

H. A. CARSON.  
SUBMARINE TUNNELING.  
APPLICATION FILED NOV. 24, 1902.

NO MODEL.

3 SHEETS—SHEET 1.

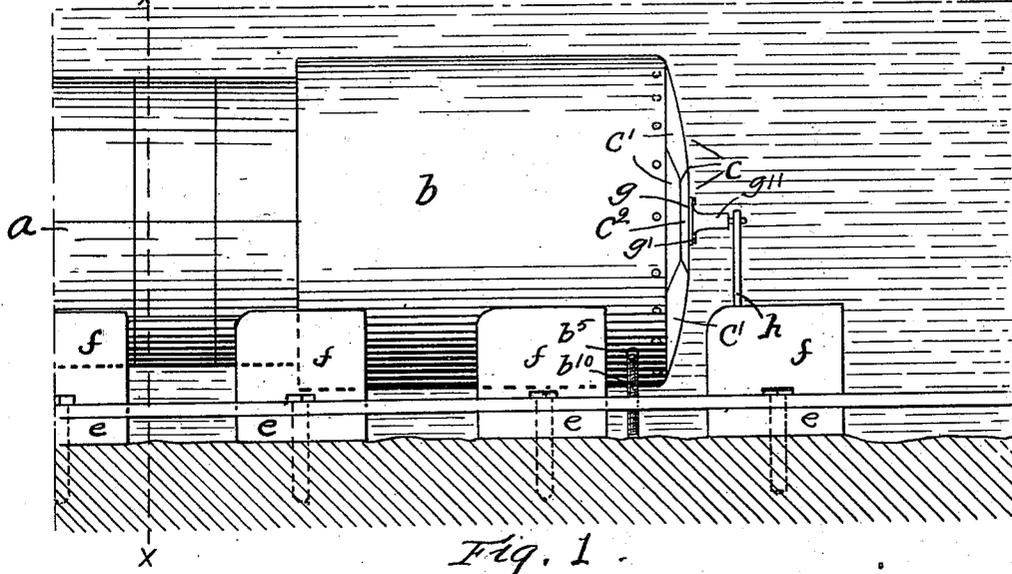


Fig. 1.

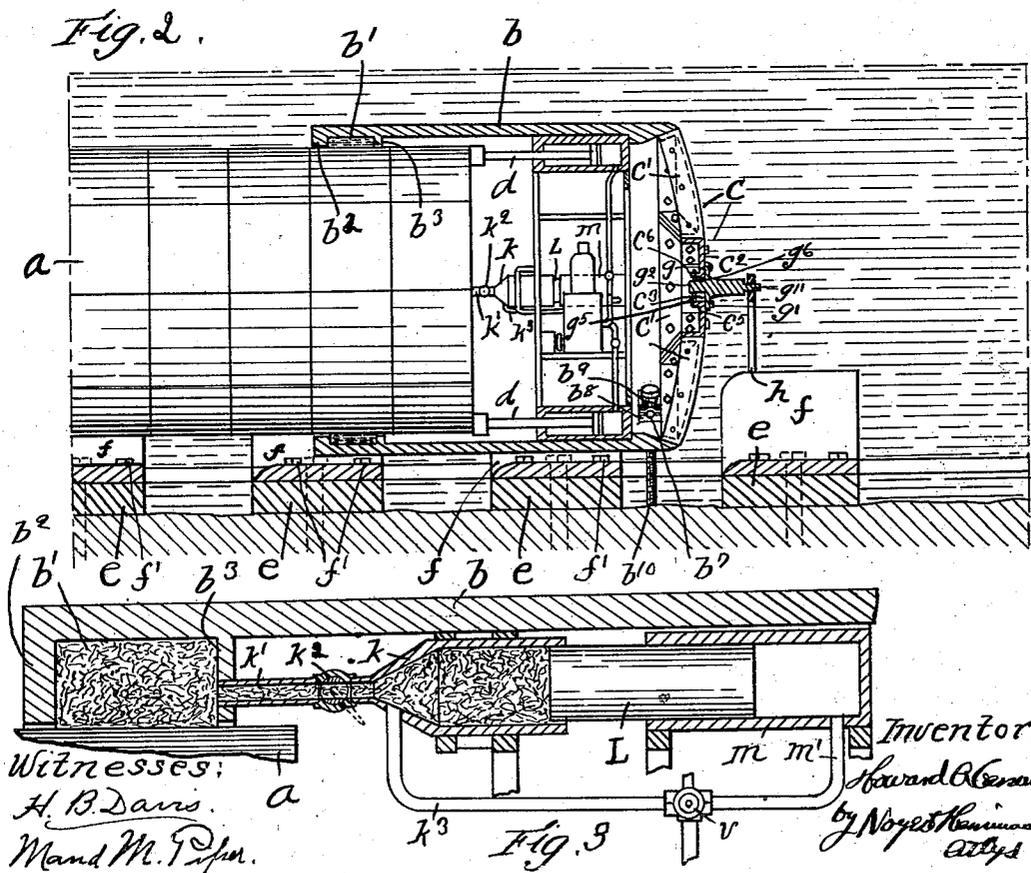


Fig. 2.

Fig. 3.

Witnesses:  
H. B. Davis. a  
Mand M. T. P. m.

Inventor:  
Howard A. Carson  
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attys



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3 SHEETS—SHEET 3.

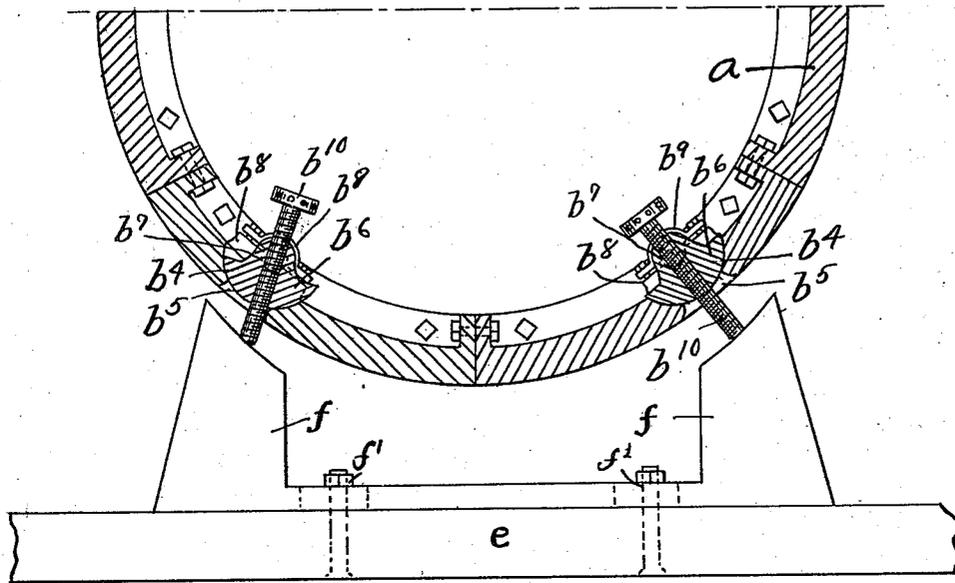


Fig. 10.

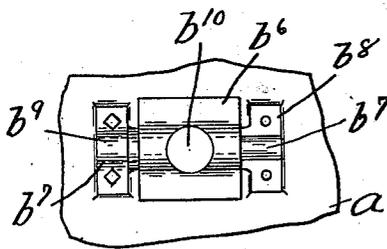


Fig. 11.

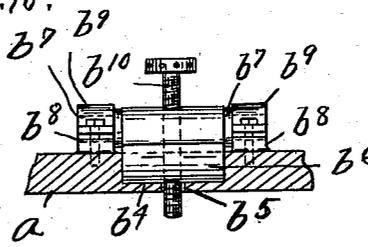


Fig. 12.

Witnesses:

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Maud M. Piper.

Inventor:

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# UNITED STATES PATENT OFFICE.

HOWARD A. CARSON, OF MALDEN, MASSACHUSETTS.

## SUBMARINE TUNNELING.

SPECIFICATION forming part of Letters Patent No. 723,986, dated March 31, 1903.

Application filed November 24, 1902. Serial No. 132,551. (No model.)

*To all whom it may concern:*

Be it known that I, HOWARD A. CARSON, of Malden, county of Middlesex, State of Massachusetts, have invented an Improvement in

Submarine Tunneling, of which the following description, in connection with the accompanying drawings, is a specification, like characters on the drawings representing like parts.

This invention relates to certain appliances employed in constructing a tunnel in water.

Tunnels have been made in the earth below water by well-known means; but so far as I am aware none have been built through water except by lowering tubes and connecting them together.

My invention has for its principal object the provision of a form of tunneling-shield which may be employed in constructing a tunnel in the earth and then may be converted so that the same shield may be used for constructing the tunnel in the water.

Another object of my invention is to provide a guiding means for the shield as it is moved forward upon the bottom or bed of the body of water in which the tunnel is laid, so that the tunnel will be built in substantially the desired position, a substantially uniform support being provided for the tunnel after it is laid, and the construction of a tunnel in the water being made practicable.

For an understanding of the means which I preferably employ in carrying out these objects reference is now made to the accompanying drawings, in which—

Figure 1 shows a side elevation illustrating the employment of my invention in building a tunnel in water. Fig. 2 is a longitudinal central section of the device shown in Fig. 1. Fig. 3 is an enlarged detail view of a means for maintaining a water-tight joint between the tunnel and tunnel-shield. Fig. 4 is an end view of the tunnel-shield and guiding means therefor when the tunnel is laid in water. Fig. 5 is a view of the inner side of the front end of the shield. Fig. 6 is a longitudinal sectional view showing the means for passing the shield from earth to water. Figs. 7 and 8 are detail views showing the adjusting means for the shield-gage. Fig. 9 is a cross-sectional view on the line  $x x$ , Fig. 1. Figs. 10, 11, and 12 are enlarged detail

views showing the adjusting means for the shield, Fig. 10 being a cross-section, Fig. 11 a plan, and Fig. 12 a longitudinal section thereof.

In building a tunnel in earth, where the excavation is to be but slightly larger than the tunnel, it has been a common practice in recent years to employ what is known as a "tunneling-shield," which consists, substantially, of a cylinder telescoping on the outside of the tunnel, with its front end more or less open and usually having a sharp front edge, means being provided for forcing the shield forward as the earth is excavated in front thereof and carried through the tunnel as it is built within the shield.

In carrying out my invention I employ similar means, as shown in Figs. 1 and 2, in which  $a$  indicates a common form of tunnel made up in sections or otherwise, and  $b$  a tunneling-shield capable of being employed in earth excavations. In order that said shield  $b$  may be used in water, it is provided with a head  $c$ , said head comprising six or more edge sections  $c'$ , all or most of which are of the same size and shape and are provided with inwardly-bent edge flanges on all sides, which are bolted together and to a seat formed on the inner side of the shield at its front end, and a center section  $c^2$ , of hexagonal form, having flanges which are bolted to the inner edge flanges of the section  $c'$ , as shown in Fig. 5. The sections of said head and their edge flanges are preferably so formed that when they are all bolted together the head will be of convex form, so as to better resist the water-pressure to which it may be subjected. The usual hydraulic jacks  $d$  are provided for forcing the shield forwardly.

In building a tunnel under water by the process herein described an approximation to its required bed must first be prepared, and this will usually be done by dredging a channel or ditch in the bed of the stream to such a depth as may be necessary to reach the desired level or grade. A channel as thus prepared necessarily has an uneven bottom, and to overcome this and other difficulties I provide therein a series of guides for the shield as it is moved forward, which preferably comprise a series of cross-ties  $e$ , each having a pair of cradles  $f$  secured to one side thereof,

said cradles  $f$  being curved on their upper ends according to the curvature of the outer surface of the tunnel and being secured to the ties by any suitable means, as bolts  $f'$ .

5 Said cradles are preferably, though not necessarily, made of metal, as it aids materially in sinking and in holding the cross-ties in place. These ties are placed in position by a diver as fast as the shield is pushed forward, each tie being set before the shield is moved onto it and firmly secured in such a position that the shield will be guided in the desired direction or to the desired position as it is moved onto the cradle. The end of the shield and the corners of the cradles and ties next the shield are preferably rounded or beveled, as indicated in Figs. 1 and 2, so that if the shield should engage the sides of a cradle or tie as it is moved forward it will be more readily guided into the correct position on the same.

In order that the diver may accurately set the cross-ties and cradles for supporting the tunnel and shield in advance of the latter, the head of the shield is provided with an adjustable gage or arm, which may be set from within the shield according to the position thereof. This device may comprise a base-plate  $g$ , which is clamped against the outer side of the middle plate  $c^2$  by means of bolts  $g'$ , which pass through apertures in said plate, which are of somewhat greater diameter than that of the bolts, said plate  $g$  tightly covering a central aperture  $c^3$  in the plate  $c^2$ , through which a projection  $g^2$ , integral with plate  $g$ , extends, this construction permitting adjustment of plate  $g$  with respect to plate  $c^2$  from within the shield. To adjust said plate  $g$  from within the shield, I may employ various devices, and among such the construction shown in detail in Figs. 7 and 8, in which the inner face of the plate  $c^2$  is shown as provided with three lugs  $c^4$ ,  $c^5$ , and  $c^6$ , and said inward projection  $g^2$  is made square and pressed on its upper and under sides by screw-threaded rods  $g^5$ ,  $g^6$ , which pass through the lugs  $c^4$  and  $c^6$  and are provided with nuts  $g^7$ ,  $g^8$ . A screw-threaded rod  $g^8$  passes through the lug  $c^5$ , and nuts  $g^9$  are provided on said rod at the opposite sides of said lug. The inner end of said rod  $g^8$  has a transversely-extending head  $g^{10}$  secured thereto, which is dovetailed in a slot in said projection  $g^2$ , so that the latter may move vertically, but not horizontally, with respect to said rod  $g^8$ . It will be apparent that by turning said nuts  $g^7$ ,  $g^8$ ,  $g^9$  said plate  $g$  may be moved to any desired position within necessary limits. The outer side of the base  $g$  is provided with a centrally-arranged horizontally and forwardly extending arm  $g^{11}$ , and a gage  $h$  is swiveled on the outer end of said arm, so that it may swing in a plane perpendicular to the center line of the tunnel and on an axis which is coincident with the center line of projection  $g^2$ . The length of the gage  $h$  is preferably equal to the distance from the center of

the shield to its outer sides, and the base-plate  $g$  is normally arranged so that the center line of projection  $g^2$  will coincide with the center line of the shield and tunnel. 70

In practice the diver will set the tie next to the one on which the front end of the shield is resting in such a position that the end of the gage  $h$  will just touch the upper curved ends of the cradle  $f$  thereon and then he secures this tie in position, so that when the shield is advanced it will be guided onto the cradle of this tie in the desired alinement with the tunnel already laid. 75 80

If just before the gage  $h$  is to be used by the diver it is found by the engineer in the tunnel that the center of projection  $g^2$  is not in the center of the tunnel, and therefore that the shield has deviated from its proper course, then the plate  $g$  will be moved until the center of said projection  $g^2$  is in said center line, so that when the diver puts the next tie in place it will be adjusted according to the position in which the shield is before it is moved. Therefore the next time the shield is moved forward its deviation from the desired course is corrected as it slides up the inclined side of the cradle and tie. This operation continues until the tunnel is laid, the shield being moved forward from tie to tie successively as they are set, the tunnel being built up inside of the shield and being covered, if expedient, after the shield leaves it. 85 90 95

In the process of tunneling in water it may at times be necessary or desirable to move the front end of the shield up, down, or sideways, and for this purpose I may provide the front end of the shield with two or more adjustable legs. (Illustrated in detail in Figs. 10, 11, and 12.) As shown in Figs. 10 and 12, I provide the shield at each side with a cylindrical-shaped seat  $b^4$ , having a slot  $b^5$  in the middle thereof and midway between its ends. A cylindrical-shaped holder  $b^6$  is fitted in said seat, said holder being provided with trunnions  $b^7$  at each end, which are journaled in bearings, the base portions  $b^8$  of which are secured to the inner side of the shield and the caps  $b^9$  of which are adjustably secured to said base portions by bolts, so that they may force the holder tightly against the seat  $b^4$ , preventing the entrance of water into the shield. By accurately fitting the holders to their seats the use of a packing between them may be avoided. Each holder is provided with a screw-threaded leg  $b^{10}$ , which passes radially through the center thereof and through the opening  $b^5$  in the middle of the seat  $b^4$ . These legs may be made of any suitable length, and the distance which they extend beyond the surface of the shield may be varied by simply screwing them out or in. Said legs may also be tipped to various inclinations by swinging the holders  $b^6$ , in which they are mounted, on their trunnions. With this means the shield may be raised or moved sidewise or obliquely in any direction by forcing the ends of the legs against the surface of the cradles or ties 100 105 110 115 120 125 130

or against the earth, and if it is found necessary to set the guide or tie lower the shield may be temporarily supported on these legs while the tie is being reset, and then the shield  
5 may be lowered. After the shield has been adjusted it may be held in the adjusted position by blocks, wedges, or earth filling, and then the legs may be withdrawn within the holders while the shield is moved forward.  
10 It may be observed in this connection that the weight of the shield will be made but little greater than the weight of the water which it displaces, so that it may be easily moved.

As the outer diameter of the shield is  
15 greater than that of the tunnel, the latter will tend to settle onto the ties and cradles after the shield leaves it. This settling may usually be prevented by earth filling and is usually unobjectionable. It may be prevented  
20 when desirable by providing the tunnel with adjustable legs  $a'$ , as shown in Fig. 9.

In order to prevent leakage of water between the shield and tunnel, I provide the inner surface of the shield with a water-tight  
25 packing, which preferably comprises an annular packing-chamber  $b'$  at its telescoping end between two inwardly-extending ribs  $b^2$  and  $b^3$ , into which a semiliquid material, such as plastic clay, is forced by suitable  
30 means. Such means may consist of a cylinder  $k$ , in which one end of a plunger  $l$  is adapted to operate, said cylinder being secured to the inner side of the shield and connected to chamber  $b'$ . The opposite end of  
35 said plunger is located in a cylinder  $m$ , also secured to the inner side of the shield in alignment with cylinder  $k$ , and air or water may be forced into cylinder  $m$  to force the plunger into cylinder  $k$  by means of pipe  $m'$ . A pipe  
40  $k^3$  may be connected to the end of cylinder  $k$  next chamber  $b'$ , and both pipes  $k^3$  and  $m'$  may be opened to a supply of air or water under pressure or to an exhaust by a three-way valve  $v$ .

A valve  $k^2$  is preferably provided in the pipe connecting the chamber  $b'$  and cylinder  $k$ , which may be closed while cylinder  $k$  is being filled. Said cylinder  $k$  is filled with plastic clay, which is forced into chamber  $b'$   
50 by the plunger  $l$  until it is completely filled. By keeping this chamber filled with clay leakage past the end of the tunnel is in a great measure prevented, even if compressed air is not employed in the tunnel. The tendency of the outside water to enter the shield may be lessened to any desired extent by means of said compressed air, the clay blocking the passage between the tunnel and shield and preventing the air and water from passing  
60 in such passage. Moreover, with this form of packing the outer side of the tunnel need not be as true and smooth as would be required with ordinary packing—such as leather, rubber, or hemp—and while packings  
65 such as these last three are easily injured or destroyed by grit and rough usage a packing such as herein provided may be constantly

renewed, and thus wear indefinitely, while it would be very difficult to renew packings of hemp, leather, &c., while the tunnel is being  
70 laid through the water.

As previously stated, when tunneling in earth the head of the shield is wholly or partly removed, and most tunnels which are laid under water must be started on shore at  
75 some distance from the water. Some means may be desirable in many cases to facilitate the passage of the shield from earth into the water. To accomplish this, I preferably employ the means illustrated in Fig. 6, in which  
80  $n$  indicates an outer tube or hood, of somewhat larger diameter than the shield  $b$ , having one end closed by the removable head  $o$  and the other end open.

The channel in which the tunnel is to be  
85 constructed is dredged as closely to the shore as possible, and then the outer tube  $n$ , which will usually be considerably longer than is conveniently indicated in the drawings, is set in the end thereof in alignment with the tunnel,  
90 with its open end next the shore. Its open end is then covered with earth, much or all of the interior being thereby filled with earth, as indicated in Fig. 6. As said shield  $b$  progresses it will enter the outer tube  $n$ ,  
95 and by the regular process of earth-tunneling it may be moved to near the forward end. When the shield  $b$  is forced into shield  $n$  a sufficient distance, the head  $c$  is secured in place in the front end of the shield  $b$ , as previously described, the water-tight packing is forced into chamber  $b'$ , and then the head  
100  $o$  of the shield  $n$  is removed from the outside by the diver. The construction of the tunnel in the water will then be carried on as before described, the shield  $b$  being pushed on through the outer tube  $n$ , as will be obvious.

Having thus described my invention, what I claim as new, and desire to secure by Letters  
110 Patent, is—

1. In combination with a tunnel, a shield having one end telescoping with the tunnel, a packing of plastic material between the shield and tunnel, and a head for closing the  
115 opposite end of said shield, substantially as described.

2. In combination with a tunnel, a shield closed at one end and having its opposite end telescoping with the tunnel, a packing-chamber  
120 between the inner surface of the shield and the outer surface of the tunnel, and means for forcing plastic material into said chamber, substantially as described.

3. In combination with a tunnel, a shield  
125 closed at one end and having its opposite end telescoped with the tunnel, a pair of inwardly-projecting ribs on the inner surface of the shield adjacent its open end, forming a packing-chamber, and means for forcing plastic  
130 packing into said chamber, substantially as described.

4. In combination with a tunnel, a shield having a head for closing one end and adapt-

ed to telescope with the tunnel at the opposite end, means for moving said shield forwardly, and a guiding-support for said shield arranged in front thereof, substantially as described.

5 5. In combination with a tunnel, a shield having a head for closing one end and adapted to telescope with the tunnel at the opposite end, means for moving said shield forwardly, a guide-support for said shield, and a gage for setting said guiding-support connected to and extending in front of said head, substantially as described.

15 6. In combination with a tunnel, a shield having a head for closing one end and adapted to telescope with the tunnel at the opposite end, means for moving said shield forwardly, a guiding-support for said shield, and a gage for setting said guiding-support connected to and extendible from within the shield, and extending in front thereof, substantially as described.

25 7. In combination with a tunnel, a shield having a head for closing one end and adapted to telescope with the tunnel at the opposite end, means for moving said shield forwardly, a guide for the shield arranged in front thereof, and means for varying the vertical and lateral position of the shield from within the same, substantially as described.

30 8. In combination with a tunnel, a tunneling-shield having one end adapted to fit over the tunnel, a removable head in separable sections for closing the opposite end of said shield, and an outer tube of greater internal diameter than the external diameter of the shield, having a head for closing one end thereof which is removable from without the shield, substantially as described.

40 9. In combination with a tunnel, a shield having a head for closing one end and adapted to telescope with the tunnel at the opposite end, means for moving said shield forwardly,

and means, passing through the walls of the shield, for varying its vertical and lateral position from within the same, substantially as described. 45

10. In combination with a tunnel, a shield having a head for closing one end adapted to telescope with the tunnel at the opposite end, means for moving said shield forwardly, means for moving the shield from within the same comprising a holder having a rounded face, an apertured seat in the shield, means for holding the face of said holder against said seat, and a longitudinally-adjustable leg passing through said holder and the aperture of said seat, substantially as described. 50 55

11. In combination with a tunnel, a shield having a head for closing one end and adapted to telescope with the tunnel at the opposite end, means for moving said shield forwardly, means for moving the shield from within the same comprising a holder having a cylindrical face, a correspondingly-shaped seat formed in the inner side of said shield having an aperture leading to the outer side, a pair of trunnions at opposite ends of said holder, rigid bearings therefor and longitudinally-adjustable legs passing through said holders and said apertures, substantially as described. 60 65 70

12. In combination with a tunnel, a shield having a head for closing one end and adapted to telescope with the tunnel at the opposite end, means for moving said shield forwardly, a guiding-support for said shield arranged in front thereof and having obliquely-disposed guiding-surfaces, substantially as described. 75

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses. 80

HOWARD A. CARSON.

Witnesses:

LOUIS H. HARRIMAN,  
H. B. DAVIS.