Sept. 15, 1931. J. F. O'ROURKE 1,823,757

SUBWAY AND TUNNEL

Filed May 13, 1926 4 Sheets-Sheet 1

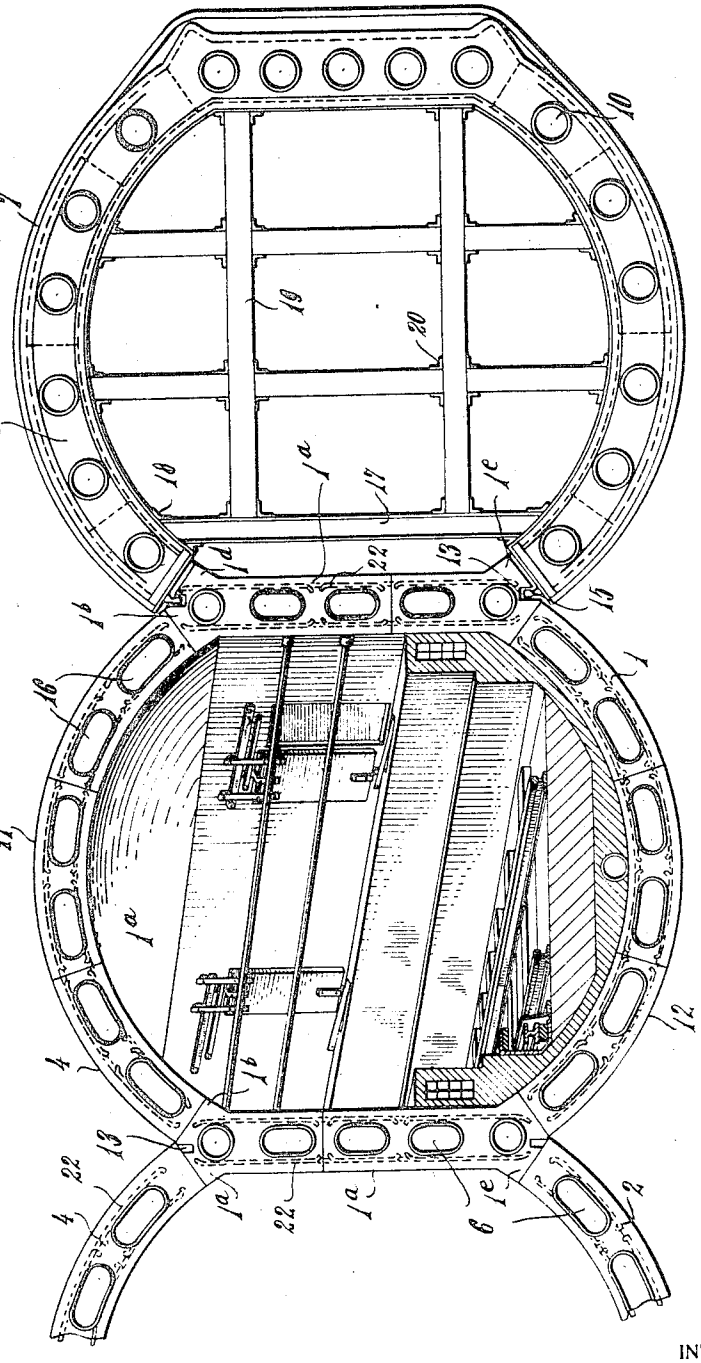


Fig. 1.

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Fig. 1.

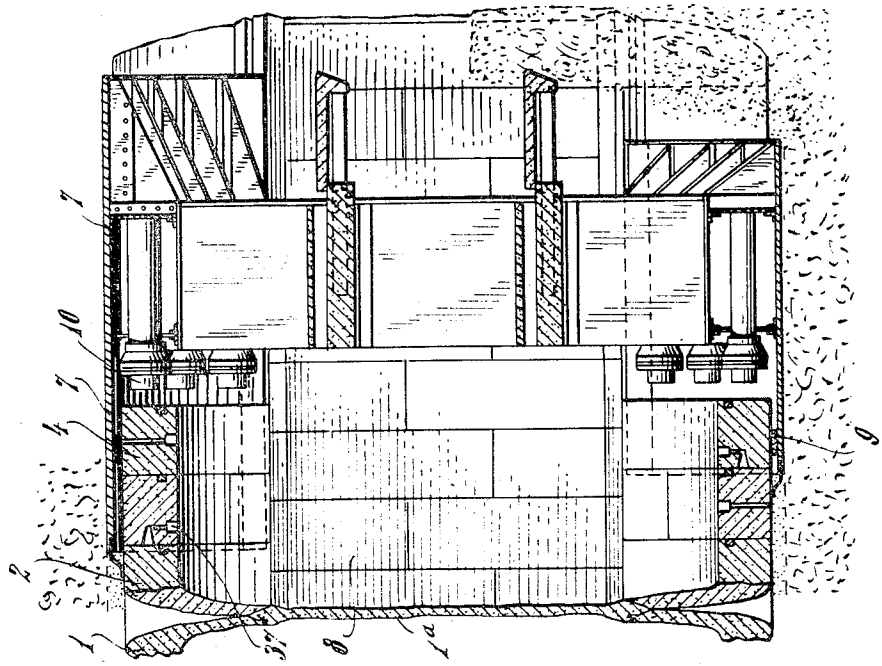
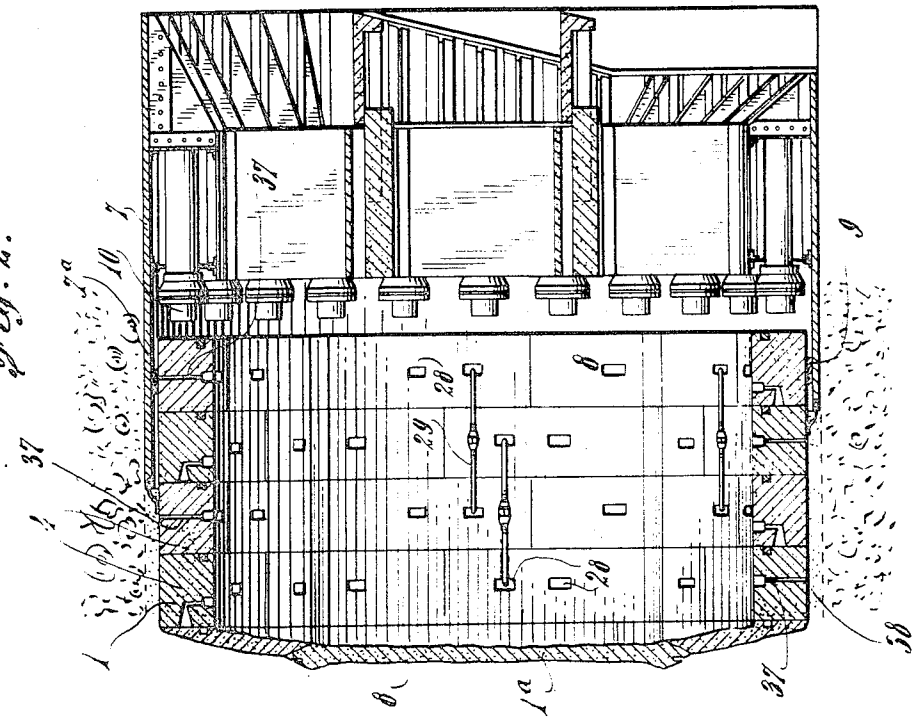


Fig. 2.



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SUBWAY AND TUNNEL

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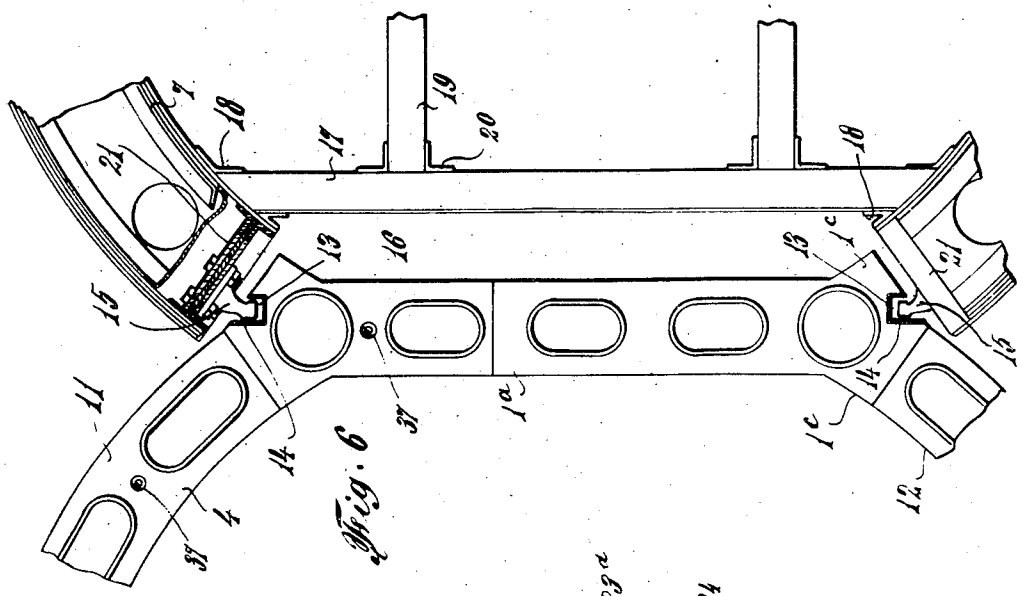


Fig. 6.

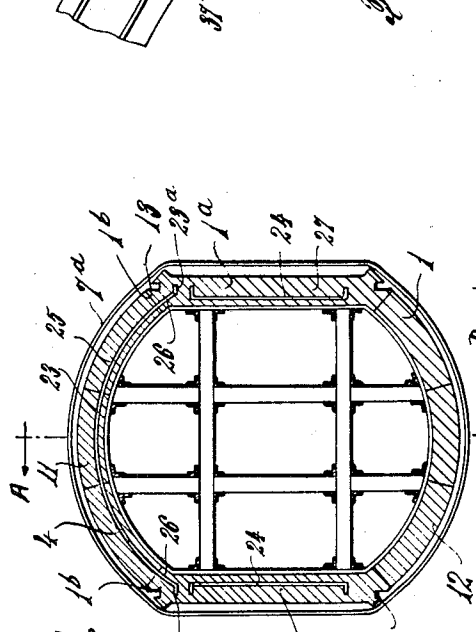


Fig. 4.

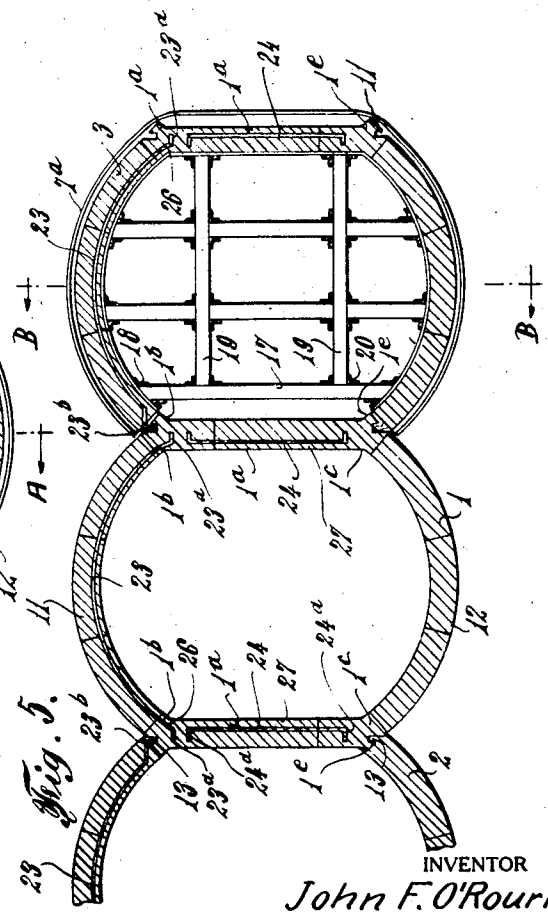


Fig. 5.

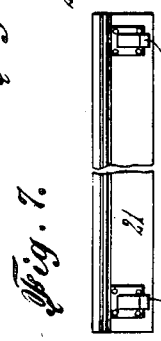


Fig. 7.

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SUBWAY AND TUNNEL

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Fig. 8.

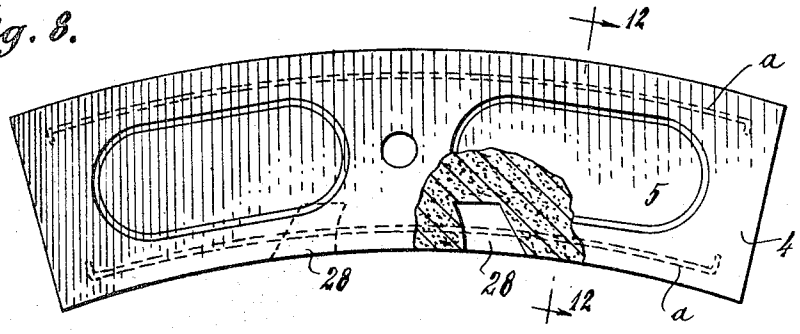


Fig. 9.

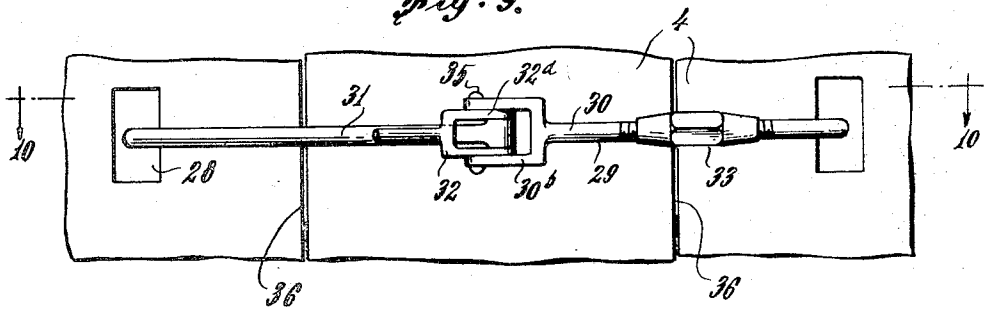
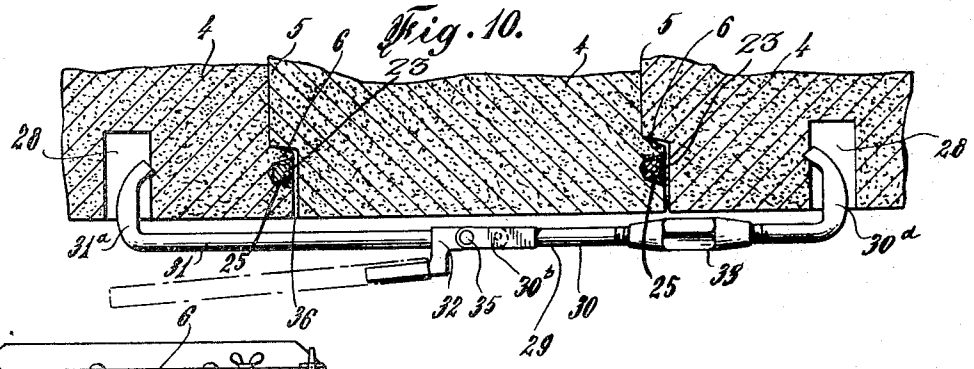


Fig. 10.



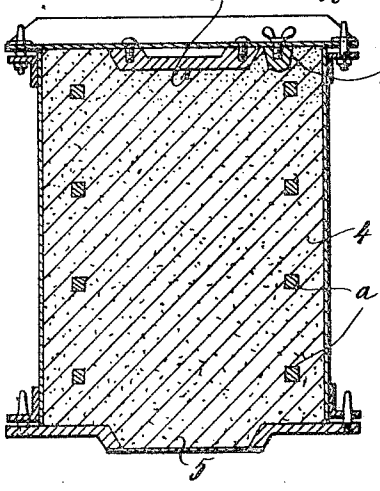


Fig. 12.

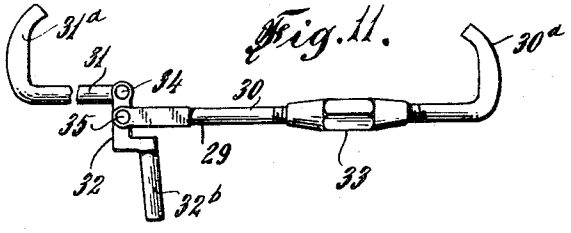


Fig. 11.

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

SUBWAY AND TUNNEL

Application filed May 13, 1926. Serial No. 108,714.

An object of my invention is to construct underground structures, such as multiple tube subways, tunnels, conduits, and the like comprising tunnels of suitable material, by building one tunnel at a time and joining such tunnel with one or more other tunnels, side by side, during the construction of the subsequent tunnel or tunnels, or by first constructing a portion of the intended length of one tunnel and then building an adjacent tunnel alongside of the first tunnel and connecting them together so that the construction of multiple tunnels will proceed concurrently, whereby I am enabled to utilize single tube shields for the construction of each tunnel so as to avail of the present efficient and economical methods by which single subways, tunnels, conduits and the like are constructed.

Another object is to provide multiple tunnels side by side having a single party wall therebetween, such wall being connected by skewbacks with the arches and inverts of one or more adjacent tunnels.

Another object is to provide a subway, tunnel or the like having successive rings comprising segments or blocks that are provided with grooves containing strengthening bars or rods, cemented in the grooves, connecting several segments or blocks of a ring to act like a beam and resist bending of the walls or arches that might be caused by external pressure.

A further object is to secure newly placed segments or blocks for a ring to a previously formed ring to retain the newly placed segments from displacement and in contact with the adjoining ring.

I accomplish my first named object by constructing the first one of the tunnels for any desired length, having side walls in a manner well known by the use of a single tube shield, driven forward in the ground, and I provide the side wall or walls of such tube with skewbacks at the top and bottom for the arch or arches and invert or inverts of one or more adjacent tunnels. In the outside portion of top and bottom skewbacks I form continuous longitudinally extending retainers, such as grooves or guides, adapted to receive projections located at the sides of a shield, at its upper and lower portions, for the next adjacent or second tunnel, the shield for the second tunnel having one side wall omitted adjacent to said projections providing the side of the shield with an open portion that will oppose a side wall of the first tunnel. By such means the open side portion of the shield is attached to and slidably guided by the retainers of the first tunnel, so that the segments or blocks for the rings of the second tunnel may be properly set within the shield with the appropriate segments or blocks resting against the adjacent skewbacks of the first tunnel. The construction is such that the shield for the second tunnel will be retained by and close to the first tunnel when said shield is shoved forwardly during the progress of the work. The second named tunnel may have similar retainers along its side wall for guiding a shield if a subsequent adjacent tunnel is to be attached to the second named tunnel. A side wall of one tunnel will comprise a party wall for another adjacent tunnel, and so on for as many tunnels as may be desired side by side.

My invention also comprises novel details of improvement 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 a part hereof, wherein

Fig. 1 is a partly sectional end view illustrating a portion of a subway or tunnel comprising multiple tunnels side by side and a shield attached to one of the tunnels in accordance with my invention;

Fig. 2 is a longitudinal section through a shield and a portion of the first tunnel of the series to be constructed, substantially on line A, A in Fig. 4;

Fig. 3 is a similar view through a subsequent tunnel of the series and the shield, substantially on line B, B in Fig. 5;

Fig. 4 is a diagrammatic view in cross section of a tunnel having a shield in accordance with Fig. 2;

Fig. 5 is a diagrammatic view in cross sec-

tion through the multiple tunnels similar to Fig. 3;

Fig. 6 is an enlarged detail, partly in section, illustrating a portion of a tunnel and a portion of a shield slidably attached thereto;

Fig. 7 is a detail view of a portion of a shield;

Fig. 8 is an enlarged edge view of a concrete segment or block for the tunnel;

Fig. 9 is an enlarged detail face view of a portion of several rings and a newly laid segment or block held together in accordance with my invention;

Fig. 10 is a section on line 10, 10, of Fig. 9;

Fig. 11 is a detail of the clamp for holding the segments together temporarily; and

Fig. 12 is a sectional view illustrating a mould for producing my improved segment or block.

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

The numeral 1 indicates a portion of the first tunnel of the series of multiple tunnels to be constructed; 2 indicates a portion of a subsequent or second tunnel to be constructed alongside of and attached to the first tunnel, and 3, (Figs. 3 and 5) indicates a portion of a third tunnel illustrated as attached to the first tunnel. The tunnels may be constructed of segments or blocks of any well known character, such as customarily used in the construction of subways, tunnels, conduits and the like. In the drawings I have illustrated the segments or blocks 4 of the class of concrete blocks having projections 5 on one face to enter complemental recesses 6 in adjacent blocks, the projections of one segment or block bearing against the back walls of the recesses 6 of adjacent blocks, such as set forth in Letters Patent No. 1,043,348, granted to me November 5, 1912. The form of segments or blocks shown is merely illustrative, since the segments or blocks for the tunnels may be of any other desired material adapted for the purpose of building subways, tunnels, conduits and the like. Reinforcing metal bars, indicated at *a* may be embedded in the concrete segments when the same are being moulded, (Figs. 8 and 12). A shield is indicated at 7, within the tail 7*a* of which the segments or blocks comprising the rings 8 of the tunnel are to be erected in an ordinary or well known way. A packing material 9 is shown interposed between the tail of the shield and the last ring constructed, (Figs. 2 and 3). The shield 7 may be of any well known variety adapted for use for constructing single tunnels for subways, tunnels, conduits and the like. The jacks 10 oppose the last ring 8 constructed within the tail of the shield adapted to bear against such ring for shoving the shield.

The tunnel 1 may be constructed in an ordinary way for any suitable distance and the same is to be constructed with at least one vertical side wall indicated at 1*a*, (Fig. 1). The upper portion of each wall 1*a* is provided with an inner skewback 1*b*, upon which the segments or blocks 4 at the ends of the arch or roof 11 of the tunnel rest, and said walls at the lower parts have inner skewbacks 1*c* that rest against the ends of the inverted arch or bottom wall 12 of the tunnel, which is supported by the ground. Along the side of tunnel 1 against which another tunnel, such as 2 or 3, is to be constructed, I provide outer skewbacks 1*d*, 1*e* with longitudinally extending retainers 13 for the shield. Said retainers are shown in the form of grooves formed in the material of the skewbacks and extending longitudinally along the outer surface of the side wall, being shown located adjacent to the extremities of the arches, and opening respectively upwardly and downwardly. When the tunnels are constructed of segments or blocks comprising concrete or analogous material, as distinguished from metal, I preferably line the groove-like retainers 13 with metal channel-like guides 14, (Fig. 6), for strength and to resist projections 15 that extend into the retainers from the shield. Said projections extend in a direction toward one another to slidably remain in the retainers 13.

When the first tunnel, such as tunnel 1, is constructed a shield will be used of ordinary character, which is complete as respecting its walls all around, to hold back the surrounding ground and to enable the rings of the tunnel to be constructed within the tail of the shield, as indicated in Fig. 4, which diagrammatically represents a cross section of tunnel 1 with the tail of the shield shown around the tunnel. When the segments or blocks for the side walls 1*a* of tunnel 1 are installed they will be provided with the retainers 13 on the exterior along the outer skewbacks, and the shield will be properly shaped to accommodate the contour of the tunnel. In the example illustrated the walls 1*a* are flat and vertical. After tunnel 1 has been constructed for any desired length, or at any time after such tunnel may have been completely constructed, and even after being put into use, a tunnel may be built on either side thereof, or on both sides, extending along tunnel 1 and attached thereto, whereby the corresponding wall 1*a* of tunnel 1 will constitute a party wall between two tunnels. For constructing subsequent tunnels one side wall of the corresponding shield will be removed or omitted, at 16, where the shield opposes a side wall 1*a* of a tunnel 1. The open portion 16 of the shield is braced by vertical braces 17 secured to the arch and invert portions of the shield in any

suitable way, such as by means of brackets 18 which may be riveted to the shield, as indicated in Figs. 5 and 6, transverse braces or beams 19 preferably being secured to the vertical braces 17, as by brackets 20, which may be riveted to said beams, whereby the arch and invert portions of the shield at the open side 16 are braced. The projections 15 are shown secured to the longitudinal beams 21 of the shield and several projections are preferably spaced apart a suitable distance along the upper and lower portions of the shield, as indicated in Fig. 7, so that the projections at the upper and lower portions enter the corresponding retainers 13 of tunnel 1. One projection 15 may be used if desired at the upper and lower portions of the shield. The projections 15 retain the shield in proper location along the side of tunnel 1, and said projections are adapted to slide along the retainers 13 as the shield is shoved forwardly during construction of a tunnel subsequent to the construction of a tunnel, such as tunnel 1, or a length thereof. The segments or blocks of the walls 1*a* have the skewbacks 1*d* at the upper portion and the skewbacks 1*e* at the lower portion of the exterior, in which the retainers 13 are located, so that the appropriate blocks of the corresponding arch and invert of the subsequent tunnel alongside of tunnel 1 may be applied through the open side 16 of the shield against such skewbacks, and so on for any subsequent tunnel or tunnels.

In order to tie together the blocks of the arches as well as the blocks of the side walls of the tunnel, and also to mechanically secure the arches to the side walls, I provide reinforcing bars 23 and 24 for the arches and side walls respectively, which bars are inserted in grooves 25 formed in the outer faces of the segments when they are being cast or moulded. The grooves 25 of the segments for the arches enter the faces of the blocks, and preferably the faces containing the recesses 6, following the general curvature of the segments of the arches, in such position that the groove 25 of one segment will register with the groove or grooves of one or more adjacent segments, so that when the segments are installed the reinforcing bars 23 may be inserted sidewise into corresponding recesses, whereby one bar will tie several segments together. The bars 23 of tunnel 1 extend beyond the ends of the arches of the rings of such tunnel and are located in appropriate recesses 26 in the side walls 1*a* of said tunnel, which register with the grooves 25 of the adjacent segments of the arch. By preference the ends 23*a* of bars 23 of tunnel 1 extend laterally in a corresponding lateral extension of the appropriate groove 26, whereby the bars 23 are anchored at their ends in the adjacent segments of the side walls, (Fig. 4). The bars 23 of a subsequent tunnel, such as tunnel 2 or 3, are bent at their ends 23*b* in such a manner as to extend into the retainer 13 of the side wall of the adjacent tunnel, such as tunnel 1, so that the corresponding bar 23 of tunnel 2 or 3 is anchored to the outer skewback of tunnel 1, (Fig. 5). The corresponding faces of the segments of the side walls 1*a* of the tunnels are provided with grooves 27 in which the bars 24 are placed, and the ends 24*a* of said bars are preferably bent laterally or to one side to enter correspondingly shaped portions of the grooves 27. When the segments of a ring have been erected the bars 23 and 24 are inserted in the corresponding grooves of the segments and cement of any suitable kind is placed in the grooves to embed the bars therein. The bars 23 and 24 serve to tie the segments of blocks or rings together in an annular or circumferential direction, the segments and bars together acting like a beam to resist bending of the walls or arches that might be caused by external pressure.

In order to retain newly placed segments of a ring being constructed securely against a previously completed ring I provide clamping means adapted to engage the newly placed segment and a segment of a completed ring. As illustrated in Figs. 2 and 8 to 11 the inner faces of the segments or blocks 4 are provided with recesses 28, there being preferably two of such recesses in each segment, in which the hook-like ends of clamping members 29 are located for forcing segments against each other. The clamping members 29 are extensible and contractible and are shown comprising a bar 30 having a hook-like end 30*a*, a bar 31 having a hook-like end 31*a*, and a lever 32 pivotally connected with said bars. The bar 30 preferably is provided with a sleeve nut 33 for adjusting the distance between the hook-ends 30*a* and 31*a*. The lever 32 is shown bifurcated at 32*a* to straddle bar 31, and the bifurcated end of the lever is pivotally connected by a pivot 34 with the end of bar 31 opposite its hook-end 31*a*, the handle portion 32*b* of lever 32 being shown offset from the bifurcated portion for operation relatively to bar 31, (Figs. 9, 10 and 11). Between the pivot 34 and handle 32*b* the lever 32, by means of pivot 35, is pivotally attached to the bifurcated end 30*b* of bar 30, which bifurcated end receives the adjacent end 32*a* of lever 32, (Fig. 9). When a segment 4 for a ring has been placed in its proper position (with its projections 5 within the opposing recesses 6 of a ring of the tunnel already erected) the hook-like ends 30*a* and 31*a* of a clamping member 29 will be placed in the recesses 28 of the newly placed segment and of a segment of a ring of the tunnel with the lever 32 offset from the plane of the bars 30 and 31, (Fig. 11), which will elongate the mem-

ber. The lever 32 then will be swung toward bar 31 to cause shortening of the member 29 and thereby to draw the hook-like ends thereof tightly against the corresponding segments for jamming and retaining the newly placed segment against the adjacent ring of the tunnel, the then position of the pivots 34 and 35 being in substantial alignment in the direction of the length of the member 29 to retain the segments clamped securely together, (Fig. 10). While the segments are retained as described the joints 36 between segments may be pointed with cement or the like and allowed to harden before removing the member 29. By preference at least two of such members 29 will be attached to each newly placed segment so as to balance the pressure along the segment. When the pointing has set as desired the members 29 may be removed from the segments, and so on as the work proceeds.

When tunnel 1 has been completed underground, or such portion thereof as may be desired, as in an ordinary way, a shield having one side open, as at 16, and provided with means for guiding it along tunnel 1, such as the projections 15, will be applied along side of tunnel 1 and will be slidably attached thereto by means of said projections and the retainers, as indicated in Figs. 5 and 6. The segments or blocks for the susequent tunnel, such as tunnel 3, will be set in ring formation with its wall 1*a* for the outer side of the subsequent tunnel within the tail of the shield in a usual way, but with the distinction that the appropriate inner ends of the segments or blocks of the arch and invert of such subsequent tunnel will be rested against the skewbacks 1*d* and 1*e* of the tunnel 1 in manner diagrammatically indicated in Fig. 5, which is permitted through the open side 16 of the shield. As each ring is set within the tail of the shield the latter will be shoved forwardly by means of the jacks 10 operating against the adjacent ring of the tunnel in well known manner. The work of constructing a subsequent tunnel along side of the first tunnel 1 may be carried on concurrently with the construction of tunnel 1, and so on for any desired number of tunnels side by side.

If twin tunnels are to be constructed the tunnel 1 may be provided with skewbacks 1*d* and 1*e* only along the side against which one subsequent tunnel will be constructed, but if it be intended that more than twin tunnels be constructed then tunnel 1 may have the skewbacks 1*d* and 1*e* on both its side walls 1*a*, as indicated in Fig. 1, wherein a portion of a tunnel 2, constructed in accordance with my invention, is represented on the left hand side of tunnel 1, and the shield for constructing tunnel 3 is represented on the right hand side of Fig. 1. Or, in case tunnel 2 is intended to be what may be termed an outside tunnel then tunnel 1 will be constructed along side of tunnel 2 with the arch and invert of the second or subsequent tunnel attached to the skewbacks 1*d* and 1*e* of the first tunnel, and such subsequent tunnel will be provided with the outside skewbacks 1*d*, 1*e*, (Fig. 5), and a third tunnel may be constructed along side of the last named tunnel, and so on for as many tunnels as may be desired side by side attached one to another.

In accordance with my invention multiple tunnels for subways, tunnels, conduits and the like may be expeditiously and economically constructed, since the work of constructing portions of two or more adjacent tunnels may proceed simultaneously. My invention is of particular advantage due to the fact that multiple tunnels may be constructed side by side in the ground with the use of single shields for each tunnel, whereby great economy is effected and security of the work is attained.

Furthermore, one or more tunnels may be constructed and put into operation and one or more additional tubes may be added at a subsequent time without interference with the use of the first named tunnel or tunnels.

At any desired time after the rings have been set and the pointing between the joints 36 has hardened grout may be forced into the joints, as through grout holes 37 in the segments or blocks, the grout being allowed to harden in the joints for producing a so-called monolithic structure. Gravel at 38 may be blown outside of the tunnel through gravel holes 39, to give immediate support to the tunnel and the surrounding ground, such as described in Letters Patent No. 1,235,233, granted to me July 31, 1917.

Having now described my invention what I claim is:—

1. A tunnel located under ground and exterior means thereon for slidably connecting thereto a shield for a parallel contiguous tunnel.

2. A tunnel located under ground and having exterior grooves for slidably connecting thereto a shield for a parallel contiguous tunnel.

3. A tunnel located under ground and having longitudinally extending exterior means thereon for slidably connecting thereto a shield for a parallel contiguous tunnel.

4. A tunnel located under ground and having exterior longitudinally extending grooves for slidably connecting thereto a shield for a parallel contiguous tunnel.

5. A curved tunnel shield having means along one side to interengage a guiding means externally of the side wall of a tunnel by which the shield may be movable longitudinally along the tunnel substantially transversely undeviatingly therefrom.

6. A curved tunnel shield having projec-

tions along one side to interengage guiding means on a tunnel externally of the wall of said tunnel by which the shield may be movable longitudinally along the tunnel substantially transversely undeviatingly therefrom.

7. The method of building a double tunnel consisting in first building a single tunnel, having means externally on the substantially vertical side thereof for directing and loosely holding a shield in slidable relation to the first mentioned tunnel and against lateral movement with relation to the single tunnel during construction of an adjoining tunnel, and constructing the second tunnel using the shield directed and held by the above mentioned means.

8. The method of building a double tunnel consisting in first building a single tunnel with a shield, having means externally on one substantially vertical side thereof for directing and maintaining a tunnel shield in longitudinally slidable relation to the first mentioned tunnel and against lateral movement with relation to the single tunnel during the construction of the second tunnel, and constructing the second tunnel using the shield directed and held by the above mentioned means.

9. The method of building a multiple tube tunnel with single tube shields consisting in first building a single tunnel with a completely enclosing shield, having means externally on the substantially vertical sides of said tunnel for directing and loosely holding shields employed in the construction of each succeeding adjoining tunnel in slidable relation to the previously constructed adjoining tunnel and against lateral movement with relation to the single tunnel, and constructing other tunnels using shields directed and held by the above mentioned means.

10. A tunnel comprising circular arches and a party wall having two skewbacks at top and bottom of same, the arches being connected to the inner skewbacks at top and bottom of the party wall and the outer skewbacks having means for slidably connecting a shield to said tunnel.

11. A tunnel comprising circular arches and a party wall having two skewbacks at top and bottom of same, the arches being connected to the inner skewbacks at top and bottom of the party wall and the outer skewbacks having grooves for slidably connecting a shield to said tunnel.

12. A tunnel or conduit lining comprising arches connected to a party wall, said party wall having exterior skewbacks containing longitudinally extending means for slidably connecting a shield to said tunnel or conduit lining.

13. A tunnel or conduit lining comprising arches connected to a party wall, said party wall having exterior skewbacks containing longitudinal grooves, a lining therefor for slidably connecting a shield to said tunnel or conduit lining.

14. A curved tunnel shield open at one side having means at top and bottom of said opening to interengage longitudinal guiding means in the exterior skewbacks of a party wall of a tunnel or conduit lining by which the shield may be movable longitudinally along said tunnel or conduit lining substantially undeviatingly therefrom.

15. A curved tunnel shield open at one side having projections at top and bottom of said opening to interengage longitudinal grooves in the exterior skewbacks of a party wall of a tunnel or conduit lining by which the shield may be movable longitudinally along said tunnel or conduit lining substantially undeviatingly therefrom.

16. A curved tunnel shield having projections at top and bottom located along an open side to interengage guiding means on a tunnel, said projections being located along side edges of the opening in the shield and projecting one in the direction of another by which the shield may be movable longitudinally along said tunnel substantially undeviatingly therefrom.

17. The method of building double tunnels having a party wall connecting the tunnels consisting in first building a single tunnel comprised of arches and a party wall with exterior skewbacks at top and bottom of the party wall containing longitudinal guiding grooves, and constructing the second tunnel using a shield with an open side slidably connected to the guiding grooves in skewbacks of the party wall.

18. The method of building double tunnels with a shield having a party wall connecting the tunnels consisting in first building a single tunnel comprised of arches and a party wall with exterior skewbacks at top and bottom of the party wall containing longitudinal guiding grooves, and constructing the second tunnel using a shield with an open side slidably connected to the guiding grooves in skewbacks of the party wall.

19. The method of building a three tube tunnel with single tube shields consisting in first building a single tunnel with a completely enclosing shield, said tunnel comprising arches and inverts connected to party walls having exterior skewbacks containing longitudinally extending grooves for directing and loosely holding projections from open sided shields to maintain them in substantially undeviatingly sliding relation to the first tunnel when the same are employed in the construction of adjoining tunnels, and next building the two adjoining tunnels with shields having one open side along the party wall, each outside tunnel comprising circular rings connected to the party wall.

20. The method of building a three tube tunnel with single tube shields consisting in first building a single tunnel with a completely enclosing shield, said tunnel comprising arches and inverts connected to party walls having exterior skewbacks containing longitudinally extending grooves for directing and loosely holding projections from open sided shields to maintain them in substantially undeviatingly sliding relation to the first tunnel when same are employed in the construction of adjoining tunnels, and next building the two adjoining tunnels with shields having one open side along the party wall, each tunnel comprising circular rings connected to the party wall.

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