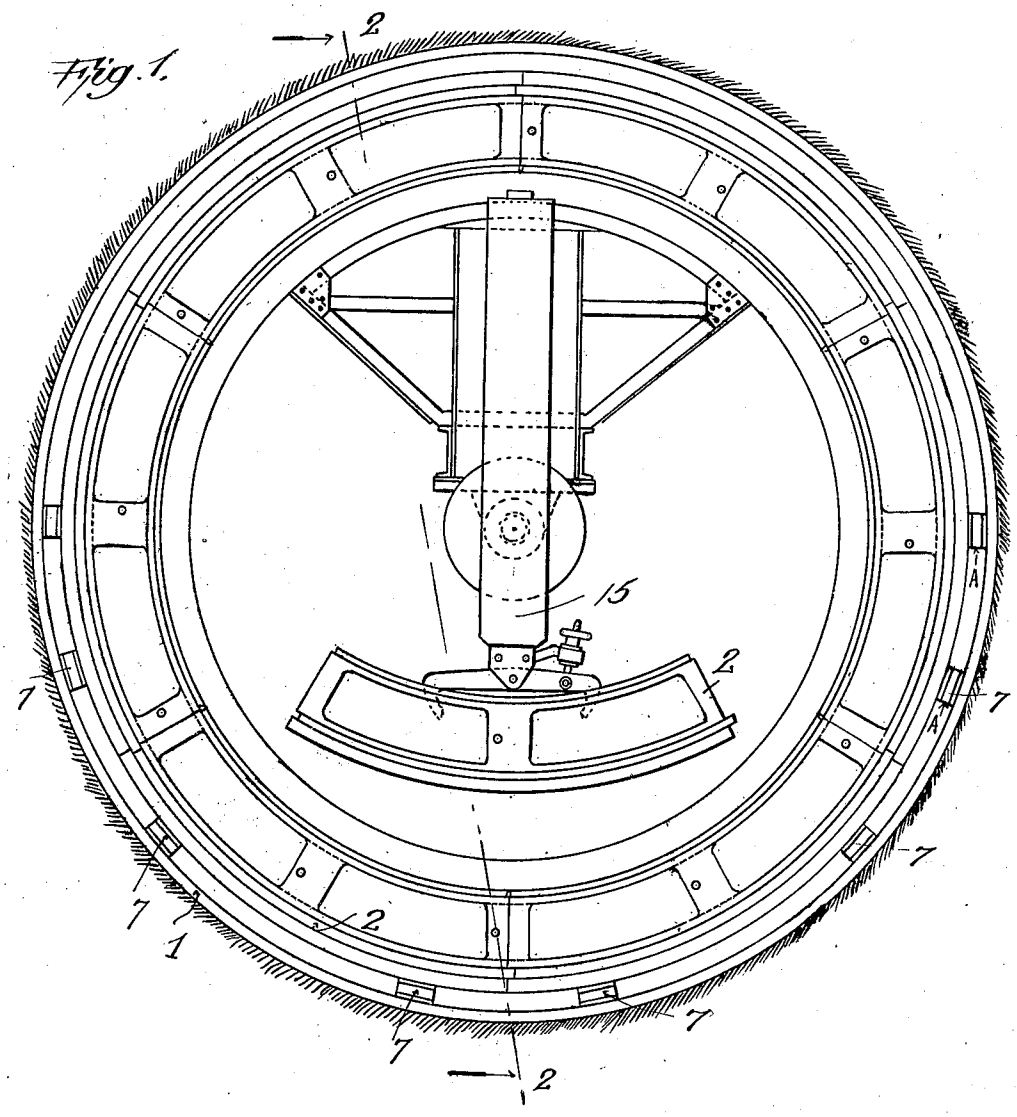
Feb. 19, 1924. 1,484,188

J. F. O'ROURKE

METHOD OF AND MEANS FOR ERECTING TUNNELS

Filed Nov. 11, 1919 3 Sheets-Sheet 1

Fig. 1.



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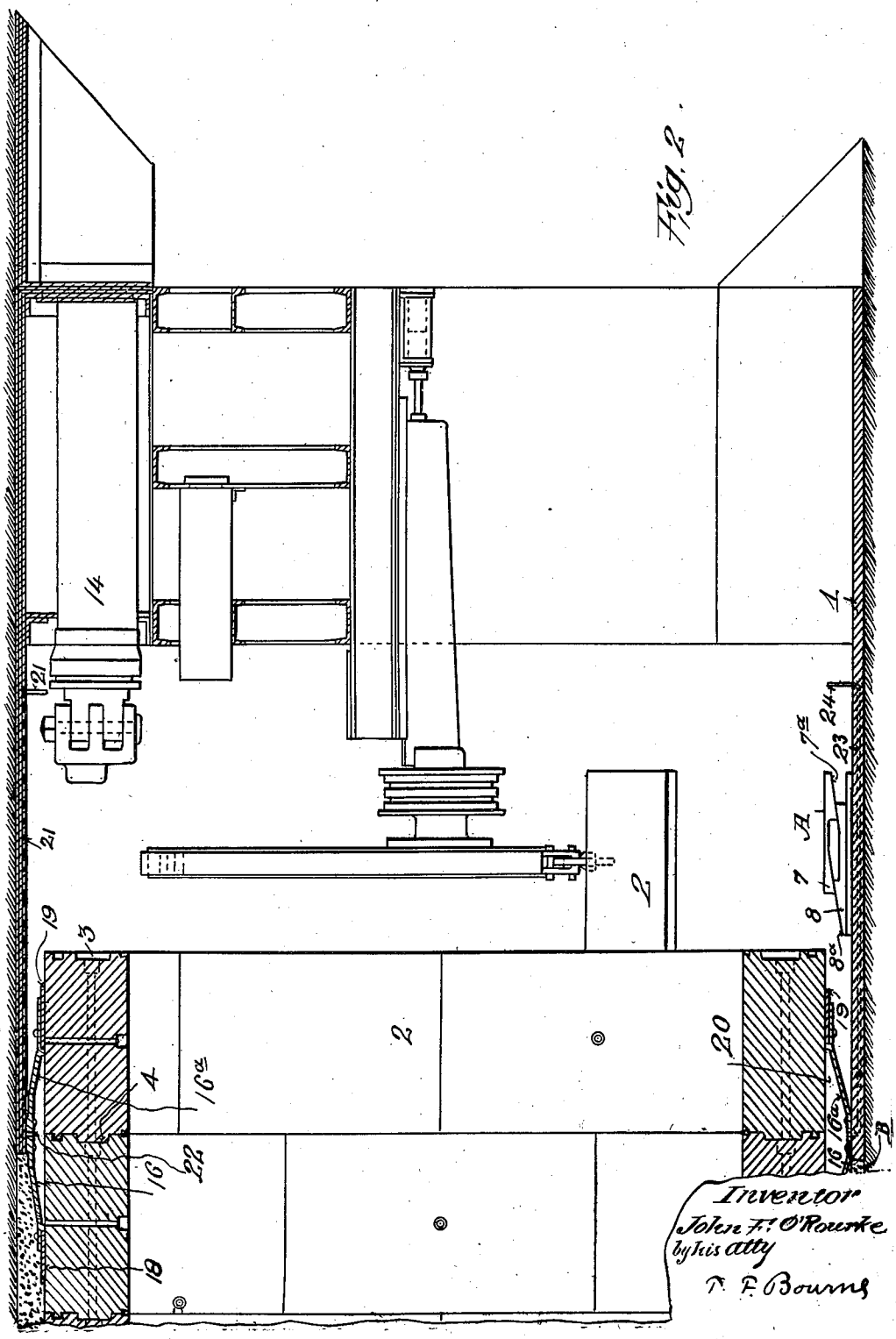
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METHOD OF AND MEANS FOR ERECTING TUNNELS

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Fig. 2.



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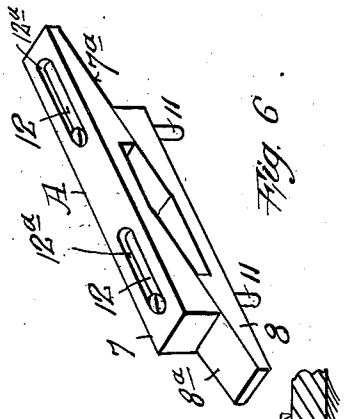


Fig. 6.

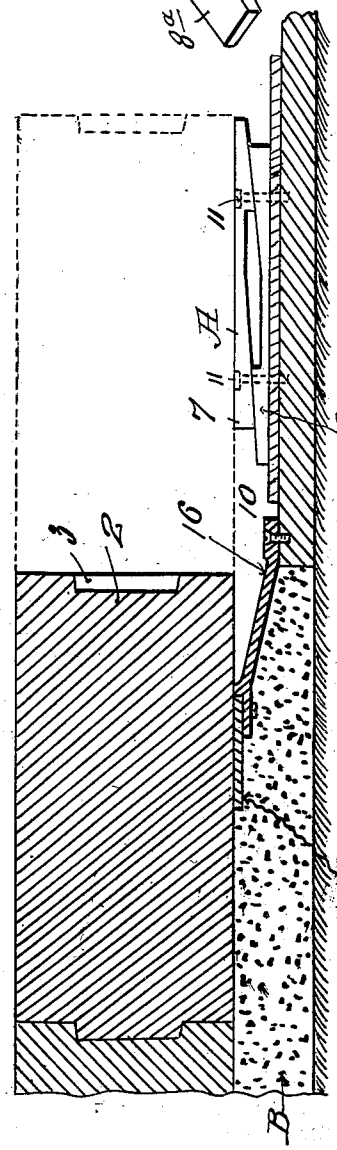
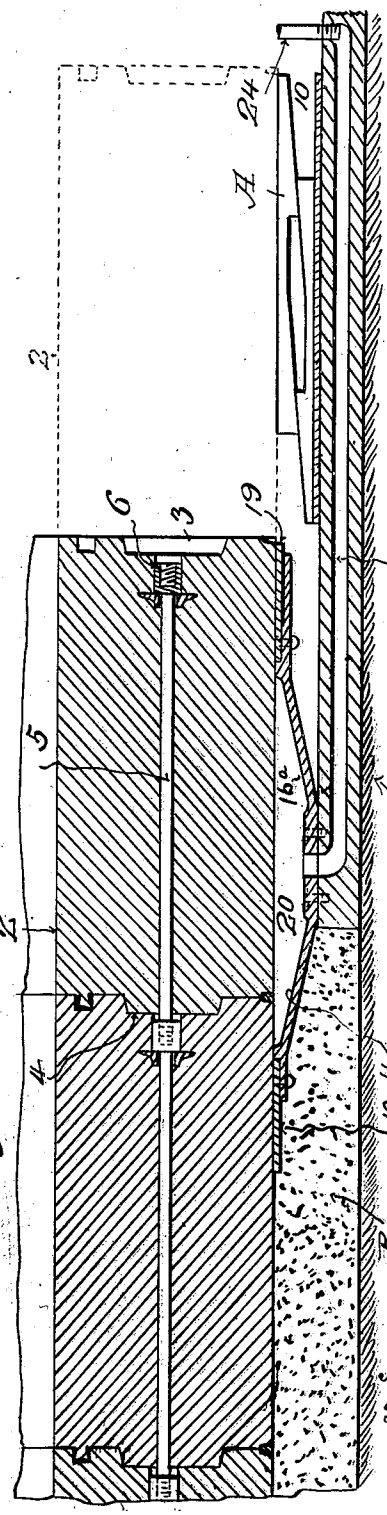


Fig. 4.



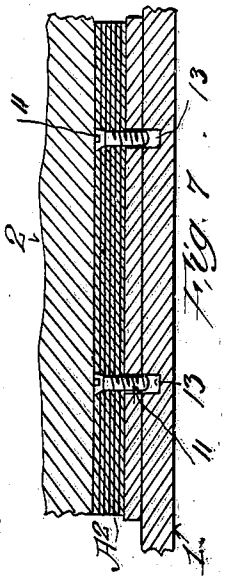


Fig. 7.

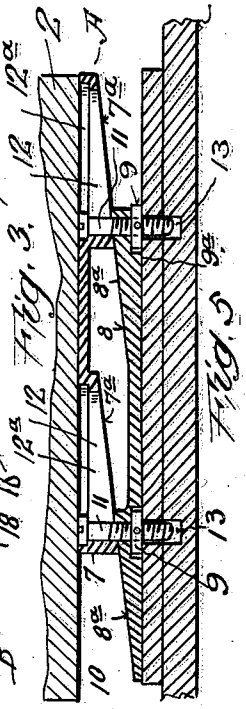


Fig. 3.

Fig. 5.

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UNITED STATES PATENT OFFICE.

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

METHOD OF AND MEANS FOR ERECTING TUNNELS.

Application filed November 11, 1919. Serial No. 337,286.

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 Methods of and Means for Erecting Tunnels, of which the following is a specification.

The practice heretofore, as known to me, in the erection of tunnel lining rings in shield-driven tunnels has been to erect the rings upon the interior surface of the bottom of the tail of the shield which was restricted to a diameter slightly greater than that of the tunnel. This was done to provide enough clearance to prevent the shield from binding on the tunnel lining and there never has been, to my knowledge, any other reason for such clearance. As the shield cannot be driven exactly to a prescribed line and grade at all times this has resulted in causing the tunnel lining to be out of its proper position whenever the shield was itself not in desired position, thus involving the tunnel in the same inaccuracy of grade and alignment at the tail of the shield that existed in the shield each time a ring was erected therein.

An object of my invention is to obviate the aforesaid inaccuracy in the erection of a tunnel lining within a shield, and to enable the rings of the lining to be set in required position within the tail of the shield notwithstanding deviation of the shield from its desired position.

In carrying out my invention I provide means within the tail of a shield to support and retain a lining ring during erection in its required position spaced from the inner wall of the tail of the shield, sufficient clearance space being provided all around between the lining ring and the interior surface of the tail of the shield to allow for error in position of the shield, such space being greater than the error of position that a carefully driven shield would exceed. Experience has shown that where a shield is driven by a competent operator it can usually be kept within one inch of its true position and it is uncommon for such error of position to be greater than two inches, so that if a clearance space two inches wide all around between the tunnel lining and the inner surface of the tail of the shield is provided the tunnel lining can be set to line and grade in accordance with my invention, notwithstanding such deviation of the shield from line and grade. Therefore, in accordance with my invention the shield is driven with reference to its axis instead of the bottom of its tail as heretofore, so that its variations may be avoided in the tunnel itself by reason of the clearance in all directions being greater than the probable variation of the axis of the shield from line and grade. In order that the tail of the shield should be kept as nearly as possible equidistant from the tunnel lining all around it, the axis of the tunnel and that of the shield should coincide. Any departure of the shield from this is what has to be corrected in erecting the tunnel. By means of my invention it is always possible to avoid material departure of the tunnel from the required line and grade. Means suitable for supporting the segments or blocks of the lining ring being erected within the tail of the shield, notwithstanding deviation of the shield from its true or desired position at any point of operation, will be hereinafter described.

It will be understood that, however accurately the work of erecting a tunnel lining within the tail of a shield is carried out, measures should be taken to retain the lining in position as erected and prevent it from settling down into the space in the excavation back of the shield that is greater in diameter than the diameter of the tunnel lining. Such retaining of the lining may be accomplished by means shown in Letters Patent granted to me July 31, 1917, No. 1,235,233, wherein loose solid material is injected into the space around the lining within the excavation as the shield is shoved forward, whereby immediate support is given to the tunnel lining around its whole circumference and retaining the lining in correct position in the excavation. Such solid material within the excavation around the tunnel lining in conjunction with my present improvements within the shield enables the lining rings to be set and retained in true position unaffected by error which may arise in the position of the shield when it is shoved. I also provide means co-operating between the tunnel lining and the shield at the tail of the latter to prevent the aforesaid loose solid material from entering

the shield at its tail and interfering with the clearance between the tail of the shield and the tunnel lining, which clearance is required for erecting the lining in its true position where the deviation of the shield is equal to the clearance provided.

Reference is had to the accompanying drawings forming part hereof wherein—

Figure 1 is a front elevation of a tunnel shield illustrating my improvements;

Fig. 2 is a section substantially on the line 2—2 in Fig. 1;

Fig. 3 is an enlarged sectional detail;

Fig. 4 is a detail section illustrating a variation from Fig. 3;

Fig. 5 is an enlarged sectional detail of the lining segment supporting and spacing means;

Fig. 6 is a perspective view of said means, and

Fig. 7 is a sectional detail of a modified form of said means.

Similar numerals of reference indicate corresponding parts in the several views.

The numeral 1 indicates a shield for driving tunnels which may be generally of any well known construction, within the tail of which shield a tunnel lining is to be erected. The tunnel lining indicated comprises segments or blocks 2 erected within the tail of the shield in ring like form in a usual manner. The segments or blocks are shown having recesses 3 on one side and projections 4 on the opposite side, the projections of one block entering recesses of the adjacent block in well known manner, such as are shown in Letters Patent granted to me Nov. 5, 1912, No. 1,043,348. The segments or blocks 2 may have rods 5 provided with screw threads at one end to engage threaded nuts or sockets 6 at the opposite end of an adjacent rod whereby the successive blocks may be tied together as they are erected, (Fig. 3), or such tie rods may be omitted (Fig. 4). It will be understood, however, that tunnel lining rings of any desired construction may be used in connection with my invention.

I have shown adjustable or expansible means interposed between the inner surface of the tail of the shield and the segment of the lining to be erected to retain said segment properly spaced from the shield in accordance with the true position of the tunnel lining, whatever position the tail of the shield may be in with respect to such true position, as follows: A spacing member A comprises opposing blocks 7, 8 having correspondingly inclined opposing co-operating faces, which members may be adjusted longitudinally one upon another to vary the thickness thereof, as required, according to the width of the space 10 receiving such member between the tail of the shield and the segment or block 2 to be erected. The block 7 is shown provided with two spaced lower inclined faces 7^a operative upon two spaced upper inclined faces 8^a on block 8, said blocks thereby being substantially wedge-like in function, whereby the height of the spacing member may be varied by adjusting the blocks 7, 8 lengthwise. The upper and lower surfaces of the blocks 7, 8, are preferably plane whereby the block 8 may rest snugly and firmly against the inner surface of the tail of the shield and the segment 2 may bear snugly against the plane face of the block 7. The blocks are shown provided with retainers 11 on one block operative in slots 12 in the other block, whereby said blocks are retained from lateral displacement one upon another and may have longitudinal adjustment. The retainers 11 are shown in the form of screws entering holes in block 8 and having heads in longitudinal recesses 12^a of block 7, whereby said heads are below the plane surface of said block not to interfere with segment 2. The retainers 11 are shown provided with nuts 9 located in recesses 9^a in the under surface of block 8 so as not to interfere with the shield. By means of said screws and nuts the blocks 7, 8 may be clamped tightly together to prevent displacement of the blocks from set position. The retainers 11 are shown protruding beyond block 8 and are adapted to be entered in recesses 13 formed in the inner surface of the skin of the tail of the shield, whereby the spacing members are retained in proper position against displacement when the segments 2 are erected and when the shield is shoved. The spacing member will be placed in position where the segment or block 2 is to be erected, and said spacing member will be adjusted as to thickness in accordance with the distance from the inner surface of the shield to the true circumference at which the outer surface of the segment or block should be placed according to the true line and grade for the tunnel lining at such point, whereby when the segment or block is set in position it will rest against such spacing member to retain the segment or block in desired position. One of said spacing members may oppose a segment 2, or two or more of said spacing members in spaced relation may be placed against the shield to receive a segment or block to be erected (Fig. 1), for the lower segments or blocks of the lining ring at least up to the segments or blocks set at the spring line. The spacing members A described may be made of different thicknesses when collapsed or normal, adapted to increase in thickness when expanded lengthwise whereby the appropriate spacing members may be used and fitted to the tail of the shield according to the width of space 10 between the shield and the segment to be erected. Instead of using the

two-part expansible spacing members described any other suitable form of spacing members may be used, such as suitable plates or wedges. In Fig. 7 I have shown plates A^2, which may be relatively thin, one of which may be used or several may be superimposed, located in the space 10 between the shield and the segment to be erected, to receive said segment according to the dimension of said space. The retainers 11 project through and from said spacing plates, extending into the recesses 13 in the shield to retain the plates from displacement.

When the segments or blocks of the ring have been set the rams of jacks 14 are operated against such ring to shove the shield, and the spacing members will be drawn with the shield, sliding along the segments into position to oppose new segments to be set for the succeeding ring, and so on, the thickness of the spacing members for the new ring being provided for as required by adjustment of the corresponding spacing members as the work proceeds.

The advantage of having the spacing members provided with adjustable blocks having inclined surfaces enables the spacing members to be adjusted as to thickness as required, while at the same time retaining the inner and outer plane surfaces thereof respectively parallel so as to provide an extended bearing against the tail of the shield and against the segments or blocks 2 in a longitudinal direction of the shield and lining.

In the case of tunnels comprising concrete segments or blocks 2, the interior surface of which becomes the finished surface of the tunnel, it is of great importance that the tunnel lining be set in correct position and there held, and by means of my invention this very important object can be readily and expeditiously attained, since whether the space 10 be correct or incorrect in width the spacing members of required thickness may be readily set against the tail of the shield to cause the segments or blocks when set against such spacing members, as by the erector 15, to be located in the correct position.

Since the aforesaid spacing members serve to permit the erection of the tunnel rings within the shield in true position according to plan it is important to retain and support the tunnel lining in such position when the shield is shoved and the spacing members move away from and release the segments of the ring last erected. Such supporting of the lining, behind the tail of the shield, may be accomplished by injecting loose solid material B in the space around the lining in the excavation behind the shield, which may be accomplished by blowing gravel or other suitable solid material into such space to retain the lining, such as set forth in my aforesaid Letters Patent No. 1,235,233. By injecting such solid material in the excavation as the shield is being shoved forwardly said solid material immediately supports the lining ring at the tail of the shield as the spacing means before described is drawn away from the lining, whereby the latter is retained in true position. A complete lining ring may remain partly or wholly within the tail of the shield when a new ring is to be erected therein, the tie bars 5 or grouting in the joints retaining the new ring where the spacing members pass therefrom (Fig. 3), or in the case of cast iron segments the bolts connecting the parts will retain the last ring set, the solid material B supporting the lining free from the shield. In some cases the tail of the shield may pass entirely or nearly so, from the last lining ring erected, in which event the spacing members will be near the tail end of the shield for the new ring to be erected (Fig. 4), the solid material B supporting the lining as said spacing members pass therefrom when the shield is shoved. In any of such cases deviation of the shield, when shoved, from a true position will not affect the true setting of a new ring, since the material B supports the lining for the placing of the spacing members of the required thickness for the new ring to be erected.

To prevent the inflow of the solid material B from the excavation into the tail of the shield I secure an annular member 16, preferably spring-like, to the inner surface of the tail of the shield, which member 16 projects rearwardly, preferably beyond the tail of the shield, to oppose the lining circumferentially. Said member may be screwed or riveted to the shield. The free annular edge of member 16 is provided with a rearwardly extending flexible member 18 to bear against the tunnel lining. The solid material B may pack against the exterior of the members 16 and 18 behind the shield, and water seeking to enter the tunnel and the shield at its tail will be excluded by forcing member 18 against the tunnel lining.

The foregoing arrangement is useful whether the tunnel be driven with or without the use of compressed air within the shield and tunnel. When compressed air is so used I provide a second annular member 16^a, preferably spring-like, screwed or riveted within the tail of the shield, projecting forwardly and toward the lining to oppose it circumferentially. The free annular edge of member 16^a is provided with a forwardly extended member 19 to bear against the tunnel lining. Air pressure within the shield will force member 19 against the lining to prevent the escape of air around the lining from the shield. The space 20 between the tunnel lining and members 16 and 16^a may

be kept under reduced pressure or partial vacuum by means of a pipe or passage 21 within the skin of the shield communicating through orifice 22 with space 20 and connected with a vacuum machine. Water that may enter said space 20 may be removed therefrom through a passage 23 in the bottom of the skin of the shield communicating through a pipe 24 (Fig. 3), with any suitable suction apparatus.

In my Letters Patent No. 1,296,312, issued March 4, 1919, a means is shown for excluding water from the tunnel and the space between it and the tail of the shield by means of a flexible projection secured to a distensible packing tube. As the clearance space in my present invention must be protected from loose solid material becoming packed therein I have shown member 16 as extending beyond the tail of the shield with its flexible member 18 rearwardly disposed and forming an exterior valve to exclude gravel or the like from passing into the shield at the time it is being packed around the tunnel lining in the space left by the shield, as distinguished from the flexible packing in my said patent that is located inwardly from the tail end of the shield, leaving a space within such tail open to the excavation behind from which loose solid material may be forced into such space. The aforesaid flexible member 16 may automatically fit itself snugly with its valve-like member 18 against the tunnel lining all around when the axes of the shield and lining coincide or when they do not coincide by reason of deviation of the shield from line and grade, whereby in either such case to exclude solid material and water from the tail of the shield.

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

1. The method of erecting a lining ring in a tunnel shield, consisting in setting a plurality of spacing means within the shield, arranging said means so that the inner surfaces thereof will be at uniform distances from the line and grade of the axis of the tunnel, and thereafter placing a lining ring upon said spacing means.

2. The method of erecting a lining ring in a shield driven tunnel consisting in placing spacing means within the tail of a shield with the faces of said means equi-distant from the axis of the line and grade of the tunnel, and setting the lining ring against said faces to locate the axis of the ring in the axis of the tunnel line and grade.

3. The method of erecting a tunnel lining, consisting in successively setting and supporting the lining rings within a shield in required line and grade independently of the position of the shield.

4. The method of erecting a tunnel lining ring, consisting in successively setting and supporting the ring within the shield in required line and grade independently of the position of the shield, advancing the shield and filling the space between the said lining and the wall of the excavation with a supporting media.

5. The method of erecting and supporting a tunnel lining within a shield, comprising setting supports of variable thicknesses within and against the lower half of the shield, the inner surfaces of which conform to the outer surfaces of the lining when the latter is in line and grade, and thereafter placing the said lining upon said supports.

6. The method of erecting and supporting a tunnel lining within a shield, comprising setting supports of variable thicknesses within and against the lower half of the shield, the inner surfaces of which conform to the outer surface of the lining when the latter is in line and grade, placing the said lining upon said supports, and thereafter injecting packing material behind said lining.

7. The method of erecting and supporting a tunnel lining within a shield, comprising setting supports of variable thicknesses within and against the lower half of the shield, the inner surfaces of which conform to the outer surface of the lining when the latter is in line and grade, placing the said lining upon said supports, shoving the shield forward, and thereafter inserting packing material behind said lining.

8. The combination of a tunnel shield, and spacing members of different depths interposed between the wall of the shield and a lining, for holding the lining in desired relation to the axis of the tunnel.

9. The combination of a tunnel shield, and adjustable lining engaging members interposed between the tail of said shield and the lining.

10. The combination of a tunnel shield with spacing means within the tail thereof to keep lining rings out of contact therewith and spaced therefrom, and means to detachably connect said spacing means with said shield.

11. The combination of a tunnel shield with spacing means within the tail thereof to keep lining rings out of contact therewith and spaced therefrom, and means to detachably connect said spacing means to the tail of the shield.

12. The combination of a tunnel shield having apertures at the tail thereof, with spacing means having projections to engage said apertures to retain said spacing means in set position against the tail of the shield.

13. The combination of a tunnel shield with spacing means at the tail thereof com-

prising a plurality of superimposed members having means to retain them in set position upon one another.

14. The combination of a tunnel shield with spacing means at the tail thereof comprising a plurality of superimposed members having co-operative inclined faces, and means to retain said members in set position one upon another.

15. The combination of a tunnel shield with spacing means at the tail thereof comprising a plurality of superimposed members having co-operative inclined faces, said members having interengaging screws and slots to retain the members in set position.

16. The combination of a tunnel shield with spacing means at the tail thereof comprising a plurality of superimposed members having co-operative inclined faces, said members having interengaging screws and slots to retain the members in set position, said screws projecting from said members to engage apertures in the tail of the shield.

17. Spacing means for tunnel shields comprising a plurality of superimposed members having opposing inclined faces, and means to retain said members in set position one upon another.

18. Spacing means for tunnel shields comprising a plurality of superimposed members having opposing inclined faces, said members having interengaging screws and longitudinally disposed slots to retain the members in set position.

19. A tunnel shield having an annular member projecting rearwardly from the tail thereof to co-operate with a tunnel lining back of the shield, another annular member projecting forwardly within the shield to co-operate therein with the lining, and means to withdraw water from the lower part of the space between said annular members.

20. A tunnel shield having an annular member projecting rearwardly from the tail thereof to co-operate with a tunnel lining back of the shield, another annular member projecting forwardly within the shield to co-operate therein with the lining within the shield, means to withdraw water from the lower part of the space between said annular members and means to withdraw air from said space.

Signed at New York, in the county of New York and State of New York this 10th day of November, A. D. 1919.

JOHN F. O'ROURKE.