

No. 629,135.

Patented July 18, 1899.

L. NIXON & W. H. KNIGHT.

SUBAQUEOUS TUNNEL AND METHOD OF CONSTRUCTING SAME.

(Application filed Mar. 23, 1899.)

(No Model.)

3 Sheets—Sheet 1.

Fig. 1.

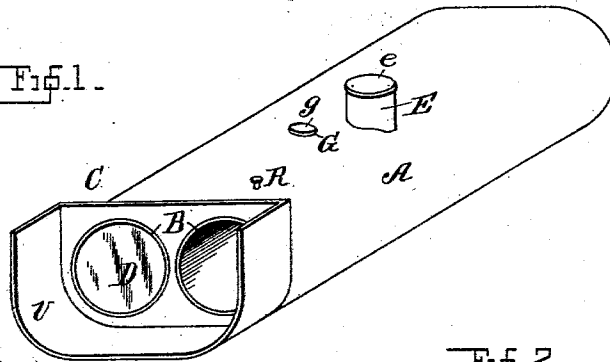


Fig. 2.

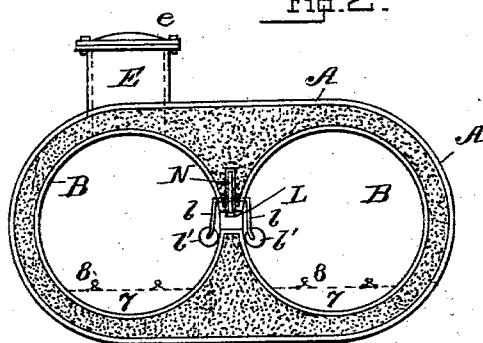
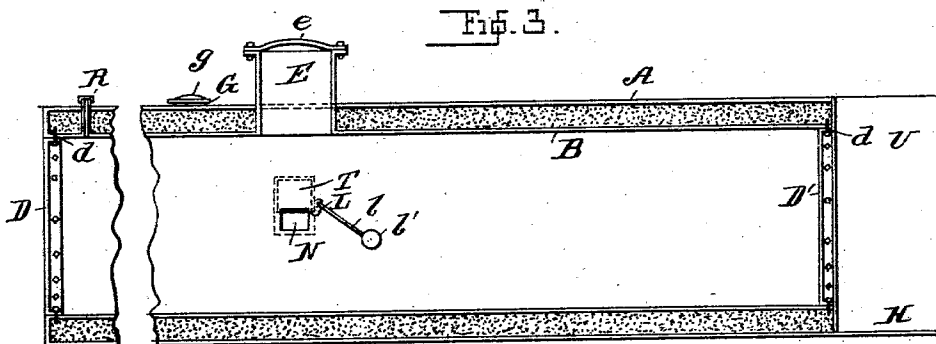


Fig. 3.



WITNESSES:

M. V. Bidgood
W. P. Hammond

INVENTORS

Lewis Nixon & Walter H. Knight

BY

Wm. V. Bidgood
ATTORNEYS

No. 629,135.

Patented July 18, 1899.

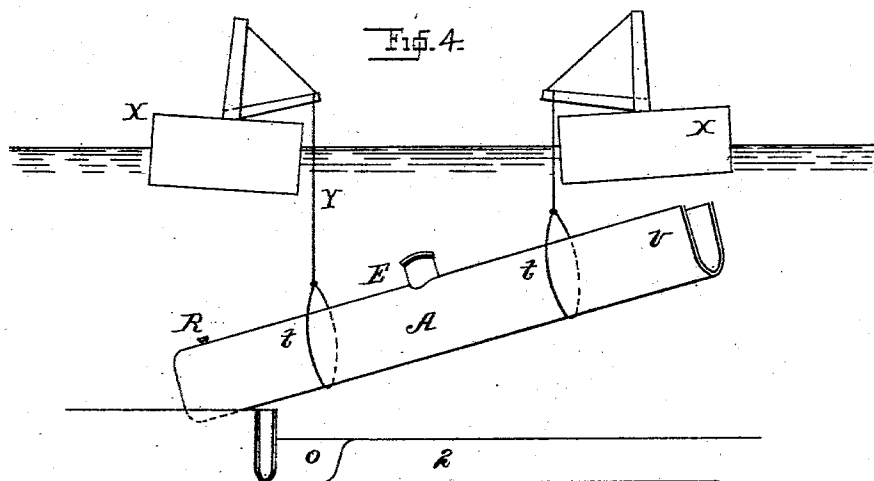
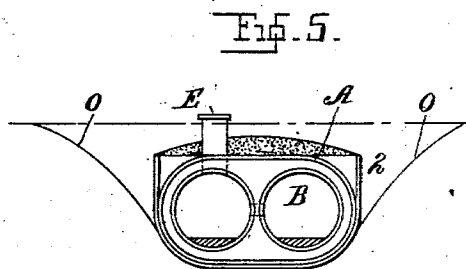
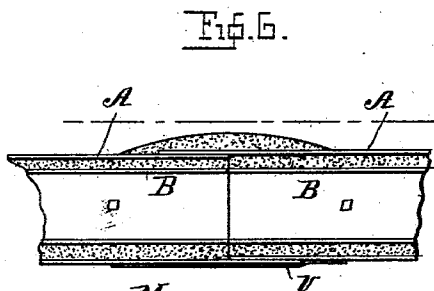
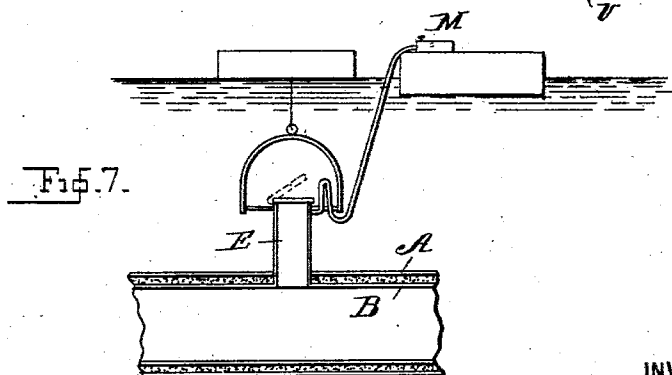
L. NIXON & W. H. KNIGHT.

SUBAQUEOUS TUNNEL AND METHOD OF CONSTRUCTING SAME.

(Application filed Mar. 23, 1899.)

(No Model.)

3 Sheets—Sheet 2.



WITNESSES:

M. J. Biggord
W. J. Hammond

INVENTORS

Levis Nixon & Walter H. Knight

BY

Wm. H. H. H. H.
ATTORNEYS

No. 629,135.

Patented July 18, 1899.

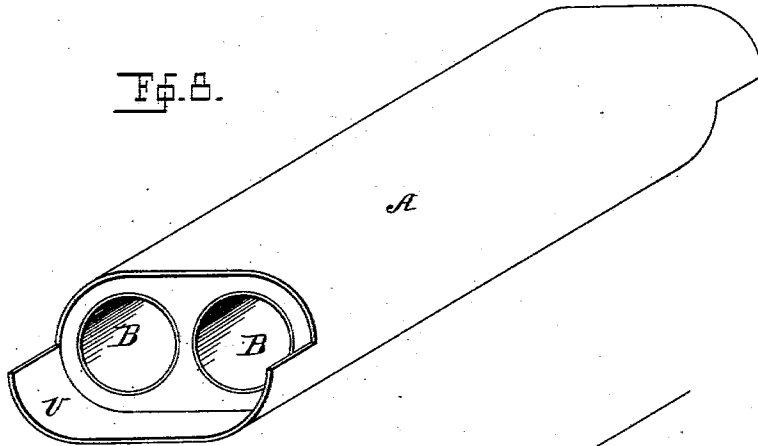
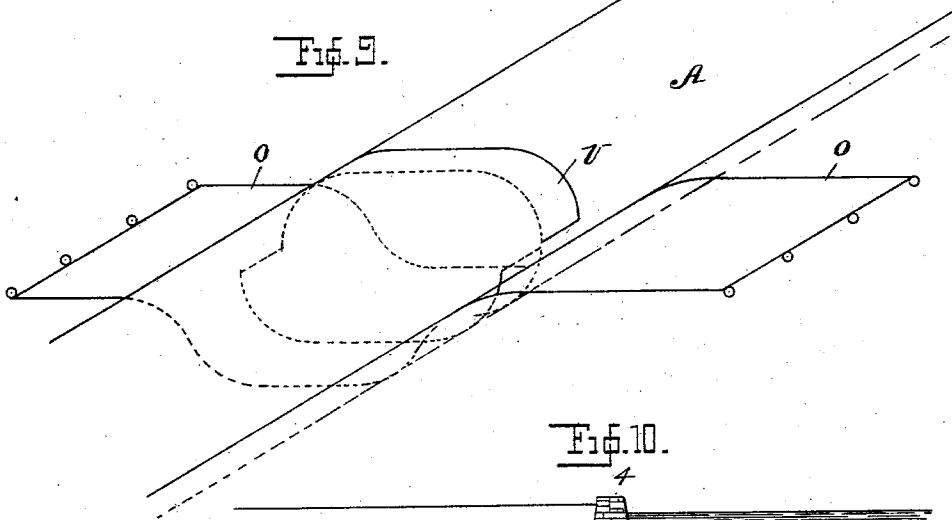
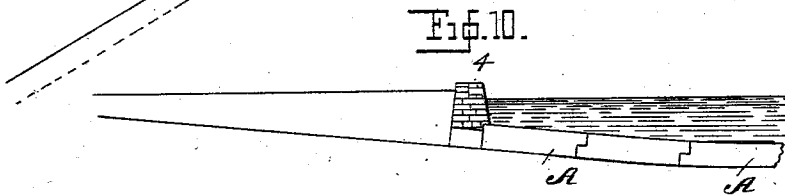
L. NIXON & W. H. KNIGHT.

SUBAQUEOUS TUNNEL AND METHOD OF CONSTRUCTING SAME.

(Application filed Mar. 23, 1898.)

(No Model.)

3 Sheets—Sheet 3.



WITNESSES:

Dr. V. Bridgman
W. H. Hammond

INVENTORS

Louis Nixon & Walter H. Knight

BY

Wm. H. Knight
ATTORNEYS

UNITED STATES PATENT OFFICE.

LEWIS NIXON AND WALTER H. KNIGHT, OF NEW YORK, N. Y.

SUBAQUEOUS TUNNEL AND METHOD OF CONSTRUCTING SAME.

SPECIFICATION forming part of Letters Patent No. 629,135, dated July 18, 1899.

Application filed March 23, 1899. Serial No. 710,188. (No model.)

To all whom it may concern:

Be it known that we, LEWIS NIXON, residing at New York, in the county of New York, and WALTER H. KNIGHT, residing at New York, (New Brighton,) in the county of Richmond, State of New York, citizens of the United States, have invented certain new and useful Improvements in Subaqueous Tunnels and Methods of Constructing Same, of which the following is a specification.

This invention relates to improvements in subaqueous tunnels and methods of constructing same; and the object of the invention is to enable the tunnel to be put in place without recourse to the costly process of underground excavation or "tunnel-driving."

We form the tunnel-sections of such material and proportions that when they are closed at the ends and dropped into the water they will present little, if any, flotative effect, so that they can readily be sunk to their final positions and then joined together. On then connecting them to terminal approaches and removing the ends or caps of each section an open tunnel comparatively free from water results, and such tunnel when loaded with the usual appurtenances of a permanent way and with the extra weight of the joint-closing instrumentalities is of sufficient weight to entirely overcome the flotative effect due to the water displacement and to rest stably and permanently in its bed. By this method of procedure a large part of the pumping out of the sunken tunnel is obviated.

We prefer to form the tunnel or each section thereof of an outer tube or shell of steel, one or more inner tubes surrounded by said shell, and a filling of cement or cemented material in the space between said inner tubes and the outer shell. Each section of the tunnel is also preferably provided with means at one end for engaging with the adjacent end of the next section to facilitate alinement and joining up, and means are also preferably provided for enabling access to the interior of each section after it is in the water and before the section ends have been opened.

Our invention consists in the special construction of the tunnel-sections for facilitating and effecting the connection or junction of the sections and in other features of construction, as hereinafter set forth and claimed.

In the accompanying drawings, which form a part of this specification, Figure 1 is a perspective view of a tunnel-section, showing also the adjacent end of the adjoining section. Fig. 2 is a transverse section of the tunnel-section, and Fig. 3 is a longitudinal section of a portion thereof. Fig. 4 shows the manner of putting the tunnel-sections in place. Figs. 5 and 6 are respectively transverse and longitudinal sections of the tunnel, showing it in place. Fig. 7 shows a means of securing access to the tunnel. Figs. 8 and 9 show a modification. Fig. 10 shows the preferred manner of constructing the terminal approaches to the tunnel.

The tunnel-sections are preferably formed, as shown in Fig. 1, of an outer cylinder A of suitable metal, such as wrought-iron, and one or more, preferably two, inner cylinders B of similar material, which are connected to and supported in the outer cylinder by means of the end plates C, closing the spaces at the end between the outer and inner cylinders, and any additional cross plates and braces that may be desirable. The inner tubes or cylinders B are preferably closed at each end by disk-shaped bulkheads D D', which may have flanges d bolted to the said inner tubes.

A turret E is preferably formed on the outer casing or cylinder A and communicates with one of the inner cylinders B, said turret being normally closed by a cover e, bolted thereon.

Each tunnel-section is preferably provided at one end with an open-topped flange extension U, which is adapted to receive and engage with the adjacent end of the next section, such flange extension having upwardly-extending sides, as shown. This flange extension is of sufficient length to project beyond the end bulkhead of the next section, and thus effectually supports the next section while the bulkheads are in place and during the construction of the tunnel.

The structure as above described is substantially hermetically closed, so that when placed in the water it will permit little, if any, water to enter it. To overcome the enormous buoyancy or flotative effect of such a structure, we fill the space between the outer cylinder and the two inner cylinders with cement or cemented material of any suitable kind, and this is done, preferably, after the

tunnel-section has been launched or deposited in the water. The empty structure, which is comparatively light and may be handled and transported with comparative ease, is put into the water and the cement or similar material V is passed in through an opening, (indicated at G in Fig. 1,) which is made in the outer casing A, and communicates with the space between the outer and inner tubes, and this filling process is continued until the structure is just awash, the parts being preferably so proportioned that the space between the outer and inner tubes will then be substantially full of cement. The section may then be closed by a cap g on opening G.

Passing over for the present certain details of construction of the tunnel-sections, we will now explain the manner in which the sections are laid in the bed of the river or other waterway to form a subaqueous tunnel.

A ditch or channel is first dredged across the bottom of the waterway, this ditch being sufficiently deep and wide to receive the tunnel-sections and depress same wholly or partly below the bed of the waterway. Such a ditch is indicated at 2 in Figs. 4 and 5. The tunnel-sections are then towed one by one to positions over the ditch and sunk to their proper places therein, it being understood that the sections are upheld in the water by virtue of the fact that the inner tubes B are filled only with air, and therefore buoy up the structure, so that by allowing a little water to flow into one end of these tubes by a valved or stoppered opening R that end is caused to pitch downward more or less, and the structure then sinks into the ditch aforesaid, its descent being regulated by any suitable means, as by support t, depending by cables Y from barges X in Fig. 4, and operated in well-known manner.

In order to bring the tunnel-sections into substantially exact alinement and facilitate the closing of the joints between the same, each section is, as above mentioned, provided with an open-topped extension or flange U at one end, which receives and engages with the unflanged end of the next succeeding section. Moreover, in order to insure such fitting together of the successive sections, which might be prevented by the mud on the bottom of the waterway running over the edge of the flange U and clogging it up, we prefer to spread in those parts of the ditch where the joints occur tarpaulins or similar flexible supports O, as indicated in Figs. 4 and 5, upon which the flanges U descend and rest. The flange U being thus protected and supported by the tarpaulin, the unflanged end of the next section on being lowered into the same is guided, stopped, and supported in substantially exact alinement with the preceding section both horizontally and vertically. It will be understood that as soon as sufficient water has been admitted into the section to sink it the valved or stoppered opening R may be closed, and the inner tubes may thus be kept com-

paratively free from water. The sections having been thus laid in the ditch, the joints are closed by depositing cement or concrete over the same, as shown at Z in Figs. 5 and 6, the flanges or open-topped extensions here serving the additional purpose of holding the cement in contact with the joint. The cement being preferably hydraulic cement, the setting thereof will permanently close the joint in the most effectual manner. Mud or silt is then scraped or dumped over the tunnel-sections and the joints, so as to completely bury the same. The tunnel-sections so deposited are separated from one another by the water-tight bulkheads D D' in the ends of each section. These may be constructed so as to be capable of removal in various ways. Thus if the flanges d thereof are both directed toward the same end of the tunnel, as indicated in Fig. 3, then if access be obtained to that end these flanges may be unbolted and the bulkheads removed one by one until the tunnel is opened up from end to end, or said flanges may both be directed toward the inside of the section, so that to remove the bulkheads access must be obtained to the inside of each section through its turret E. To effect this a diving-bell may be lowered over the turret as indicated in Fig. 7, and a pipe, which leads from any suitable pump M or source of compressed air, is connected with the turret E, and compressed air is forced into the section until the hydrostatic pressure due to the superincumbent water is overcome or equalled by the pressure within the section. The cover e may then be unfastened and raised, and access may thus be gained to one of the inner tubes, which communicates with the other inner tube by one or more cross-passages N, which may be large enough to permit the passage of a man through same.

While the ditch wherein the tunnel is laid may be extended on each side from the river-bed up through the river-bank to proper terminal points, we prefer to terminate the tunnel at each end as follows: The ditch having been formed to, nearly to, or somewhat beyond each bank of the waterway and the tunnel having been laid therein as above described, a permanent dam or wall 4, of masonry or its equivalent, is built over the end of the tunnel, as shown in Fig. 10, and the line of the tunnel is then continued outwardly and upwardly by means of an open cut to surface-level.

To facilitate ventilation and prevent undue air-pressure in the tunnel in advance of trains moving rapidly therein, as well as to enable communication between the inner tubes B, we provide the openings or ports N between said tubes, and in order to prevent an accidental or intentional flooding of one of the tubes from flooding the other tube we may provide each port with an automatically-closing door, such as indicated in Figs. 2 and 3, where T is a plate sliding vertically above and across the opening N and L is a catch

normally holding said plate in a raised position, so as to keep the port N open, said catch being connected to a lever l in each cylinder B, carrying a float l', so that when water gains access to either cylinder the catch is operated by the corresponding float to trip the plate, which descends by its own weight and closes the opening.

It will be understood that when the tunnel has been laid and buried as heretofore described any water therein, including the water which was allowed to flow in to sink it, may be pumped out, the weight of the superincumbent material and of the cement-filled structure being sufficient to overcome the flotative effect due to the water displacement. The inside of the tunnel may then be lined or patched wherever necessary with cement or masonry to give it uniformity of outline, and by similar means a road-bed 7 may be formed in each of the inner tubes. The weight of this road-bed and of the other accessories of a permanent way, such as rails 8, will further serve to weight the structure, the intention being that the final dead-weight thereon shall be considerably more than the flotative effect due to the water displacement, so as to eliminate any danger of uplifting of any part of the tunnel by the vibration caused by passing vehicles.

The modification shown in Figs. 8 and 9 is similar to the form above described, except that the flange extensions at the ends do not extend up beyond the central horizontal plane of the tunnel-section and are formed at each end of each section, being at the top at one end and at the bottom at the other end, so that on allowing the end with the overhanging flange extension to drop over the end with the under-extending flange extension the two sections will mutually overlap, as indicated in Fig. 9, and a large and effective joint-surface will be formed. In any case the flange extension is a partial extension only—that is, it only extends part way around the end of the section, so as to permit of the sections being brought into engagement without being first exactly aligned.

While we have described our improved construction of subaqueous tunnel with especial reference to a tunnel with two inner tubes, it is apparent that many of the features of construction, such as the flanged ends and the general idea of inner and outer cylinders with intermediate cement, are applicable to tunnels with one inner tube.

The original tunnel-sections may, if desired, be made of sufficient weight to slightly overbalance the flotative effect, so that they will tend to sink, in which case temporary means, such as pontoons, must be provided for supporting them on the surface of the water until the proper time for sinking them. They are then lowered into place by their own weight, being grounded by guy-cables or otherwise from the pontoons.

The tunnel-lining may be of any suitable

cemented material, such as concrete, masonry, &c.

Having thus described our invention, what we claim, and desire to secure by Letters Patent, is—

1. A tunnel-section for subaqueous tunnels, comprising a tubular structure with an end extension extending only partly around its end.

2. A tunnel-section for subaqueous tunnels, comprising a tubular structure provided with bulkheads near its end, and having an end extension extending only partly around its end and extending beyond the bulkhead.

3. A subaqueous tunnel composed of sections, each section having an open-topped extension at one end engaging with and receiving the adjacent end of the next section.

4. A subaqueous tunnel composed of sections each section having at one end an open-topped extension, with upwardly-extending sides, receiving and engaging with the adjacent end of the next section.

5. A subaqueous tunnel comprising a casing, two tunnel-ways formed therein and communicating with one another by openings, doors for closing said openings, and means for closing said doors automatically when the water enters either tunnel-way.

6. A subaqueous tunnel composed of a number of sections, a flexible support placed under the joints between the sections and a covering of cement placed over the joints.

7. A subaqueous tunnel composed of a number of sections, each section having an open-topped flange extension, with upwardly-extending sides which receive the adjacent end of the next section, a covering of cement placed over the joint and received and held by said upwardly-extending sides of the flange extensions.

8. In a subaqueous tunnel, the combination of adjacent sections, each having a partial extension extending over and partly surrounding the end of the other section, and extending only partly around the section end.

9. In a subaqueous tunnel, the combination of adjacent sections, one of which has a bottom extension at one end, projecting beyond the top of said section and engaging with the adjacent section.

10. In a subaqueous tunnel, the combination of two adjacent sections, each of which has a semitubular extension adapted to engage with the end of the other section.

11. A construction for subaqueous tunnels, comprising two adjacent tunnel-sections each having an interior bulkhead near its end, of extensions from one section overlapping and partly surrounding the adjacent section and extending beyond the bulkhead therein.

LEWIS NIXON.
WALTER H. KNIGHT.

Witnesses:

M. V. BIDGOOD,
J. GREEN.