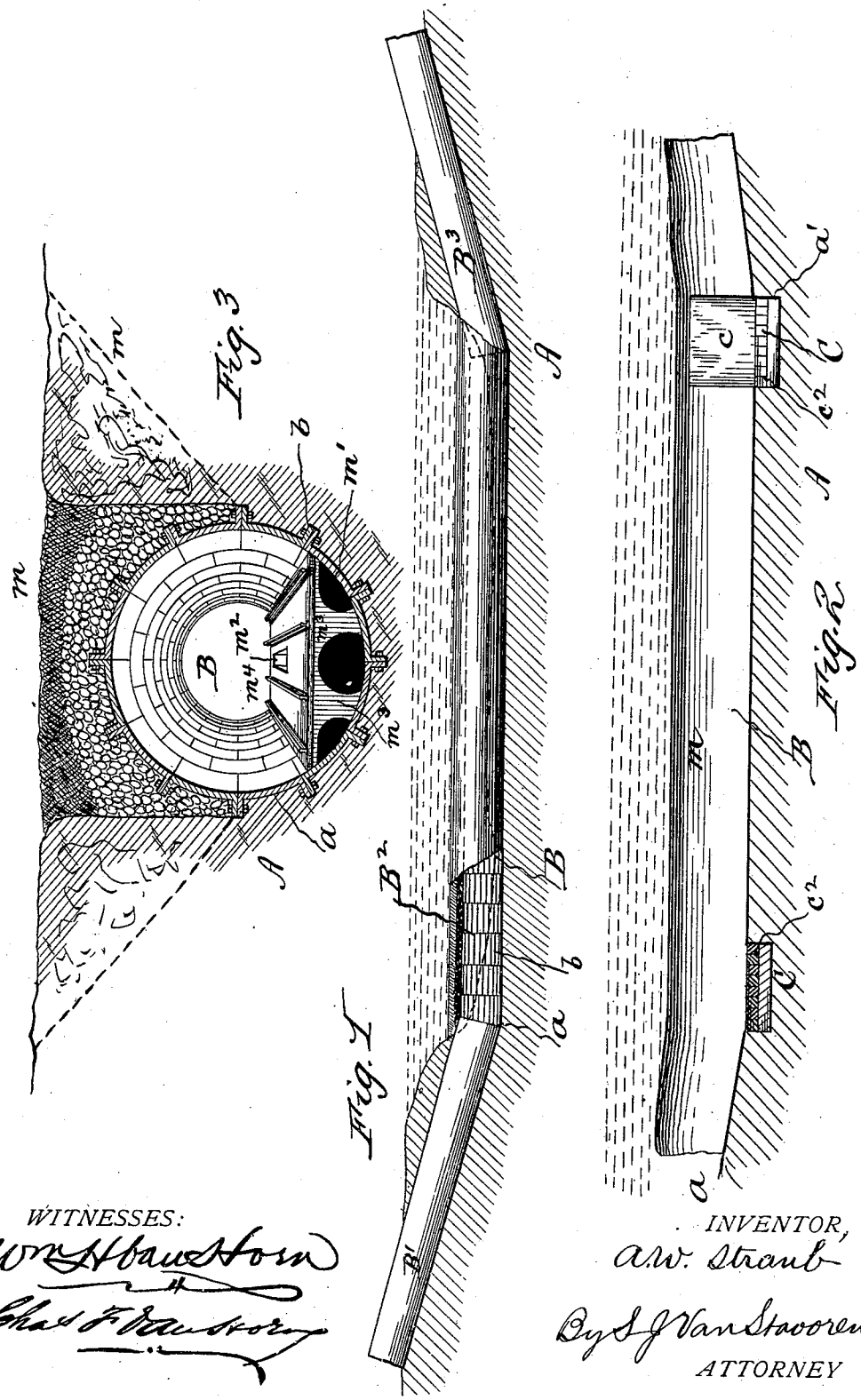
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A. W. STRAUB.

SUB-RIVER TUNNEL.

No. 400,804. Patented Apr. 2, 1889.



WITNESSES:

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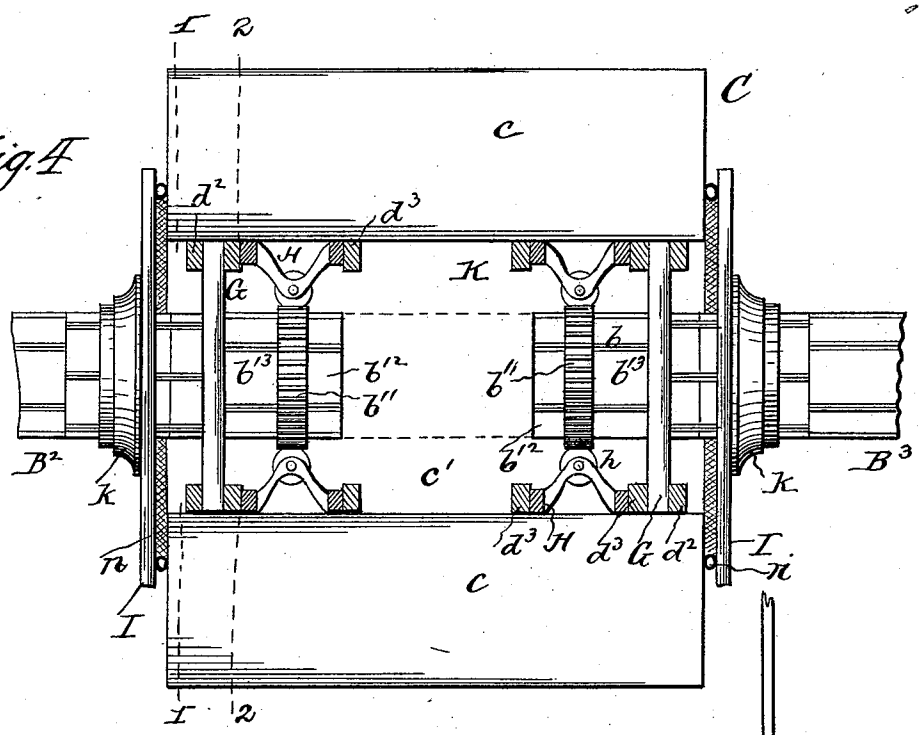
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A. W. STRAUB.

SUB-RIVER TUNNEL.

No. 400,804. Patented Apr. 2, 1889.

Fig. 4



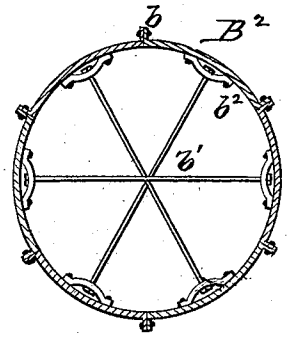


Fig. 5

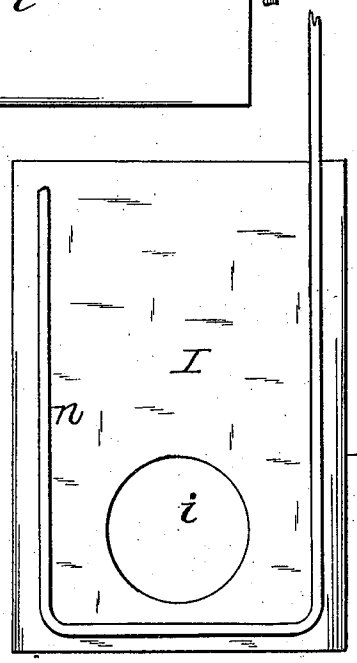


Fig. 6

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(No Model.) 4 Sheets—Sheet 3.

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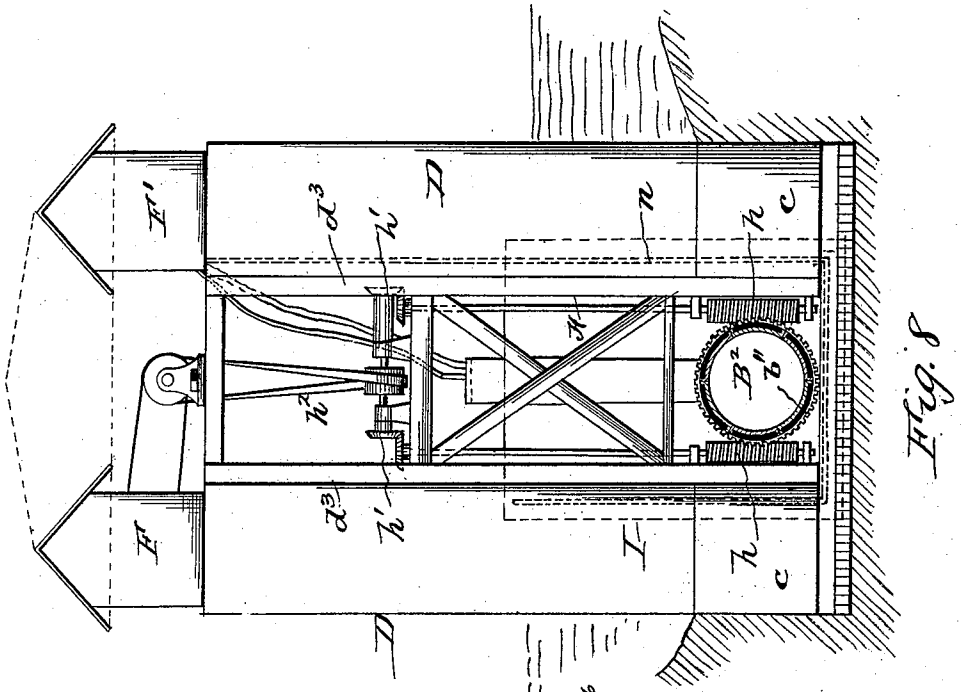


Fig. 8

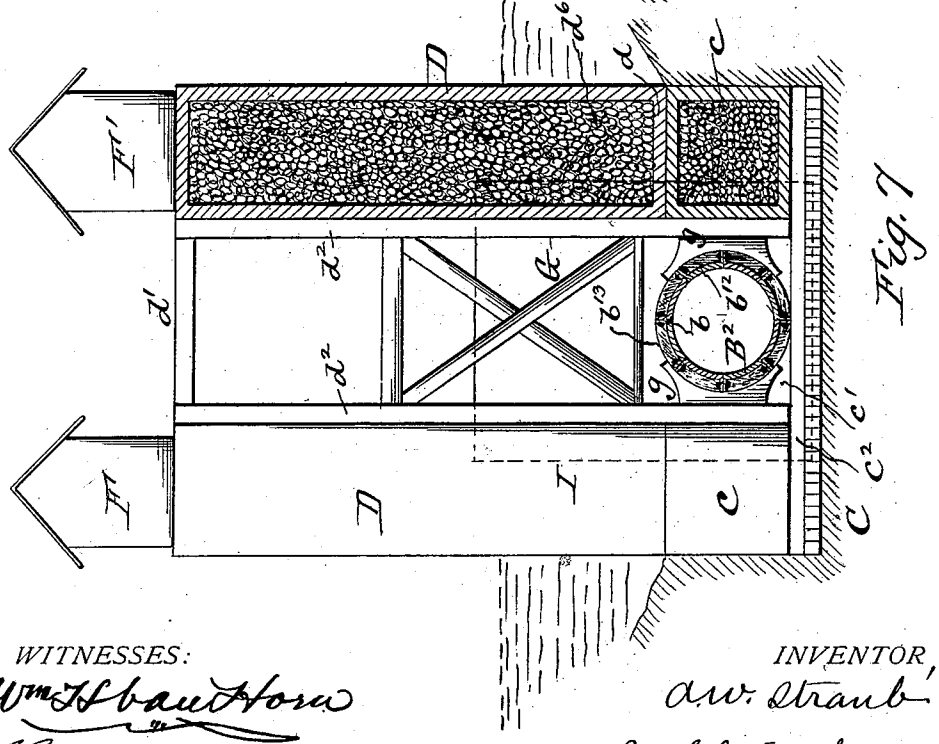


Fig. 7

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(No Model.) 4 Sheets—Sheet 4.

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SUB-RIVER TUNNEL.

No. 400,804. Patented Apr. 2, 1889.

Fig. 9

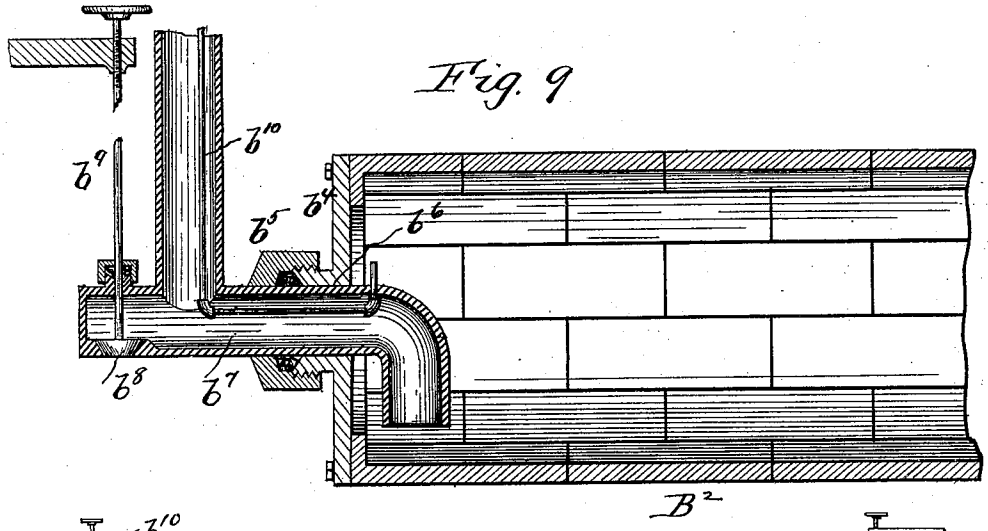


Fig. 10

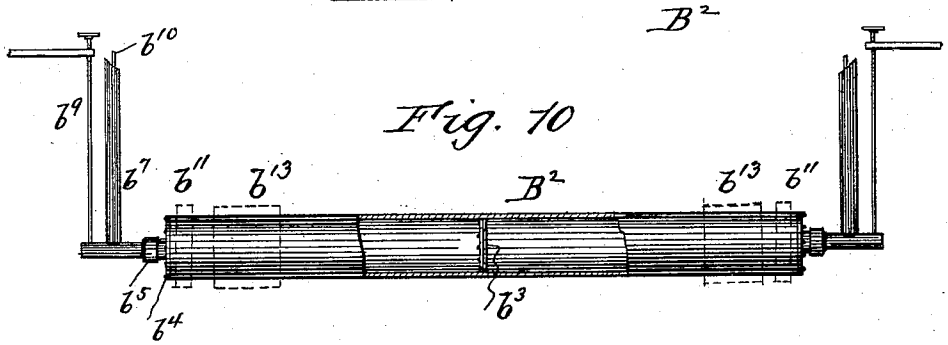
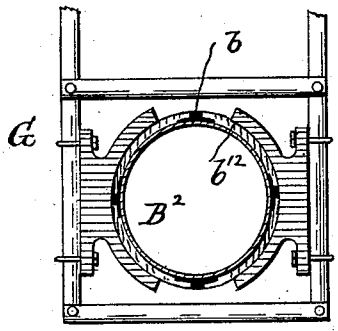


Fig. 11



WITNESSES:

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UNITED STATES PATENT OFFICE.

AMBROSE W. STRAUB, OF PHILADELPHIA, PENNSYLVANIA.

SUB-RIVER TUNNEL.

SPECIFICATION forming part of Letters Patent No. 400,804, dated April 2, 1889.

Application filed January 28, 1888. Serial No. 262,213. (No model.)

To all whom it may concern:

Be it known that I, AMBROSE W. STRAUB, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Sub-River Tunnels, of which the following is a specification.

My invention has relation to the form of sub-river or aqueous tunnels the sections of which are built or constructed above ground and floated to and lowered into a prepared line of way previously dredged or otherwise made in the river-bottom.

My invention comprises the construction or building on the surface of cylindrical tubular metal tunnel-sections, of which, preferably, two extended lengths or sections constitute the bank or shore approaches, which, when inserted into position at the bottom of the river, have a downward grade and are connected to the intermediate or central sections by short sections, said connections being accomplished within removable caissons built in the river around the adjacent ends of the shore and central sections, and all of said sections being anchored by a top and partial side covering of cement and broken stone.

In carrying my invention into practice I proceed substantially as follows: The line or route of the tunnel being determined, I select a point or location at a suitable distance from each shore or bank, which points or locations are for convenience of description called the "terminal" or "meeting" points of the center and shore-approaching tunnel-sections, whereat are located suitably-constructed foundations and caissons arranged at right angles to the line of the tunnel to admit of lowering said sections to and laying or sinking them upon the previously-prepared river-bottom, and of finally connecting them together to form a continuous tunnel. When these caisson points or locations are determined, the river-bottom is dredged or washed away on the line of the tunnel from bank to bank to form a channel or way of a depth and cross-section somewhat larger than the diameter of the tunnel. At right angles to this channel or way at the caisson points or locations other channels or ways are dredged or otherwise cut out, and in these transverse channels are deposited suitable foundations consisting of a flooring or raft having end boxes, suitably weighted between which and above the flooring is an open space, through which the tunnel passes. Upon the end boxes are secured upright weighted columns of preferably oblong form in cross-section corresponding to and being flush with the foundation-boxes. These columns extend upwardly to some distance above high-water mark, and are suitably weighted, so as to prevent their displacement, and are at their upper ends suitably connected, as desired. Upon the upper ends of these columns or upon their connections are preferably located the engine or other power houses required, as hereinafter stated.

During the time that the river-bottom is being dredged or channeled and the foundations and columns built, as above described, the tunnel-sections are being constructed upon the shore or bank or other suitable locality. These tunnel-sections may be built as desired; but I prefer to make them of boiler-plates suitably riveted together, with outside longitudinal peripheral ribs or flanges, removable closed ends or bulk-heads, and corresponding central internal bulk-heads or partitions, internal removable brace-rods and end worm-wheels, bearings, and water and air pipes passing through each end to the interior of the tunnel-sections. The latter when completed are floated to the columns or caisson points previously built in the river, as above described, and their ends are suitably mounted upon bearing-frames moving in guides or ways secured to the columns and also upon power-frames having corresponding guides or ways and gear or power connection between the worm-wheels on the tunnel-section and the power or engine appliances located on the top of said columns. Said sections at their ends are also provided with suitably-constructed gates of a width wider than the distance between the columns and of a length extending from the bottom of said foundations to above high-water mark. As soon as the tunnel-section so floated is in position with its appurtenances between the columns, as described, and its ends and the air and water pipes connected to suitable pumping-engines located on said columns,

the section is lowered into the ditch or way previously dredged or cut out, and after reaching the latter it is rotated to admit of its longitudinal peripheral flanges removing from said way or channel any loose material or dirt deposited in said way or channel after it has been dredged or formed, so as to admit of the section obtaining for itself a firm and level foundation throughout its entire length. As the section is sunk or lowered into position the gates affixed to its end assume a vertical position and come in contact with the sides of the columns to form between said parts a portion of the walls of caissons leading down between said columns to the end of the tunnel-section. After all the sections are in place the water in the caissons is duly pumped out to admit of access to said section ends for the purpose of connecting them together to complete the continuity of the central sections with the shore-approaching sections, all as hereinafter set forth.

My invention accordingly consists of the combinations, constructions, and arrangements of parts as hereinafter described and claimed.

Reference being had to the accompanying drawings, wherein Figure 1 represents a cross-section, partly in elevation, indicating a river and showing a completed tunnel with the foundations and boxes at the caisson-points removed and embodying my invention; Fig. 2, a like view of tunnel laid across a river-bottom in accordance with my invention, the foundation and boxes for the meeting-terminals of the central and shore or bank sections or caisson-points being shown left in position after the tunnel is completed. Fig. 3 is a cross-section of the tunnel completed or laid, drawn to an enlarged scale, and showing the top weighted and cemented covering or anchoring therefor; Fig. 4, a plan, partly sectional, of the meeting terminals of a central and a shore or bank section, or one of the caisson-points therefor, showing the caissons fully formed and by dotted lines the section of tunnel uniting said terminals. Fig. 5 is a cross-section of the metal tunnel, showing the removable cross-rods therein for bracing the tunnel-section while being conveyed to and sunk to the river-bottom; Fig. 6, a rear view of caisson-gate, showing packing therefor; Fig. 7, a section, partly in elevation, on the line 1 1, Fig. 4, showing the foundation, boxes thereon, columns on said boxes, one of the gates forming the caisson, power-houses on the columns, the tunnel, and bearing-frame therefor; Fig 8, a like view on line 2 2, Fig. 4, showing the power-frame and appliances for rotating the tunnel-section when it is lowered to the river-bottom; Fig. 9, a longitudinal section of a part of one of the tunnel-sections drawn to an enlarged scale, showing one of the removable ends or heads for the section and the air and water pipes therefor; Fig. 10, a sectional elevation of a tunnel-section, showing said air and water pipes at each end and middle bulk-head in the tunnel to divide it into two compartments, the removable cross-stay or brace-rods not being shown; and Fig. 11, an elevation, partly in section, of part of the bearing-frame for the tunnel-section.

A represents a river-bottom, across the line of which is dredged or otherwise formed a ditch, channel, or way, a, of a depth and width substantially larger than the diameter of the tunnel B.

At two or more points located as desired from the shores or banks and at right angles to the way or ditch a are ditches or ways a' for the reception of foundations C, having end boxes, c c, with intervening open space c'. These foundations I prefer to make of the nature of a suitably-constructed raft or flooring of timbers c^2, the top surface of which is on a level with the bottom of the channel or way a. The end boxes or chambers, c c, are also made of wood, suitably calked or made water-tight, and are stone or otherwise weighted or ballasted to sink said foundation and boxes to their position in the ways or ditches a'. The boxes are in width or length flush with the longitudinal edges of the raft-floor c^2, as shown in Fig. 4.

Upon or to the boxes c c are secured in any suitable manner upright columns or towers D D, which I prefer to make of wood, calked or made water-tight on all four sides, and having preferably a bottom, d, as shown. These columns or towers project some distance above high-water mark, as shown in Figs. 7 and 8, and are duly weighted or ballasted, as deemed most convenient, and indicated at d^6, to keep them in position against displacement by tidal, floating, or other influences, and to further maintain them both in a rigid position relatively to one another they are connected at their upper ends by beams d' d', which form a flooring for one or more engine or power houses, F F', as indicated in full and dotted lines, Fig. 8.

To the opposing sides of the columns or towers D are secured ways or guides d^2 d^2 and d^3 d^3, for the reception of frames G and H, respectively. The frame G at its lower end is provided with bearing-blocks g of a diameter corresponding to the largest or exterior diameter of the tunnel-sections, for a purpose hereinafter described. The frame H has mounted upon it one or more vertically or otherwise located worms, h, and gearing h' therefor, which is connected to a drawing or driving chain or belt, h^2, leading from the power or engine house F. These frames have a sliding or up-and-down movement in the ways or guides d^2 d^2 and d^3 d^3 on the columns D D. The driving-chain h^2 for the gearing on frame H is suitably taken up or let out, as the up-and-down movement of frame H requires.

The tension device for belt or driving chain h^2 may be located in the power or engine house, and is not shown in the drawings, as such devices are well known, and the detail

construction and arrangement of same form no part of my invention.

The tunnel-sections B′ B^2 B^3 are constructed or built on the banks or shores of the river adjacent to the location intended for the tunnel, and these sections are preferably made in one length—that is to say, the central or middle section, B^2, of the tunnel between the two shore-sections B′ B^3 is preferably made in one piece, as also are the shore-approaching sections; but they may be otherwise constructed, or, if desired, may be composed of more than one section. These sections, especially the middle section, B^2, is preferably composed of boiler-plates riveted together in any suitable manner. These plates may be so formed that when united a series of exterior longitudinal peripheral ribs, *b*, are formed on the section, or said ribs may be otherwise secured to the outside of the tunnel-section, as desired.

In the interior of the tunnel-section at intervals are secured stay or cross rods *b′*, which are so secured in position that they are removable from the section. To effect this suitable brackets are secured to the inside of the tunnel-sections, as indicated at b^2, and the rods *b′* are right and left threaded or bolt-connected to said brackets, as desired.

At or near the middle of the tunnel-sections is secured in any suitable manner a removable bulk-head or partition, b^3, and at each end are corresponding ends or heads b^4, having a central stuffing-box, b^5, and opening b^6, for the passage of a tube, b^7, which is provided with a valve, b^8, having operating rod or lever b^9, and through which passes an air-tube, b^{10}. The latter after entering the sections preferably projects upwardly therein, and the former or water-tube, b^7, taking the reverse direction, as indicated. At or near each end of said section on the outside is secured a worm-wheel, b^{11}, and to the rear of the same the intervals between the flanges are filled up with blocks or segments b^{12}, of wood or other material, to form a smooth or round surface or bearing b^{13}. Before or after the tunnel-sections are floated to the caisson-points, as desired, gates or caisson ends I, having at their lower ends circular openings *i*, fitting the bearings b^{13} of said sections, are mounted thereon, which gates sink with the sections, and as they sink they assume a vertical position and overlap and bear against the sides of the towers or columns D and the flooring c^2 to complete the caisson K between said columns. (See Fig. 4.) The joint between the gate and tunnel-section is suitably packed as deemed necessary; but I prefer to employ an elastic annular flap, *k*, surrounding and embracing the tunnel-section and secured to the outside of the gate, so that the pressure of water will close said flap upon the bearing b^{13} of said section to form a water-tight joint. The meeting-surfaces of the gate and tower or columns and flooring c^2 are also suitably packed; but I prefer to fasten to the gate a flexible tubing, *n*, which is connected to a water or other pump in the pumping or engine house F, so that when said gate is in position the tubular packing may be filled with water or other material to swell out or adjust said tubular packing, as required, at different points to effect a water-tight joint between said meeting parts. This tubular packing and its connections are plainly shown in Figs. 6 and 8. After the tunnel-sections are floated to the caisson-points and the gates I, duly affixed thereto, the bearing-ends b^{13} of the sections are inserted in the frames G and the worm-wheels b^{11} on the sections placed in engagement with the gearing on the power-frame H, whereupon said tunnel section and frames are lowered until the section begins to sink into the ditch or way *a*, at which time the power appliances on frames H are rotated to revolve the tunnel-section and cause its peripheral ribs *b* to scoop or take up loose dirt or débris deposited in said channel after being formed, and thereby obtain its proper and level position in said way throughout its entire length.

To easily and readily sink the tunnel-sections, the valves b^8 are opened to fill the chambers in the tunnel-section, and in sinking, if one end descends faster than the other or there is any irregularity in alignment of the tunnel-section as it descends, part of the water in one or the other of the section's chambers is pumped out through the tube b^7 and air introduced into said chamber through pipe b^{10} to preserve said alignment.

The pipes b^7 and b^{10} are connected in any suitable manner to the pumping devices in the engine-house F′, as illustrated in Fig. 8.

The stuffing-boxes b^5 on the ends of the tunnel-sections are employed to admit of rotating the latter independently of the water and air pipes b^7 b^{10}. When the sections B′ B^2 B^3 are in position within the ditch or channel *a* at the bottom of the river and the caissons K are duly formed, the latter are pumped out to obtain access to the tunnel-section ends within said caissons, as shown in Fig. 4, for the purpose of uniting them by a short section to complete the tunnel, as indicated by dotted lines, Fig. 4, which short sections may be introduced into the caisson and connected to the tunnel-section ends, as desired. Before doing this, however, or subsequently thereto, as desired, the top of the ditch or way *a* is filled up with broken rock or other material mixed with cement, as indicated in full or dotted lines in Fig. 3, to form an outside bracing, *m*, to maintain the configuration of the tunnel and also to weight or anchor it to prevent displacement of any part of the same by tidal floating or other influences, and further to protect its upper part against injury. As soon as the anchoring *m* for the tunnel-sections, as above described, is completed the end and middle bulk-heads and appurtenances connected thereto are removed from the tunnel sections, as also are the removable braces or cross-rods *b′*, and on the bot-

tom of the tunnel a cement or other desired flooring, m', is constructed, having well-holes m^2 for moisture, from which the latter is from time to time pumped out, and cross-ties m^3 for the railway-tracks m^4. Suitable footways may be formed in the tunnel-sections as desired. After the tunnel-section ends in the caissons K are united by the short sections of tunnels the last-named sections are interiorly finished and exteriorly anchored, as above described, for the main sections to complete the tunnel, whereupon the gates I, towers or columns D, and the appurtenances thereon are alone preferably removed, leaving in position the boxes c c and flooring c^2, as indicated in Fig. 2; but, if desired, the boxes c c may be also removed when the flooring c^2 is not used in the construction of the tunnel, as indicated in Fig. 2.

A tunnel constructed as above set forth, it will be noted, is located at or slightly below the surface of the river-bottom, and preferably does not project above the same, so that it does not in any manner affect the tidal flow of the river or interfere with navigation thereon.

I do not herein claim the method or process of constructing a tunnel across rivers or analogous places as above described, as I intend making the same the subject-matter of a separate application.

As it is obvious that the details of construction of the novel parts above described and the provision of means for carrying out my invention may be greatly varied without departing from the spirit of my invention, I do not limit myself to the same as above set forth.

It will be noted that in all cases the end or shore sections dip or have a downward grade to the central tunnel-sections, which are preferably located below the top of the river-bed, as shown, so as to maintain the depth of the middle channel of the river at a normal depth and avoid interference with the passage of ships or steamers.

What I claim is—

1. A sub-river tunnel composed of a series of long sections separated from each other by short sections which are secured at each end with one of the long sections, and an anchorage of broken material and cement upon the top and at the sides of the tunnel-sections, and the top surface of the anchorage being approximately flush with the river-bed, substantially as set forth.

2. In combination with a sub-river channel or way, a section of a tunnel having longitudinal peripheral ribs in said way, caissons at the ends of said tunnel-section, and power appliances supported upon said caisson and in gear with said tunnel-section to rotate it in said channel or way, substantially as set forth.

3. A tunnel for river-bed, composed of sections and laid in a channel-way in the river-bottom, and having at its joints a foundation and end boxes, between which the tunnel passes, substantially as set forth.

4. The combination of a foundation composed of a flooring having end boxes with intervening space or interval and a tunnel resting on said flooring between said boxes, substantially as set forth.

5. In combination with a sub-river channel or way, a foundation composed of a base-plate or flooring having end boxes with intervening space or interval, columns or piers on said boxes, power appliances on said columns or piers, movable frames, and guideways therefor on said columns, substantially as set forth.

6. The combination of a foundation composed of a flooring or base-plate having end boxes with intervening space or interval, columns or piers on said boxes having power appliances and movable frames, gates or sides for said columns to form caissons between the columns and gates, and a tunnel resting on said flooring between said boxes and passing through said gates, substantially as set forth.

7. A metal tunnel-section having removable bulk-heads and interior stay-rods to retain the form of the section while building the section and floating and sinking it to position at the bottom of the river, substantially as set forth.

8. In combination with a sub-river channel or way, a section of a tunnel, removable caissons at the ends of said tunnel-section, and power appliances upon said caissons in gear with the tunnel-section, substantially as set forth.

9. A tunnel-section having end and middle removable bulk-heads, stuffing-boxes on the end bulk-heads, and air and water pipes passing through said end heads, substantially as set forth.

10. The combination, with sub-river tunnel-sections, the caisson-foundation C, uprights D D, and gates or ends I, having openings for the passage of the tunnel-sections, and packing between said uprights and the gates or sides and between the latter and the tunnel-sections, substantially as set forth.

11. The combination, with tunnel-sections B^2 B^3, of a removable caisson having removable ends I, through which said tunnel-sections pass, and slides or frames G H, substantially as set forth.

12. A tunnel-section having exterior longitudinal ribs, removable end bulk-heads, stuffing-boxes on the end bulk-heads, air and water pipes passing through said end heads, and outside gear-wheels at or near the ends of the section, substantially as set forth.

13. The combination of a caisson having frames H and power appliances, and a sub-river tunnel-section having outside gear-wheels connected to said power appliances, as and for the purpose set forth.

14. In combination with a sub-river channel, a tunnel-section, removable caissons for said section, and power appliances on the caissons in gear with the tunnel-section for

lowering the latter to and for rotating it in the subway, substantially as set forth.

15. The combination of foundation C, having open ends, and side columns or towers, D, and the gates or ends I, substantially as set forth.

16. In combination with a sub-river channel, tunnel-sections, and removable caissons located at the opposing ends of successive tunnel-sections, substantially as set forth.

17. In combination with a sub-river channel, tunnel-sections separated from each other, so as to leave a space between their ends, and removable caissons joining said ends, substantially as and for the purpose set forth.

In testimony whereof I affix my signature in presence of two witnesses.

AMBROSE W. STRAUB.

Witnesses:
S. J. VAN STAVOREN,
CHAS. F. VAN HORN.