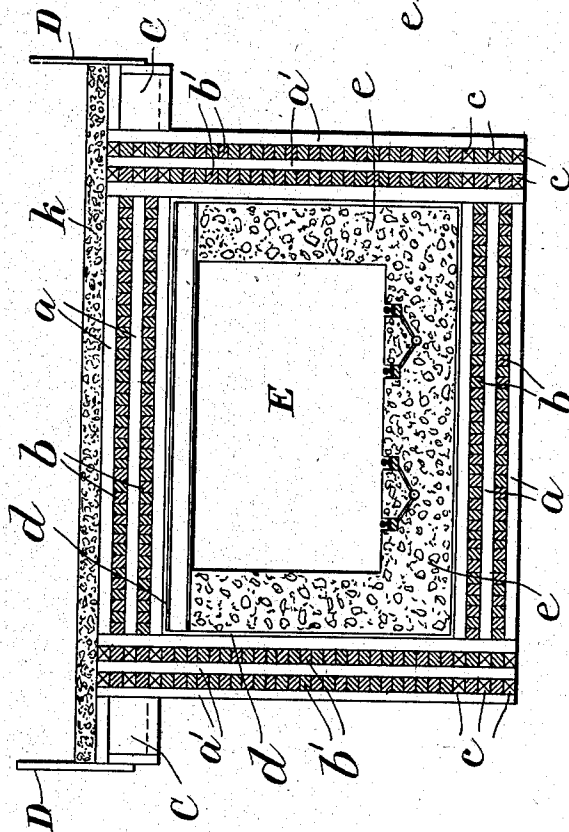


Fig. 2.



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2 SHEETS—SHEET 2.

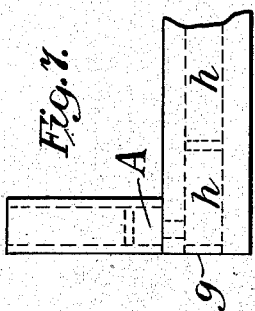
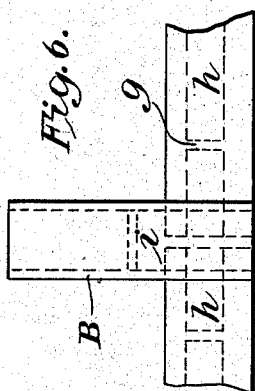


Fig. 3.

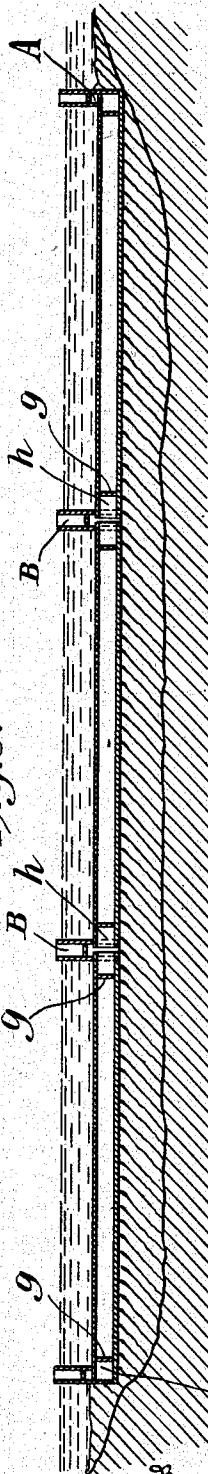


Fig. 4.

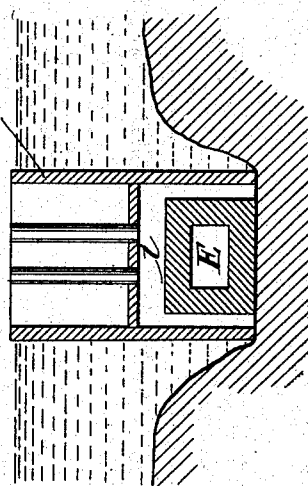
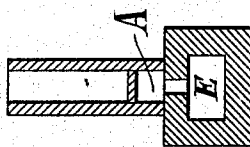


Fig. 5.



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# UNITED STATES PATENT OFFICE.

THOMAS KENNARD THOMSON, OF YONKERS, NEW YORK, ASSIGNOR OF  
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## SUBAQUEOUS-TUNNEL CONSTRUCTION.

SPECIFICATION forming part of Letters Patent No. 718,173, dated January 13, 1903.

Application filed August 21, 1902. Serial No. 120,453. (No model.)

*To all whom it may concern:*

Be it known that I, THOMAS KENNARD THOMSON, a citizen of the United States, residing in Park Hill, Yonkers, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Subaqueous-Tunnel Construction, 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, and more particularly to that branch of the art of tunnel construction which concerns tunneling under rivers, harbors, or other bodies of water.

In the construction of subaqueous tunnels as at present practiced there may be said to be two general methods of procedure. According to one of these methods, which is probably the older of the two, excavations are commenced at either terminal of the tunnel and are continuously advanced from one terminal to the other underneath the bed of the stream. As fast as these excavations are made the tunnel-walls are constructed, and the entire labor of constructing the tunnel is required to be performed within caissons or similar devices, in which the pressure of the atmosphere is proportional to the depth of the water above the tunnel.

Owing largely to the difficulties of working at any considerable depth under the above-mentioned conditions, the second method of subaqueous-tunnel construction was devised. This method comprises the building of the tunnel in longitudinal sections upon the nearby bank or shore, towing or floating said sections to a place upon the stream which is approximately above their respective permanent positions, and finally sinking said sections into place and fastening together their adjacent ends.

The present invention is concerned with the structure of tunnels built according to the latter of the methods above outlined. Its general object is to improve the structural features of subaqueous tunnels and to provide a subaqueous tunnel which shall not only be absolutely safe, but even damp-proof.

In the accompanying drawings, in which the scale of each figure is varied in order to

show the several parts most conveniently, Figure 1 is a longitudinal sectional view of a portion of one of the sections of the tunnel. Fig. 2 is a transverse sectional view of one of the sections of the tunnel. Fig. 3 is a longitudinal sectional view of the tunnel, showing working shafts communicating with caissons at the several joints of the tunnel-sections and also at either end of the tunnel. Figs. 4 and 5 are transverse sectional views of the tunnel, taken at one of the joints and at one of the ends of the tunnel, respectively, and showing sectional views of the caissons employed at those points. Figs. 6 and 7 are side elevations of the tunnel at one of the joints and at one of the ends thereof, respectively.

These several tunnel-sections, which, as above mentioned, are constructed upon the bank or shore adjoining their permanent positions, are preferably alike both in their structure and dimensions. Each section comprises a frame of wood, which is preferably built in the form of a hollow rectangular box open at both ends. It will be understood that the dimensions of the frame or box will differ according to the uses or conditions which may prevail in any given case; but hereinafter for the sake of clearness the invention will be discussed with reference to the conditions which ordinarily prevail in the construction of subaqueous tunnels for purposes or uses connected with railroad transportation.

The length of the tunnel-sections may be made as great as convenience in construction and handling may dictate, and it is at present preferable to make them at least one thousand feet long. The frame of the sections is preferably constructed of twelve-by-twelve timbers, all of the timbers being cut square and secured together by bolts without any halving or dovetailing. The timbers are arranged and joined together in such a way to form the frame-walls that the latter comprise several layers of timbers, which are indicated at  $a a'$  and  $b b'$  in Figs. 1 and 2 of the drawings. All the timbers in the same and alternate layers are arranged parallel with each other and either longitudinally or transversely in the frame, while the timbers in an adjacent layer are arranged crosswise or normally with respect to timbers in the layer to

which it is adjacent. The numbers of layers of timbers employed will determine the thickness and strength of the frame of the section; but it is immaterial, so far as this invention is concerned, how many layers the frame-wall may contain. In the drawings five layers of timbers are shown to comprise the frame, thus rendering the frame-walls about five feet thick in case twelve-by-twelve timbers are employed.

The edges of the frame are formed by the transversely-arranged timbers *a* and *a'*, the timbers *a* in the top and bottom walls of the frame and the timbers *a'* in the side walls of the frame alternately extending the entire width of the frame. The small square spaces *c*, which are thereby left in the edges, may be filled with small cubes of wood or concrete or any other material or left vacant, if desired. If preferable, also, vacant spaces may be left within the wooden frame, which may be filled with concrete or other material.

As soon as the sections of the frame are formed, as above described, they are each lined with a suitable waterproofing material *d*, over which a layer of concrete *e* is placed. Said layer *e* preferably comprises a substantial body of concrete, which is molded to form the interior of the tunnel. As shown in the drawings, there is but one central conduit *E*, forming the interior of the tunnel, the thickness of the concrete layer in this case being about equal to the thickness of the frame—i. e., about five feet. It will be understood, however, that there may be as many conduits within the tunnel as desired, and they may be of any particular shape to suit varying conditions of use, and where more than one conduit forms the interior of the tunnel the walls between the several conduits may be of concrete or of any other suitable material. The roof of the sections is preferably strengthened on the interior by the addition of I-beams *f*, between which the concrete is laid and supported.

After the sections have been as completely finished as possible upon the shore they are ready to be towed or floated upon the river or stream to a place which is approximately directly above their permanent position. While the sections are being constructed upon the shore, however, the bed of the stream may be dredged, so as to remove any obstacle which may be in the proposed line or path of the tunnel and also to form a channel and a suitable foundation for the several sections of the tunnel to rest upon. In case the bed of the stream so dredged is too soft to form a suitable foundation for said sections it may be reinforced by dumping quantities of stone or concrete thereon or by driving piles therein.

The several sections which have been completed in the manner hereinbefore described and which have been towed out upon the stream are now ready to be sunk into place. Before sinking, however, it is preferable to add a layer of concrete *k* upon the tops of

each of the tunnel-sections, which layer serves both to overcome the buoyancy of the section upon which it is laid and also to protect it when in place from injury from anchors, sunken vessels, or anything else that might be brought by the stream in contact with the roof of the tunnel. In order to further neutralize the buoyancy of the several tunnel-sections, they are adapted to be loaded, and for this purpose they are provided with cribs, (not shown in the drawings,) which may be secured to the outside of same in any suitable manner and into which stone or other heavy material may be dumped.

In order to control and facilitate the sinking of a section, one or more coffer-dams *D* are built upon the top of the same before the section is loaded. Then the loading is carried to a point which is just sufficient to sink the section in case the coffer-dams were not attached to the same. By removing now the sides of the coffer-dam or by otherwise gradually admitting water into the interior of the coffer-dam the section may be sunk to any desired depth. Instead of employing a coffer-dam or in conjunction with the same side chambers *C* may be built upon the sides and near the top of the several sections, these side chambers extending longitudinally the entire length of the sections and being provided with any suitable means whereby water may be admitted into or discharged from the interior of said chambers. These side chambers may be built upon the tunnel-sections before they are floated out into the stream, or, if preferable, they may be placed thereon just previous to sinking the sections and before the concrete is laid upon the top of the same, which concrete is then added to cover the tops of the side chambers as well.

Temporary bulkheads or diaphragms *g*, forming water-tight compartments *h*, are provided in the several sections in order to prevent the water from entering the interior of the sections while sinking and to otherwise assist in the sinking. As many of these diaphragms or partitions may be provided as may be found desirable in any special case, and these bulkheads or partitions are so placed in the ends of the sections as to leave a water-tight compartment in each end of about one hundred feet in length. It is preferable, also, that the concrete lining of the tunnel shall not extend into these end compartments of the several tunnel-sections, but that these end portions of the sections be left unfinished in order to facilitate the joining of the adjacent ends in case these ends for any reason should overlap. In such a case the end portions may be easily removed to the desired extent and a diagonal or curved section may be inserted between the ends, the interior of said diagonal or curved section being shaped to conform to the curvature which the track is to assume at this point.

Either one of the extreme or end sections of the tunnel is first sunk into its permanent

position. Both of these extreme sections are provided with a working shaft, which is built upon the same before sinking at the shore ends of said sections, respectively, which shafts are provided so that the land portion of the tunnel may be started from these ends as soon as these sections are in place. These extreme sections will also be provided before sinking with working chambers or pneumatic caissons A, secured to the shore ends of said sections, which caissons will be used to start the headings for the approaches to the tunnel.

As soon as the first section has been sunk to place the second section is floated, so as to be approximately directly above its permanent position, and said second section is then sunk in the same manner as the first section, so that its end adjacent to the end of the first section will be near but will not abut against said first section. The second section before being lowered to place is also provided with a working shaft or pneumatic caisson B, secured to its end adjacent to the end of the first section, and said caisson is arranged upon the second section and is of such shape as to be adapted to straddle the end of the first section adjacent to the second section. It will be understood that the caissons herein referred to denote the working chambers, which are formed around the several joints of the tunnel-sections in the manner described to facilitate the sealing of said joints, and that the word "caisson" as used in this specification does not in any case refer to the sections themselves or any of their compartments, which, technically considered, might be included within the term.

As soon as the second section is sunk to place the joints formed by the walls of the caisson and the first section are packed or calked in order to form a water-tight compartment within the caisson, and air-pressure is established within said caisson, and the two sections of the tunnel are united within the caisson-chamber. In order to protect and strengthen the joint, it is preferable to add a layer of concrete on the exterior of the tunnel around the same, and this may be accomplished by filling the space between the caisson-walls and the sections. The upper part of the caisson may be then removed and, if desired, used upon the next section. In this way the several sections of the tunnel are successively sunk to place and joined. If preferable, however, both of the extreme or end sections may be sunk at the same time and the mean or intermediate sections may be laid by working from both ends simultaneously. As soon as all these sections have been sunk to place and their several ends secured together in the manner above specified the interior diaphragm or portions and bulkheads may be removed and the tunnel will be complete from terminal to terminal.

I do not herein claim the method above described of building subaqueous tunnels, as this method forms the subject-matter of a

separate application, Serial No. 120,452, filed by me on August 21, 1902.

I claim as my invention—

1. A frame for a tunnel comprising a plurality of timbers secured together so as to leave intervening spaces between certain of the timbers, substantially as described.

2. A frame for a tunnel comprising a plurality of timbers secured together so as to leave intervening spaces between certain of the timbers, said intervening spaces being filled with a relatively heavy protective material, substantially as described.

3. A frame for a tunnel comprising a plurality of timbers secured together so as to leave intervening spaces between certain of the timbers, said intervening spaces being filled with concrete, substantially as described.

4. A tunnel-section comprising a plurality of timbers secured together to form a hollow frame, a lining of concrete within said frame, and a waterproofing material between said frame and lining, substantially as described.

5. A frame for a tunnel comprising a plurality of layers of timbers, the timbers in the same layer being arranged parallel with each other, and the timbers in adjacent layers being arranged transversely, substantially as described.

6. A tunnel having a plurality of longitudinal sections, each of which sections has a frame comprising a plurality of timbers secured together so as to leave intervening spaces between certain of the spaces, substantially as described.

7. A subaqueous tunnel having a solid timber frame resting in or on the bottom of a stream and a layer of concrete on the top of said frame, substantially as and for the purpose set forth.

8. A subaqueous tunnel having a plurality of longitudinal sections which are secured together, and a protective covering of concrete around the exterior of said tunnel at each of the several joints of the adjacent tunnel-sections, substantially as described.

9. A subaqueous tunnel comprising a timber frame, a waterproof lining within said frame, an inner protective layer of concrete or similar material, I-beams or strengthening-beams in the roof of the tunnel and a layer of concrete or other protective material upon the top of the tunnel.

10. A tunnel-section for a subaqueous tunnel adapted to be floated or towed to a place in a stream which is above its permanent position, and then to be lowered to place, said tunnel-section having secured to it at one end a pneumatic caisson which caisson is adapted to straddle both the end of the section it is secured to and the adjoining end of the adjacent section, substantially as and for the purpose set forth.

11. A tunnel-section for a subaqueous tunnel adapted to be floated or towed to a place in a stream which is above its permanent position, and then to be lowered to place, said

tunnel-section having secured to it at one end a pneumatic caisson, which caisson is adapted to straddle both the end of the section it is secured to and the adjoining end of the adjacent section, and side chambers secured to the sides of said sections near the top, substantially as and for the purpose set forth.

12. A tunnel-section, comprising a plurality of timbers secured together to form a hollow frame, a lining of concrete within said frame, a portion of said section at either end thereof being left unfinished, substantially as and for the purpose set forth.

13. A tunnel-section, comprising a plurality of timbers secured together to form a hollow frame, a lining of concrete within said frame, and a compartment at each end of said section into which the concrete lining does not extend, substantially as and for the purpose set forth.

14. A tunnel-section for a subaqueous tunnel, adapted to be floated or towed to a place in a stream which is above its permanent position, then to be lowered to place to form one of the extreme sections of the tunnel, said tunnel-section having built upon it at its shore end a working shaft, substantially as and for the purpose set forth.

15. A tunnel-section for a subaqueous tunnel, adapted to be floated or towed to a place in a stream which is above its permanent position, and then to be lowered to place, said tunnel-section having secured to it at one end a vertically-disposed working shaft or caisson which caisson is adapted to straddle both the end of the section it is secured to and the adjoining end of the adjacent section, substantially as and for the purpose set forth.

16. A subaqueous tunnel, comprising a timber frame, an inner protective layer of concrete or similar material and I-beams or strengthening-beams in the roof of said tunnel.

17. A subaqueous tunnel, comprising a timber frame, a waterproof lining within said frame, an inner protective layer of concrete conformed to the shape of the interior of the tunnel and forming one or more conduits therethrough.

This specification signed and witnessed this 14th day of August, A. D. 1902.

T. KENNARD THOMSON.

In presence of—

ALFRED W. KIDDLE,  
ROSWELL S. NICHOLS.