J. F. O'ROURKE.

TUNNEL SHIELD.

APPLICATION FILED FEB. 4, 1918.

1,296,312.

Patented Mar. 4, 1919.

3 SHEETS—SHEET 1.

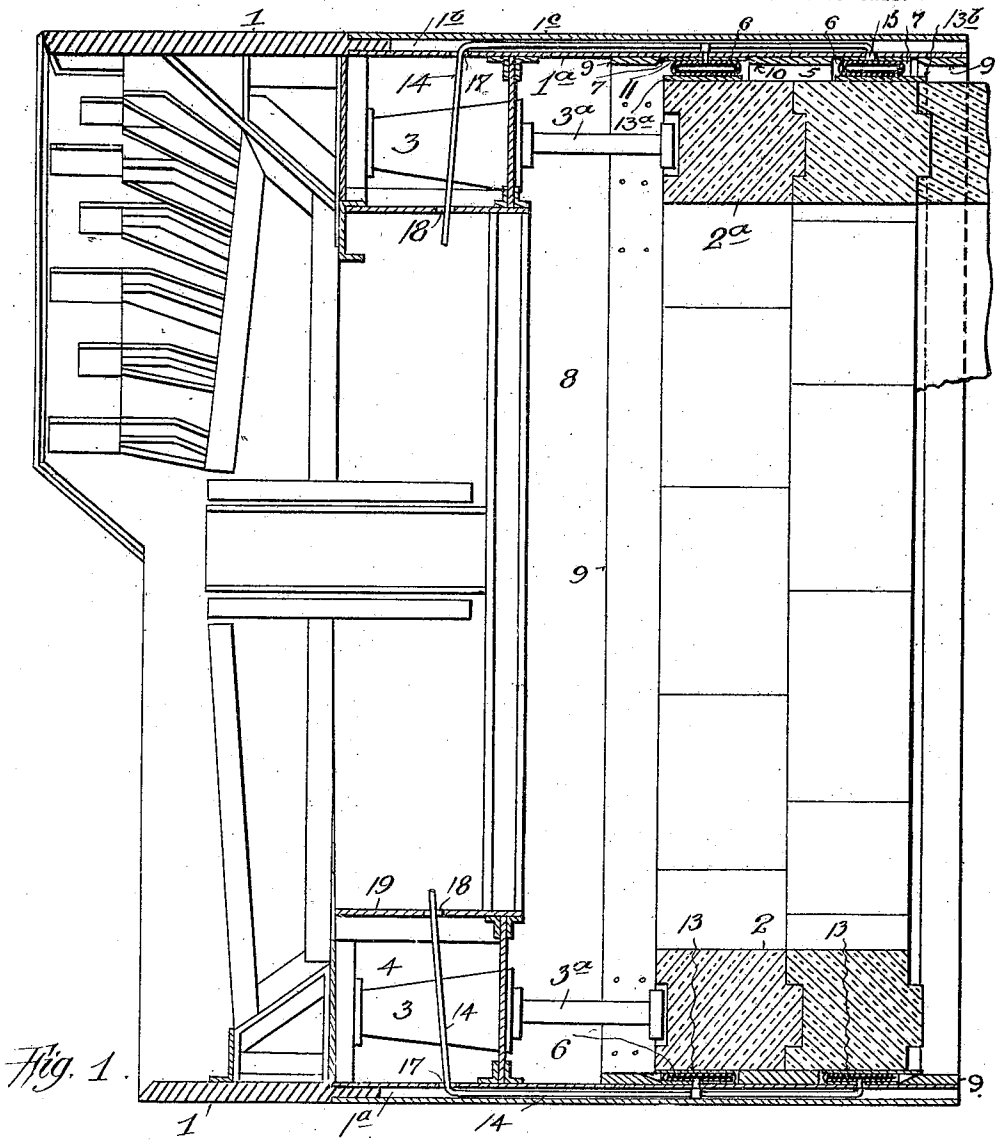

Fig. 1.

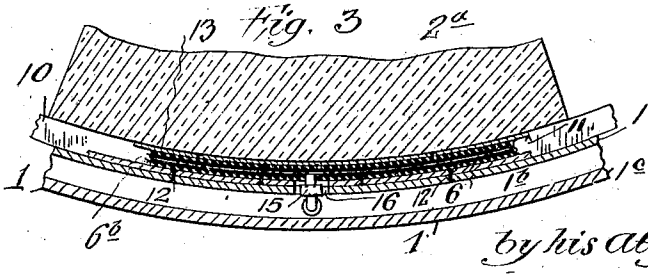

Fig. 3

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3 SHEETS—SHEET 2.

Fig. 4.

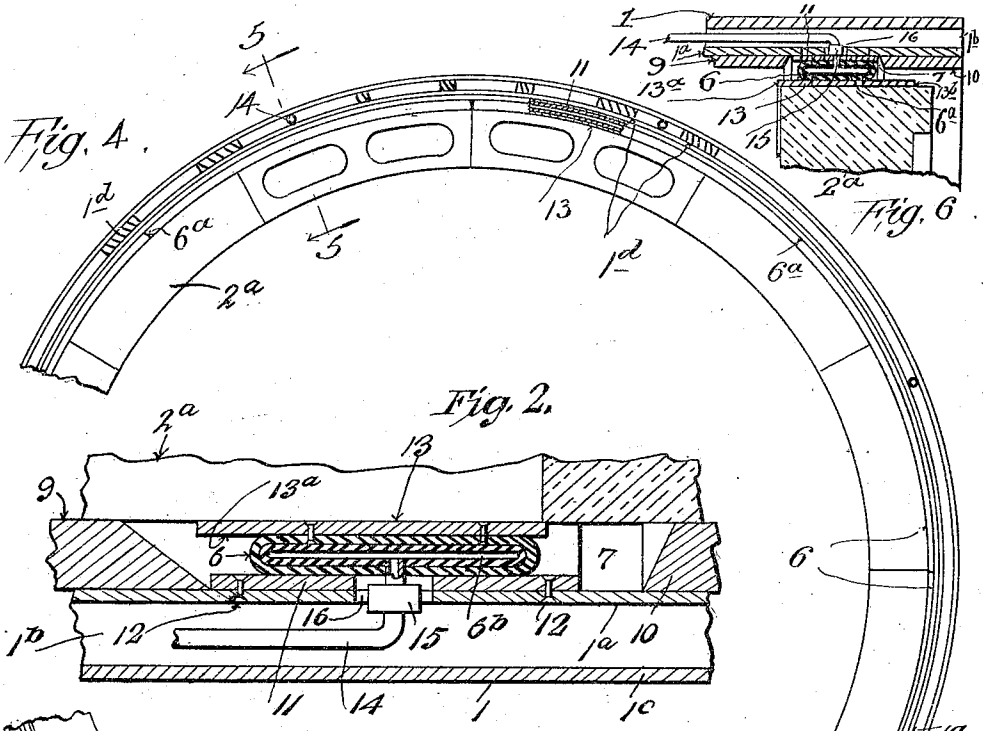
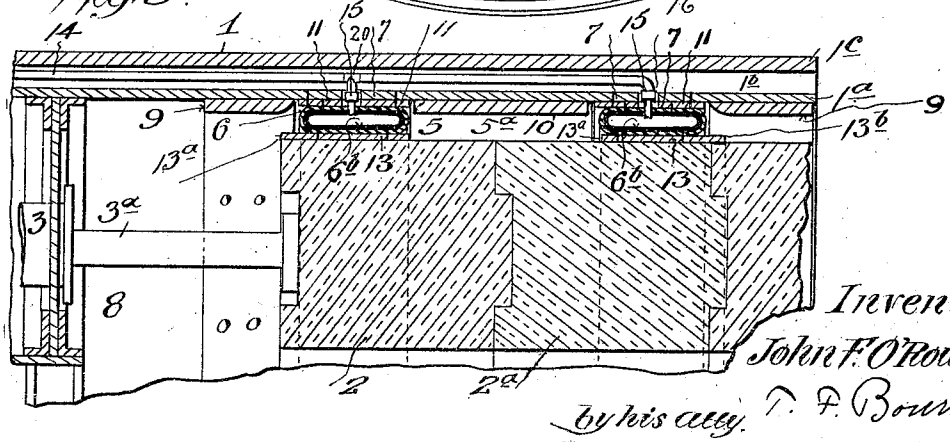


Fig. 6.

Fig. 2.

Fig. 5.



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3 SHEETS—SHEET 3.

Fig 7.

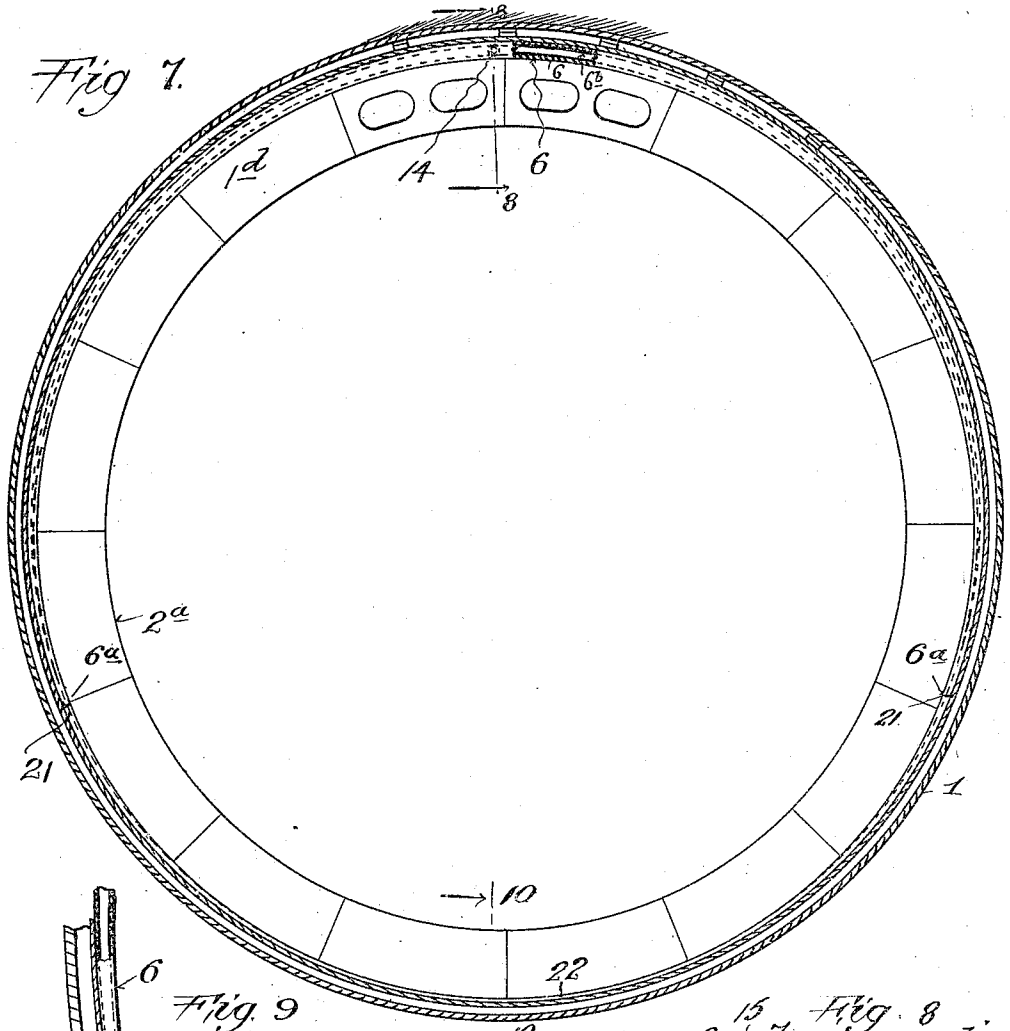

Fig. 9

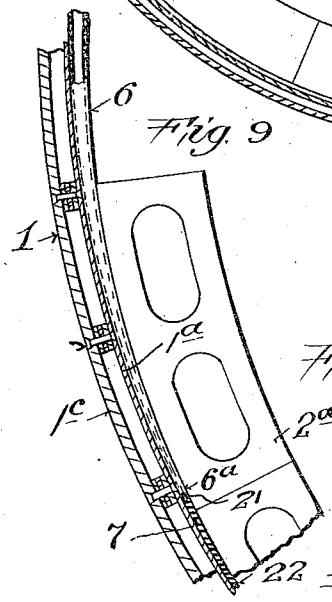

Fig. 8

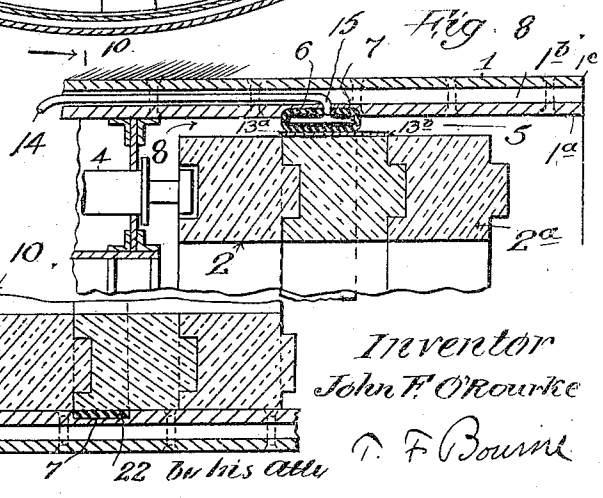

Fig. 10.

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UNITED STATES PATENT OFFICE.

JOHN F. O'ROURKE, OF NEW YORK, N. Y.

TUNNEL-SHIELD.

1,296,312. Specification of Letters Patent. Patented Mar. 4, 1919.

Application filed February 4, 1918. Serial No. 215,231.

To all whom it may concern:

Be it known that I, JOHN F. O'ROURKE, a citizen of the United States, and resident of New York city, borough of Manhattan, in the county of New York and State of New York, have invented certain new and useful Improvements in Tunnel-Shields, of which the following is a specification.

Where tunnels are constructed with the use of a shield, within the tail of which the tunnel lining is erected, step by step as the work progresses, compressed air is used within the shield and within the tunnel to hold back surrounding water and other material. Such lining is of less diameter than the internal diameter of the shield, hence there is a space between the inner surface of the shield and the outer surface of that portion of the lining that is within the shield, through which space air from the tunnel may escape and also through which space water may enter from the outside.

The object of my invention is to provide improved means to block the escape of such air from the shield along the exterior portion of the lining therein, and yet not to interfere with the required shoving of the shield as the excavation for the tunnel proceeds at the forward part of the shield, and also to provide means to prevent flow of water form the ground around the lining into the tunnel through the space between the lining and the shield.

In carrying out my invention I provide a distensible or inflatable tube adapted to fit in the space between the tail of the shield and the portion of the tunnel lining therein, and means to permit distension or inflation of such tube within such space to expand the tube against the inner surface of the shield and the opposing portion of the tunnel lining, and to permit desired degree of collapse or deflation of such tube whenever required, as when the shield is shoved forwardly. For some purposes I prefer to secure a relatively firm or rigid backing to the tube, such as a metal plate, which may be secured to the inner surface of the tail of the shield to retain the tube thereon and prevent its creeping or displacement from the shield when the latter is shoved, which plate facilitates attachment of the tube to the shield or its detachment therefrom. I also prefer to provide said tube, on its face opposing the tunnel lining, with a laterally projecting web, such as a leather strip, adapted to bear against the opposing tunnel lining to assist in making a close joint with the lining, thereby to aid in blocking or preventing the escape of air from the shield or the entrance of water therein.

In a preferred form of my invention I provide the inner surface of the shield with an annular recess within which the aforesaid distensible or inflatable tube is adapted to be fitted, whereby such tube will be opposed on its outer periphery by the material of the shield and on its inner periphery by the material of the tunnel lining. Any desired number of such tubes may be arranged around the inner surface of the skin of the shield, and each tube may be suitably shaped according to the width of the portion of the space between the shield and the tunnel lining in which the tube may be located, and each circle of tubing may comprise one or more sections.

My invention comprises novel details of improvement and combinations of parts that will be more fully hereinafter set forth and then pointed out in the claims.

Reference is to be had to the accompanying drawings forming part hereof, wherein,

Figure 1 is a vertical section through a shield and a portion of a tunnel lining, illustrating my improvements in the space between the shield and lining;

Fig. 2 is an enlarged sectional detail view of the lower part of Fig. 1;

Fig. 3 is a section substantially on the line 3, 3, in Fig. 2;

Fig. 4 is an end view of Fig. 1, partly in section;

Fig. 5 is an enlarged detail sectional view at the upper portion of the shield, taken substantially on the line 5, 5, in Fig. 4;

Fig. 6 is a sectional detail illustrating the shield provided with a single annular recess and a single distensible packing tube;

Fig. 7 is a cross sectional view of the shield illustrating a modification;

Fig. 8 is an enlarged detail section on the line 8, 8 in Fig. 7;

Fig. 9 is an enlarged fragmentary view of a portion of Fig. 7 and

Fig. 10 is a cross section on the line 10, 10 in Fig. 7.

In the acompanying drawings the numeral

1 indicates a shield, which may be of any suitable or wellknown construction, adapted for use in tunnel construction, and at 2 is a portion of a tunnel lining adapted to be erected within the tail of the shield in a well-known manner. The lining illustrated comprises contiguous rings which may be constructed of sections 2^a comprising concrete or metal. At 3 are jacks within the jack ring 4 at the tail of the shield, the jacks having plungers or rams 3^a adapted to operate against the tunnel lining for shoving the shield in an ordinary manner. The portion of the lining 2 erected within the tail of the shield is of less diameter than the interior diameter of the tail of the shield, whereby a space 5 is formed around the lining within said tail, through which space air from within the shield and the tunnel may escape and water from the tunnel boring may enter the shield through such space unless the latter be blocked or closed. It has been customary to block up such spaces with bags of sand, clay or the like, also with movable metal plates at the face of the lining and in contact with the inner surface of the shield. The attempts to prevent the escape of air or the ingress of water with such crude means have never succeeded, so far as I am aware.

In accordance with my invention I provide in the space 5 between the tail of the shield and the periphery of the adjacent portion of the tunnel lining one or more distensible or inflatable tubes, indicated generally at 6, to form a packing to resist the escape of air from within the tunnel and shield through such space, and to block the inflow of water. Said packing tube may be made of canvas and rubber or in any other suitable manner, such as in the general nature of a single or double tube pneumatic tire, capable of withstanding pressure when distended or inflated in space 5 to bear forcibly against the opposing surface of the tail of the shield and the tunnel lining. Said packing tube is shown arranged in circular form within the tail of the shield and may be of any desired length. Tube 6 may be of such a length as will be adapted for convenient handling and such tube will be closed at opposite ends 6^a. A single tube 6 may be used, or several shorter tubes may be used with the ends adjacent, as abutting or overlapping, to form a continuous packing within space 5, as illustrated in Fig. 4. Since the tunnel lining rests upon the bottom of the tail of the shield, and is of less diameter than the inner diameter of said tail, the space 5 is variable in width on opposite sides of a vertical line through the shield and lining, and the diameter of the packing tube 6 may be such as best adapted to fill the corresponding portion of such space when the tube is distended or inflated. The tube or tubes 6 may be made in tapering form, if preferred; as illustrated in Figs. 7 and 8, corresponding with the tapering form of space 5. The inner surface of the skin of the shield, within the tail thereof, is shown provided with an annular recess 7 opposing the portion of the tunnel lining within the tail of the shield, in which recess the corresponding tube or tube sections 6 are fitted, such recess serving to retain the tube in position against the shield when the latter is shoved forwardly along the tunnel lining. There may be two or more of such recesses 7, each containing the tube or tubes 6, spaced apart within the tail of the shield, as illustrated in Figs. 1 to 5, or there may be a single recess 7 within the tail of the shield, as illustrated in Figs. 6 to 10. The position of the recess or recesses 7 is preferably such as to oppose the lining ring or rings just behind the space 8 within the tail of the shield in which a succeeding ring is to be set (Figs. 1 and 5), whereby the ring or rings 6 will not interfere with the setting of a lining ring in the space 8, as indicated in Fig. 8, and whereby when the shield is shoved forwardly the packing ring or rings will be drawn forwardly by and with the shield over the last ring set, substantially to the position indicated in Figs. 1 and 5. Recess 7 may be formed in the tail of the shield in any suitable manner. I have shown the inner surface of the skin of the shield provided with annular rings 9, 10, secured in spaced relation within the tail of the shield, providing the space 7 between said rings, as illustrated in Figs. 1 to 6. Said rings may be riveted to the skin of the shield. Where two or more recesses 7 are provided within the tail of the shield, one or more additional rings may be secured to the shield in spaced relation, such as a ring 9 at the righthand side of ring 10, as illustrated in Fig. 5, where two spaced recesses 7 are shown.

By preference, the packing tube 6 will be secured to a backing plate 11 (one for each tube). Said plate may be of metal, riveted or otherwise suitably secured to said tube and adapted to be secured to the skin of the shield within the corresponding space 7, as by screw studs indicated at 12. The arrangement described permits the packing tubes to be detachably secured to the skin of the shield enabling correct replacement of the tubes, and the backing plate connection between the tube and shield affords resistance to displacement of tube 6 and prevents its separation from the shield when the shield is shoved along the tunnel lining, and when the pressure within the tube may from accident or intention be reduced at any time. By preference, the packing tube

6 will be faced on the surface opposing the tunnel lining with a strip or shoe, indicated at 13, to bear against the tunnel lining, to take wear thereon, which strip or shoe may be of leather and suitably riveted to tube 6. I prefer that at least one edge portion 13^a of strip 13 should project laterally from the side of tube 6, so as to be free to be pressed forcibly against the opposing tunnel lining by air pressure from within the shield, as illustrated at the lefthand side in the drawings, adjacent to the space 8. Where two or more of the packing tubes 6 are spaced apart within the tail of the shield, such tubes or tubes nearest the tail of the shield are preferably provided with webs projecting from the corresponding strip or shoe 13 toward the rear of the shield, as indicated at 13^b. Where a single tube or a single annular series of tubes 6 are utilized within the tail of a shield, I prefer that the strip or shoe 13 have the marginal webs 13^a, 13^b projecting on opposite sides of the tube, as illustrated in Figs. 6 and 10. The projecting portion 13^b serves to obstruct the flow of water into the tail of the shield through the space 5 from without at the rear of the shield. When spaced annular packing tubes are provided (Figs. 1 and 5) there will be a dead space 5^a between said tubes, which may be charged, more or less, with air or water, or both, serving to aid in obstructing the escape of air from the tunnel or the flow of water into the tunnel. The web 13^a, by bearing against the tunnel lining will act to obstruct the outflow of air from the tunnel somewhat in the nature of a valve in an air compressor, and the web 13^b will obstruct the flow of water somewhat in the nature of a valve in a water pump.

By preference, the tube 6 may be provided with an inner tube 6^b, in the nature of the inner tube of a pneumatic tire, and such inner tube 6^b may be connected with a supply hose or pipe 14 in any well known manner. To furnish fluid for distending or inflating the packing tube, I have shown a connection at 15 for hose 14, adapted to enter a hole 16 in the inner wall 1^a of the skin of the shield, as well as to enter a hole in plate 11. The hose or pipe 14 is shown located within a space 1^b between the inner and outer walls 1^a, 1^c of the shield. The hose 14 may extend through an opening 17 in wall 1^a and through an opening 18 in the wall 19 of the jack ring within the shield, whereby such hose may be connected with any suitable supply means for forcing air or water into the distensible or inflatable packing tube 6. When there are two or more annular sets of packing rings 6, one supply hose or tube 14 may be provided for each spaced pair of tubes 6, for connection together by a suitable coupling at 20 (Fig. 5), or each tube 6 may have a separate hose or tube 14 connected therewith. The arrangement of the spaces 1^b within the skin at the tail of the shield between the longitudinal spacing strips 1^d thereof permits of the separate installation of the charging hose or tube 14 free from the tunnel lining without any interference with it or the usual erectors and other instrumentalities within the shield.

In some cases it may not be desired to extend the distensible or inflatable tube or tubes 6 completely around the tunnel lining, and in such cases the inflatable tube may terminate at any desired part of the shield, such as indicated at 21 in Figs. 7 and 9, and the corresponding recess 7 below the points 21 may be provided with a packing 22, such as of solid rubber or analogous material, against which the sections of the tunnel rings may be successively placed, which packing 22 will be of a character adapted to withstand the pressure of the lining ring thereon, acting in the nature of a gasket. In such case the upper ends of the packing 22 and the lower ends 6^a of the adjacent tube or tubes 6 will abut, as indicated in Figs. 7 and 9.

With the arrangements of Figs. 7 to 10 the packing tube 6 may be in a single piece or in sections, as before described.

In accordance with my improvements the packing will be around the portion of the lining within the tail of the shield at all times during the progress of tunneling and may be maintained in distended or inflated form to a desired pressure while a tunnel ring is being installed or erected within the space 8. When the shield is to be shoved forwardly, the pressure within the distensible packing may be reduced to a desired extent to reduce friction and permit the forward movement of the shield without unduly straining the packing, and when the shove of the shield has been completed the packing may be again distended, and so on for each shove of the shield. An advantage of my improvements is that the escape of air from within the tunnel and shield is effectively prevented by reason of the ability to maintain a desired pressure within the distensible or inflatable packing to force it against the opposing walls of the shield and tunnel lining, in a uniform manner all around, whereby the expense of maintaining air pressure in the tunnel or shield is lessened. Furthermore, by means of my invention air pressure may be restricted to one or more chambers in the forward part of the shield, the packing serving to exclude the water from the tunnel through the space at the tail of the shield. Another important result of my invention is that where the un-

balanced air pressure is great, as in a tunnel of large diameter in which multiple air pressures are used in the forward part of the shield, a cover of earth at the tail of the shield may be of the same thickness as that necessary for the cover at the forward part of the shield, because my improvement confines the tunnel air from escape at the tail.

Furthermore, the pressure of air or water on the lateral webs or projections of the distensible tubes of itself causes obstruction of the passage of compressed air or water from or into the tunnel.

Having now described my invention what I claim is:

1. A shield for tunneling having means attached to the tail thereof to bear against a tunnel lining therein, said means having a surface opposing the shield and exposed to exterior fluid pressure within the space between said means and said shield, said means being forced by said fluid against said lining to prevent the passage of said fluid past said means.

2. In a shield for tunneling, a series of members fastened to the tail of the shield in end relation to one another in the space between said shield and a tunnel lining therein, and means connected to said members and forced into contact with the lining by external fluid pressure.

3. A shield for tunneling having a packing tube located against the inner surface of the tail of the shield in the space between said shield and a tunnel lining therein, and means secured to said packing tube and projecting laterally therefrom adapted to bear upon the lining by fluid pressure upon the outer surface of said means.

4. A shield for tunneling having a distensible packing tube located against the inner surface of the tail of the shield in the space between said shield and a tunnel lining therein, a flexible projection secured to the tube and projecting laterally therefrom, said projection being adapted to bear along its free edge upon the lining by fluid pressure upon the outer surface of said projection, and means to supply fluid to said tube for distention while within said space.

5. A shield for tunneling having a distensible packing tube located against the inner surface of the tail of the shield in the space between said shield and a tunnel lining therein, flexible projections secured to the tube and projecting laterally therefrom freely on opposite sides, said projections being adapted to respectively bear along their free edges upon the lining by fluid pressure upon their outer surfaces independent of the degree of inflation of the tube, and means to supply fluid to said tube for distention while within said space.

6. A shield for tunneling having a distensible packing tube located against its inner surface within the tail of the shield in the space between said tail and a tunnel lining therein, said tube having a plate secured to its outer surface and located between the tube and the shield, said plate being secured to the shield to fasten the tube bodily against the shield, and means to supply fluid to said tube for distention while within said space.

7. A shield for tunneling having an annular recess in its skin within the tail of the shield, said tail having a longitudinal hollow portion, a distensible packing tube within said recess to oppose a tunnel lining within the tail of the shield, said tube having a plate secured to its outer surface and located between the tube and the shield, said plate being secured to the shield to fasten the tube bodily against the shield, and means within said hollow portion of said tail communicating through a wall of the shield with said tube for its distention while within the space between the shield and lining.

8. A shield for tunneling having spaced walls at its tail providing a space therebetween, a distensible packing tube located against the inner surface of the shield within the tail thereof to oppose a tunnel lining within the shield, said tube having a plate secured to its outer surface and located between the tube and the shield, said plate being secured to the shield to fasten the tube bodily against the shield, the inner wall of the shield being provided with openings communicating with said space between said walls, and a tube communicating with said packing tube and located within said space and openings and adapted for communication with pressure supply means within the shield.

9. A shield for tunneling having distensible packing tubes located against the inner surface within the tail of the shield to fill the space between the shield and the tunnel lining, and means to supply each of said tubes for distention while within said space, one of said tubes being located near the end of the tail of the shield, and the other tube located a distance therefrom toward the front of the shield providing a space between said tubes, the first named tube serving to prevent ingress of water and the other tube serving to prevent egress of air from the tail of the shield.

10. A shield for tunneling having distensible packing tubes located against the inner surface within the tail of the shield to fill the space between the shield and a tunnel lining, and means to supply each of said tubes for distention while within said space, one of said tubes having a flexible projection extending toward the rear end

of the shield to bear against the lining to exclude ingress of water and the other tube having a flexible projection extending toward the forward part of the shield to bear against the lining to prevent egress of air from the shield.

Signed at New York city, in the county of New York and State of New York, this 2nd day of February, A. D. 1918.

JOHN F. O'ROURKE.

Witnesses:
T. F. BOURNE,
MARIE F. WAINRIGHT.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."