Jan. 9, 1923.

1,441,698

J. C. MEEM.

TUNNEL CONSTRUCTION.

FILED APR. 13, 1922.

2 SHEETS—SHEET 1.

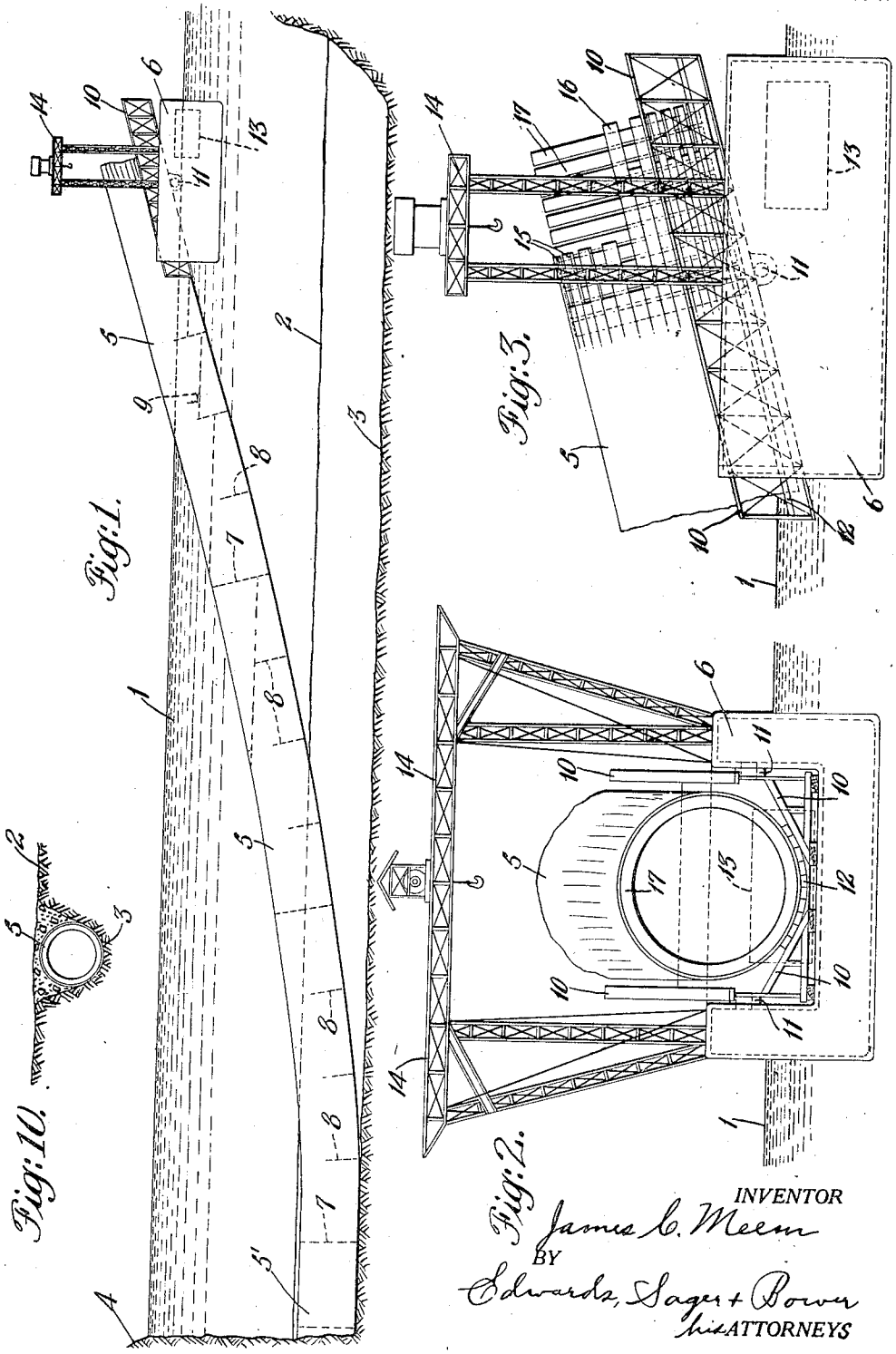


Fig. 1.

Fig. 3.

Fig. 2.

Fig. 1a.

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2 SHEETS—SHEET 2.

Fig: 4.

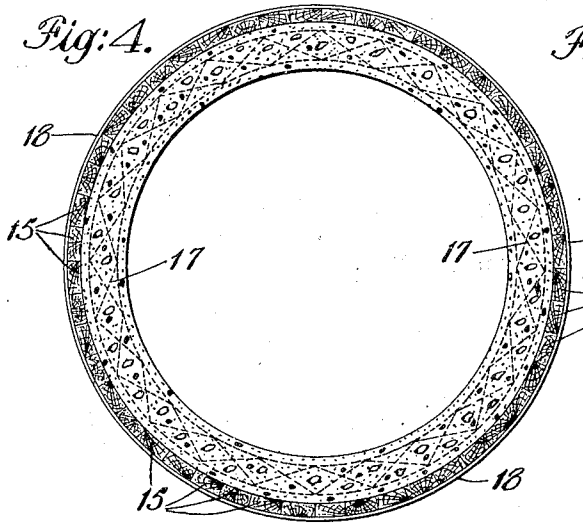


Fig: 5.

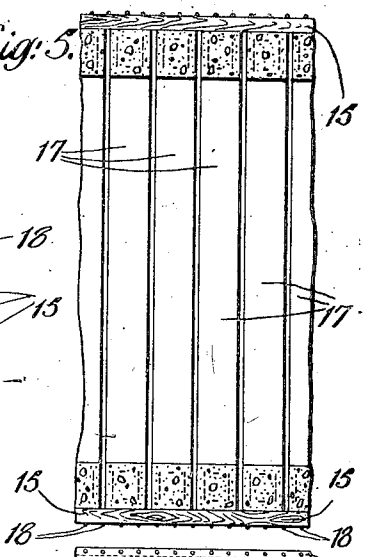


Fig: 6.

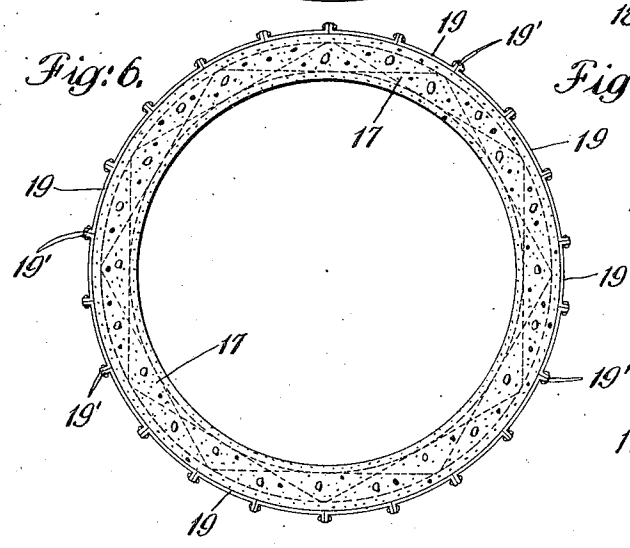


Fig: 7.

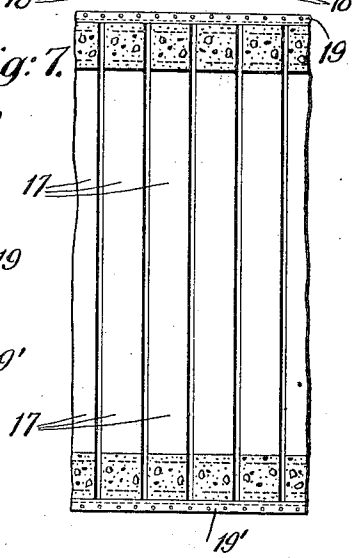


Fig: 9.

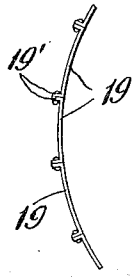
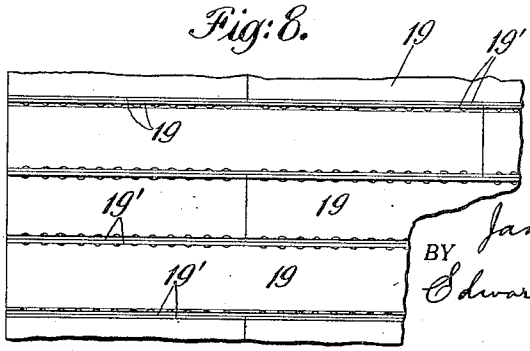


Fig: 8.



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UNITED STATES PATENT OFFICE.

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TUNNEL CONSTRUCTION.

Application filed April 13, 1922. Serial No. 552,075.

To all whom it may concern:

Be it known that I, JAMES C. MEEM, a citizen of the United States, residing at Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Tunnel Constructions, of which the following is a specification.

This invention relates to a method of building and laying a subaqueous tunnel adapted for use by cars, trains, vehicles, or as a tunnel or conduit for any purpose desired. The method and form of construction is adapted for any required size of the tunnel and any number of trackways or roadways; and may be circular in form or elliptical, oval or of other form of cross section to suit the particular requirements.

The main object of my invention is to provide a method and form of construction, especially adapted for comparatively long distances, and which may be carried out with economy, rapidity of construction and safety, while at the same time attaining great strength and durability of construction. Another object is to provide a method and form of construction which will permit the tunnel to lie near the surface of the bed of the river or other body of water, thus shortening the length of and reducing the grades required with the usual forms of construction. Another object is to provide a method and form of construction which may be proceeded with continuously and which is adapted for practically any length of tunnel and for any size or type of cross section. These and other objects and advantages of my invention will be understood from the following description and accompanying drawings.

Fig. 1 is a side view showing the tunnel in the process of construction and laying in place. Fig. 2 is an end view of the construction barge showing a section of the tunnel in place on its cradle. Fig. 3 is a side view of the construction barge and showing the side view of the tunnel at the end under construction. Fig. 4 is a cross section of the tunnel as formed on the construction barge showing one form of construction. Fig. 5 is a sectional view taken longitudinally of the tunnel as formed on the construction barge; Fig. 6 is a cross section of the tunnel as built on the construction barge and showing a modified form of construction; Fig. 7 is a vertical longitudinal section of the tunnel as constructed on the barge; Fig. 8 is a side view of a portion of the plates used in the form shown in Figs. 6 and 7; Fig. 9 is an end view thereof, and Fig. 10 is a section showing the tunnel in final position on the bed of the river, harbor or other body of water.

According to this method, the tunnel is built on a floating barge in the form of a shell which may be of wood or steel and there is added thereto interior strengthening means such as precast concrete ribs spaced sufficiently from each other to allow the necessary flexibility in laying the tunnel. The tunnel is built continuously after the preliminary building of one section and sinking one end in place. With that end in place, on a dredged bottom, and the other end resting on the floating barge, the barge is gradually moved ahead as the tunnel is constructed and payed out.

A length of the tunnel is first built on temporary barges with one end resting on the main construction barge. This length will depend upon the size of the tunnel and may be from 500 to 700 feet in length for a tunnel adapted to have trackways. This first section is towed into position and one end is allowed to sink into its place on a dredged bottom, the temporary barges being scuttled and the tunnel being allowed to be filled with water to more readily accomplish this. With the fixed end in place on the bottom, the tunnel rises in a gradual curve to its place on the permanent construction barge. The radius of curvature of the tunnel in its rise to the barge will be such as not to exceed the permissible flexibility of the tunnel as constructed and may be in some cases of 2,000 feet radius. The construction barge carries a rocking cradle which may be of lattice-girder construction and the end of the tunnel under construction is built on and carried by this cradle, which will adapt itself to the proper angle of the tunnel at the tangential end of the curve formed by the tunnel.

Fig. 1 shows the method and arrangement generally, the mean water level being indicated at 1, the normal bottom at 2 and the dredged area for receiving the tunnel being indicated at 3. One shore or starting end of the tunnel is indicated at 4. The tunnel 5 is shown with one end 5′ in position on the bed near the shore, at which point the tunnel may be continued to the left of the

figure by other methods of construction. The tunnel is shown rising to the right of the figure on a very gradual curve to the construction barge 6. At suitable intervals, which may be from 100 to 300 feet, are formed during its construction on the barge, full section bulk-heads 7 and between them at suitable intervals are a number of lower half or baffle bulkheads 8. As the tunnel is completed and payed out, water is allowed to enter through suitable valves sufficient to let it move gradually to its lowest position and the baffle bulkheads are provided so as to obtain a proper distribution of the water along the upper end of the tunnel as indicated in Fig. 1, so that the water will not all flow to the lower end of the tunnel. The water level in the sections as retained by the bulkheads is indicated by the dotted lines 9 in Fig. 1, and the water permitted to enter is regulated by the valves to suit the requirements and secure the necessary steadiness and submersion of the tunnel. As portions of the tunnel arrive in final position, the inlet valves are closed and the full section bulkheads will permit the water to be pumped out of each section in sucession and the interior of the tunnel permanently finished.

The construction barge 6 is U-shaped at one end as shown in Fig. 2, and forms an inclined trough in which is located the cradle 10, preferably of lattice-girder construction and which is pivotally supported on the barge at 11. The cradle has a base portion 12 conforming generally to the shape of the lower portion of the tunnel and is adapted to support the end of the tunnel under process of construction. The cradle normally assumes an inclined position in the trough of the construction barge and by reason of its pivotal support will assume an angular position adapted to that of the end of the tunnel which is under construction and will adjustably take care of changes in water level due to tides or other causes, and also differences in depth of the tunnel below the mean water level as determined by the depth of the dredged area in which the tunnel is placed. Fig. 3 shows the upper end of the tunnel in place on the cradle and as most of the weight of the tunnel will be carried by one end portion of the construction barge, a suitable counterbalance will be provided at the opposite end of the barge such as a water ballast tank indicated at 13. For convenience in construction the barge is provided with a derrick or with a traveling crane structure 14, shown as having an overhang at the sides for moving construction material from the sides to the cradle, as the construction continues.

During construction the shell of the lower portion of the tunnel is first assembled and in the form shown in Figs. 4 and 5 the shell is made of wooden staves 15 or heavy planking which are relatively staggered or toothed as indicated in Fig. 3. After the lower portion of the staves are assembled in prolongation of the tunnel as indicated at 16 in Fig. 3, a suitable water proofing such as pitch and burlap is then laid over the staves. A series of reinforcing rings 17 of the diameter of the tunnel are then set in place on the lower portion of the tunnel shell. These rings are of reinforced concrete pre-cast and seasoned and are brought alongside the construction barge and set in place as above described by a derrick or the crane 14. The concrete rings will be spaced from each other by a small amount sufficient to permit necessary flexibility of the tunnel and yet give the requisite strength to the construction. In the one trackway tunnel, these rings may have a width of one to two feet and spaced a few inches from each other. The rings may be connected at the springing line by encasing their projecting reinforcing parts in concrete, but the rings are left detached at the top and bottom to allow for vertical flexibility. When a sufficient number of rings are in place to make up a required length of the tunnel, the top half portion of the water-proofing is applied and the wooden staves are added over the outside of the rings and water-proofing to complete the construction of the shell. Hoops of wire cables 18 are then applied and tightened around the tunnel constructed as above and stapled to the staves to permanently bind the tunnel together, the staves being spiked for additional strength. The barge is then allowed to move ahead for the construction of an additional length of the tunnel, while an equivalent length sinks behind to its permanent bed, and the intermediate portion retains the gradual curvature up to the construction barge.

Instead of using a wooden stave or barrel type of construction, the shell may be made of steel plates 19, and in the form shown in Figs. 7, 8 and 9, the steel plates are of comparatively long length in the form of channel bars arched to conform to the diameter of the tunnel and have ribs or flanges 19′ at their edges shown in Fig. 9. These steel plates extend lengthwise of the tunnel and are assembled in staggered relation as shown in Fig. 8 and the flanges riveted, bolted or welded together. The abutting ends of the plates may be welded in place on the construction barge as assembled. With this construction the general method of assembly is the same as above described, the lower portion of the steel shell being first assembled on the barge and water-proofing added on that portion if necessary. The rings 17 are then successively lowered into

place in the lower portion of the shell as already described and the upper portion of the shell then added to complete the same around the concrete rings. The steel shell will have sufficient flexibility to permit the tunnel to assume the required curvature from the barge to the bed and the spaced rings fitting within the shell will similarly allow sufficient flexibility.

As the sections of the tunnel are finally laid in place, the water is pumped out from the permanently laid sections between full bulkheads and the interior of the tunnel is completed by filling in the spaces between the ribs with concrete and cement, and thus permanently lock the cement rings together.

While the tunnel built as above described is sufficiently flexible in long lengths, yet in short lengths the tunnel has greater longitudinal strength and stability than any other form of construction heretofore proposed or built. It also enables the tunnel to adapt itself more safely and economically to the dredged bottom by bridging the hollows and pressing down the peaks. This method of construction is also well adapted to join special sections of tunnel under water where necessary under certain conditions; such as having to build a tunnel under a very wide bay, where it could be constructed in several sections simultaneously, the abutting ends being subsequently joined under water. In the case of an unusually long tunnel it may be advantageous to work from the middle towards each shore simultaneously; that is, building and submerging the middle or central portion first and constructing the shoreward ends each on its own construction barge or float. The upper surface of the tunnel and the sides may be covered or filled in around the tunnel with concrete or other material as shown in Fig. 10 for more permanently bedding the tunnel in place.

Although I have described a preferred method and form of construction, the same may be varied without departing from the scope of this invention, as may be desired to suit the requirements for different sizes and shape of tunnels and various other considerations.

I claim:—

1. The method of constructing a subaqueous tunnel which consists in constructing the tunnel on a floating support by forming a tunnel shell and locating a succession of rings within the shell and paying out the tunnel from the floating support as the construction progresses.

2. The method of constructing a subaqueous tunnel which consists in constructing the tunnel on a floating support by forming a tunnel shell and locating a succession of concrete rings within the shell and paying out the tunnel from the floating support as the construction progresses.

3. The method of constructing a subaqueous tunnel which consists in constructing the tunnel on a floating support by forming a tunnel shell and locating a succession of rings within the shell spaced from each other and paying out the tunnel from the floating support as the construction progresses.

4. The method of constructing a subaqueous tunnel which consists in constructing the tunnel on a floating support by forming a tunnel shell and locating a succession of concrete rings within the shell spaced from each other and paying out the tunnel from the floating support as the construction progresses.

5. The method of constructing a subaqueous tunnel which consists in constructing a lower shell portion of the tunnel on a floating support, placing thereon a series of rings, completing the upper portion of the shell over the rings, and paying out the tunnel from the floating support as the construction progresses.

6. The method of constructing a subaqueous tunnel which consists in constructing a lower shell portion of the tunnel on a floating support, placing thereon a series of rings spaced apart from each other, completing the upper portion of the shell over the rings, and paying out the tunnel from the floating support as the construction progresses.

7. The method of constructing a subaqueous tunnel which consists in constructing a lower shell portion of the tunnel on a floating support, placing thereon a series of rings spaced apart from each other, completing the upper portion of the shell over the rings, and paying out the tunnel from the floating support as the construction progresses and filling in the spaces between the rings after the tunnel has taken its permanent position.

8. The method of constructing a subaqueous tunnel which consists in constructing the tunnel on a floating support, paying out the tunnel from the floating support as the construction progresses, permitting water to enter the tunnel near its upper end, and providing baffle bulkheads for causing the water in the partially filled tunnel to be distributed along its length.

9. The method of constructing a subaqueous tunnel which consists in constructing the tunnel on a floating support, paying out the tunnel from the floating support as the construction progresses, permitting water to enter the tunnel near its upper end, and providing baffle bulkheads for causing the water in the partially filled tunnel to be distributed along its length and providing full bulkheads in the tunnel at greater intervals than the intermediate baffle bulkheads.

10. The method of constructing and lay-

ing a subaqueous tunnel which consists in building a length of the tunnel on floating supports and extending one end to a construction float, then sinking the tunnel carried by said supports while retaining one end on said float, continuing the construction of the tunnel on said float, and paying the tunnel out from said float as the construction progresses.

11. The method of constructing and laying a subaqueous tunnel which consists in building a length of the tunnel on floating supports and extending both ends to construction floats, then sinking the tunnel carried by said supports while retaining both ends on said construction floats, and paying the tunnel out from said floats as the construction progresses.

12. The method of constructing and laying a subaqueous tunnel which consists in building a length of the tunnel on floating supports and extending both ends to construction floats, continuing the construction of the tunnel on said floats, paying the tunnel out from said floats as the construction progresses, and finally sinking said completed section and joining to completed sections already in place.

JAMES C. MEEM.