April 14, 1931. F. DONALDSON 1,800,819

METHOD AND MEANS FOR CONSTRUCTING TUNNEL STATIONS

Filed June 30, 1930 4 Sheets-Sheet 1

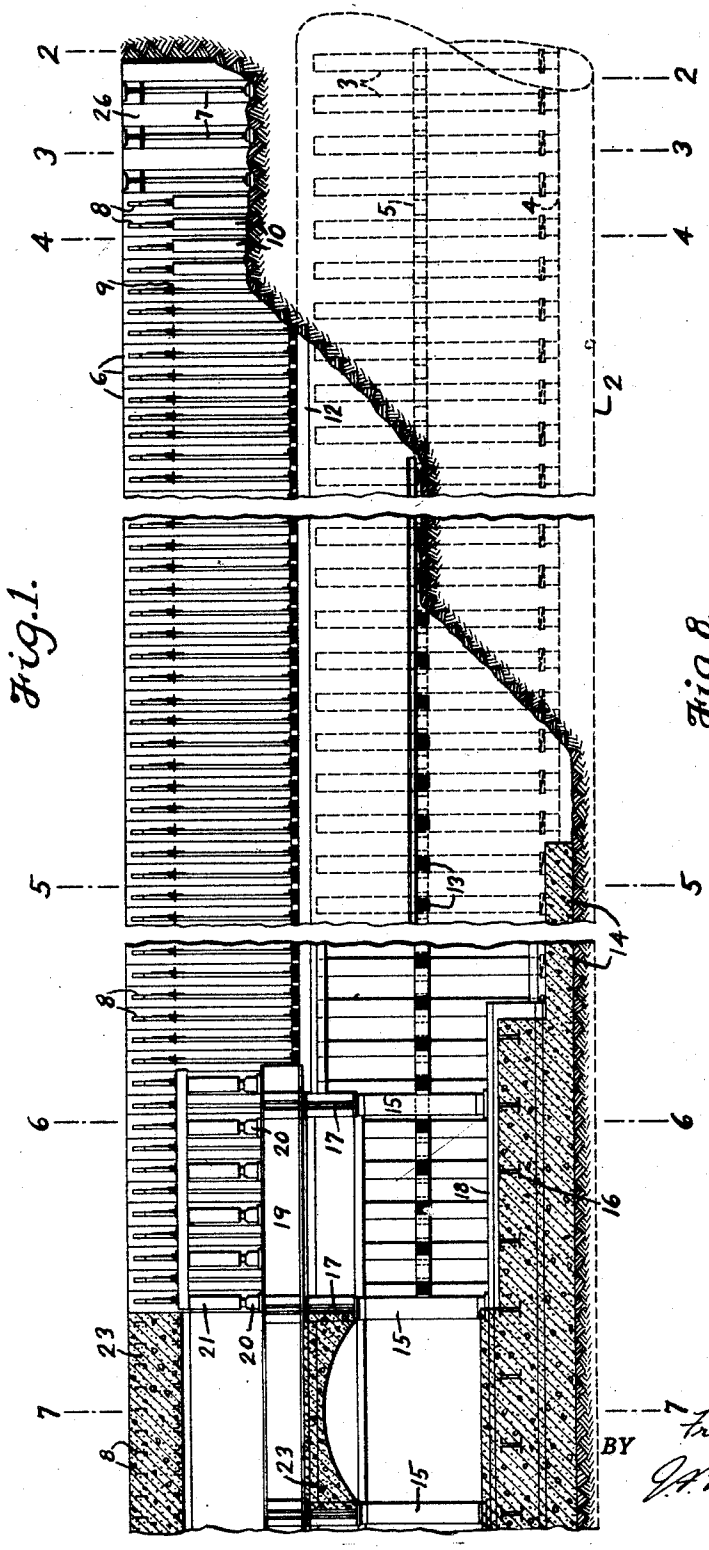


Fig. 1.

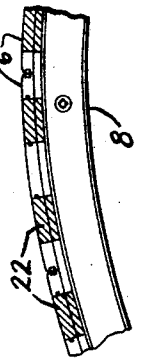


Fig. 8.

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Fig. 2.

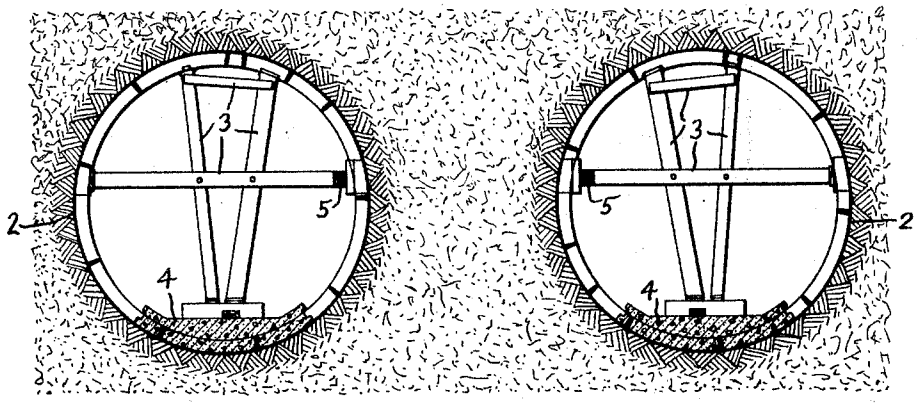
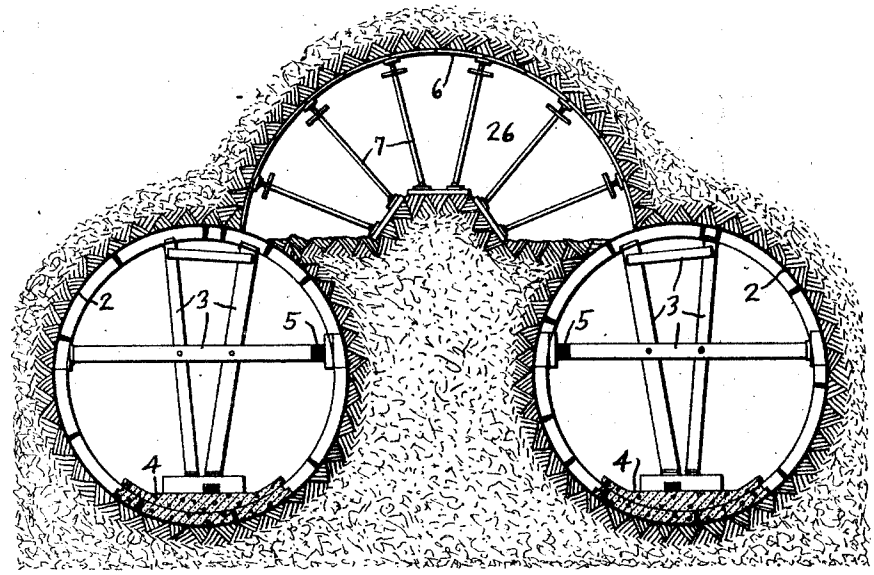


Fig. 3.



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METHOD AND MEANS FOR CONSTRUCTING TUNNEL STATIONS

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Fig. 4.

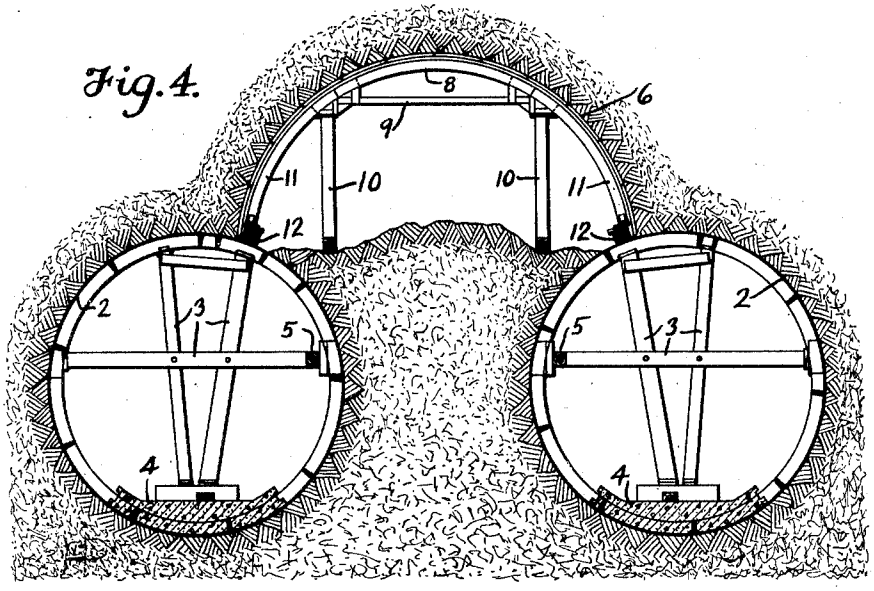
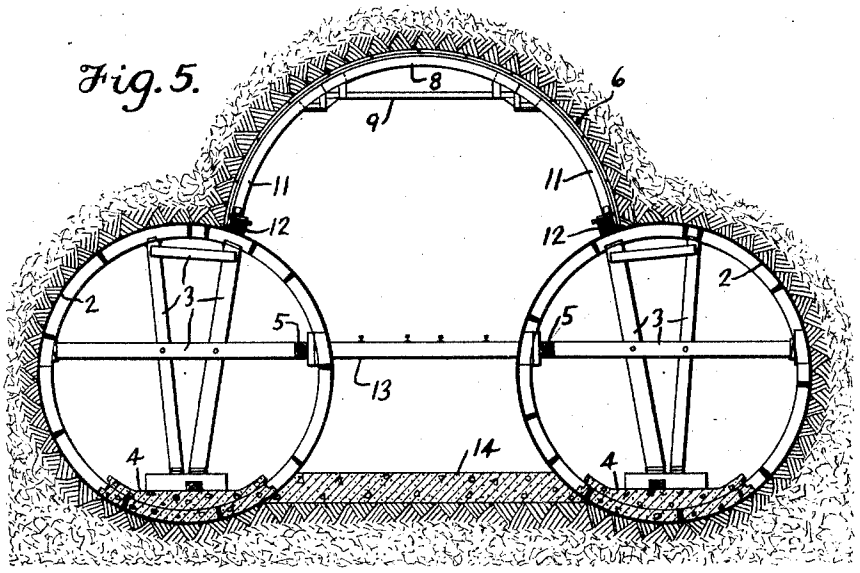


Fig. 5.



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Fig. 6.

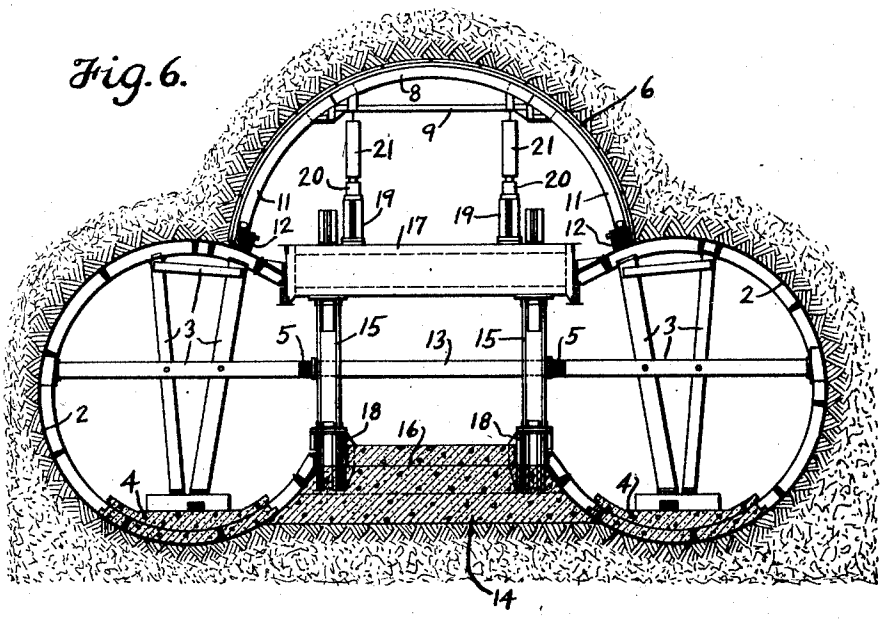
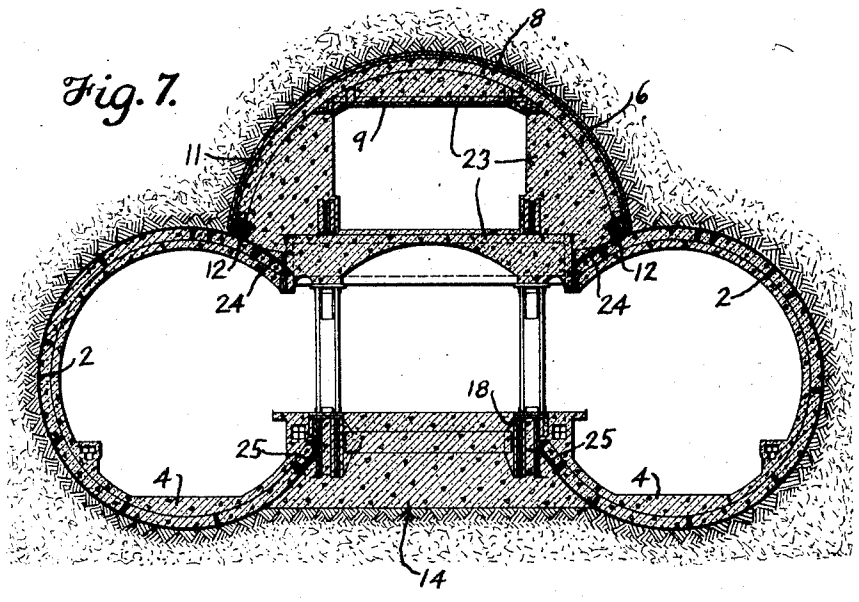


Fig. 7.



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UNITED STATES PATENT OFFICE

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METHOD AND MEANS FOR CONSTRUCTING TUNNEL STATIONS

Application filed June 30, 1930. Serial No. 464,746.

In the construction of subaqueous or other shield-driven railroad tunnels, particularly for subways, it is usually advisable to construct a station not far from the edge of the river or at least in the soft ground portions of the tunnel. Such tunnels are ordinarily composed of two independent parallel cast-iron-lined tubes driven with shields under compressed air. Stations such as those referred to are customarily built by the removal, segment by segment, of the adjacent portions of the cast-iron lining of the two tubes and the piecemeal construction of a passageway between them that will serve as an island station. Such construction has proven difficult, dangerous and exceedingly slow.

On account of the difficulties previously experienced, I have devised an improved method of and means for constructing a station or enlargement in soft ground between parallel tubes previously driven. Among the objects of this invention are to expedite very greatly the construction of such stations, to reduce the cost of such work materially, and to prevent settlement of the surface and consequent disturbance of superincumbent structures or public utility facilities beneath the surface of the ground.

My invention consists of the driving of a new tunnel arch between the tubes, preferably by the tunnel plate method, the haunches of said arch being supported upon the shells of the two tubes and the shells of the tubes being in turn supported interiorly by upright timbers or other temporary struts or supports, so as to permit the subsequent removal of the portions of these shells adjacent to one another. The tunnel plates are supported immediately after placing by arch-rings made of structural members, and, during the subsequent excavation and construction of the interior portions of the station, these arch-rings act as true arches and their end reactions are transmitted through the tube linings to the timbers or internal supports hereinbefore mentioned. It is, of course, necessary subsequently to remove these timbers, and the overlying loads carried by the arch must then be transmitted through suitable structurable members to a new floor slab directly beneath the arch. The top portions of the arch-rings are therefore preferably constructed so as to serve as beams or girders after the loads are transferred to the permanent structure and through it to the floor slab, and the temporary supporting timbers are removed. In practice, said top portions constitute bow-string trusses.

In more detail, the process of construction is as follows:—

The tube tunnels are supported interiorly by properly placed struts, preferably of timber. The arch tunnel is driven, preferably by the so-called tunnel plate method, above and between the two tubes, and the overlying load is supported by arch rings bearing at their ends against the tops of the tunnel linings. The material beneath the arch and between the tubes is removed to a level approximately that of the bottom of the tubes and a concrete or other foundation slab is placed. The linings of both original tubes between the foot of the arch and the top of the new floor slab are removed, horizontal struts being supplied as required to take care of the lateral pressure of the earth outside of the tubes. The permanent structural framework of the station is constructed in the open space beneath the arch, but the final closures between this structural framework and the bow-strings and between the framework and tunnel linings are not made at this time. Suitable jacking means are provided between the structural framework of the station and roof of the station tunnel, the framework is stressed to a degree determined in accordance with the expected final load, and while this stress is maintained the closures referred to are made.

In the accompanying drawings forming part hereof:

Fig. 1 is a vertical longitudinal section of a station in course of construction, including a completed portion, intermediate portions being broken out to economize space on the drawing;

Figs. 2–7 are sections taken on corresponding section lines of Fig. 1 illustrating different steps or stages in the method; and

Fig. 8 is a fragmentary sectional view on a larger scale.

The shells of the two previously driven tunnel tubes are marked 2, these shells being preferably composed of usual cast-iron segments. As a preliminary, these shells are braced internally, for a distance corresponding to the length of the station to be constructed, by timber struts 3 wedged between the concrete inverts 4 and the upper segments of the shells. The timbering also preferably includes transverse braces 5.

While the steps of constructing the station are successive, it will be understood that they progress simultaneously at different points along the length of the station location, as indicated in Fig. 1.

At the head end of the work, an arched top heading 26 is driven, this top heading being supported promptly as it is advanced, by means of known pressed steel tunnel plates 6, which are temporarily braced by trench jacks or the like 7.

Following thereafter, curved structural members 8, preferably of channel section, having chord members 9, are placed beneath the tunnel plates on temporary supports 10, and are wedged up against the plates. The trench jacks are removed, and lower curved channel members 11 are placed between the ends of the members 8 and longitudinal sills 12 resting on the tube shells, and are wedged tight. The members 8, 11 then constitute arch-rings or arch-ribs which carry the overlying earth load and the load of any superimposed structures, and apply their end reactions to the tunnel shells, which in turn are supported internally by the struts 3. The temporary posts can then be removed.

The upper bench being then excavated, transverse track sills 13 may be laid, these track sills being useful also for transverse bracing. The lower bench is excavated, and the concrete 14 is placed on the sub-grade.

At this stage the segments of the inner or adjacent portions of the tunnel shells are removed.

The permanent structural steel work of the station, including, for example, uprights 15, lower transverse members 16, upper transverse girders 17 and longitudinal girders 18, is erected on the floor slab. The concrete of the platform is poured up to the top of the transverse channels 16.

Temporary longitudinal girder beams 19 are placed on the transverse girders 17, and hydraulic jacks 20 and posts 21 are interposed between these temporary girders and the ends of the bow-string trusses. The jacks are then actuated to impose on the framework of the station a downward stress closely approximating the expected final loading of the station. Then, and not until then, the final closures are made between the arches and the framework of the station, and likewise between this structure and the shells of the tubes.

The closure between the framework and the bow-string trusses forming the roof beams is formed by placing the concrete 23 of the upper or mezzanine part of the structure. The closures between the framework and the tube shells consist of special castings 24 and 25 wedged between the tube segments and the framework.

Finally, the bracings in the tubes are removed and the concreting inside the tubes is completed.

Certain of the tunnel plates are provided with openings through which grout is pumped outside of the lining in the first instance, and in order to have the metal of the station roof surrounded on all sides by concrete, concrete blocks 22 may be interposed between the tunnel plates and the arch-rings.

While the preferred mode of execution has been described in some detail, it will be understood that the procedure and the elements which enter into it may be modified within the scope of the invention as defined in the claims.

I claim:

1. In the construction of a station or enlargement in tunnel between two previously driven tunnel tubes, the excavation of said station or enlargement under the protection of arch-rings bearing upon the top of the shells of the tubes, the shells in turn being supported by temporary struts within the tubes.

2. A method of constructing a station between two previously driven tunnel tubes, which comprises tunneling the station under the protection of arches, causing said arches to bear upon the tops of the shells of the tubes, and supporting the shells in turn by temporary internal struts, thereafter taking out the adjacent portions of the shells, constructing the interior of the station, and eventually transferring the reaction of the load overlying the station from the tube shells to the permanent structure directly beneath.

3. A method of constructing a station between two previously driven tunnel tubes, which comprises tunneling the station under the protection of arch-rings which are placed to bear upon the tops of the shells of the tubes while the shells are supported in turn by temporary internal struts, the top portions of said arch-rings being adapted to serve eventually as roof beams, removing the adjacent portions of the tube shells, constructing a permanent framework in the station enlargement, connecting said beams with said framework as parts of the permanent structure, and thereafter removing the temporary struts from the tubes.

4. A method of constructing a station or enlargement in tunnel between two pre-

viously driven tunnel tubes, said method involving the provision of arch-rings the top portions of which are adapted to serve eventually as roof beams, the method comprising placing temporary supports inside the tube shells, excavating an arch tunnel between the tubes and progressively placing said arch-rings so that they bear on the tops of the tube shells, completing the excavation of the station or enlargement beneath the protection of the arch-rings, constructing a permanent structure in said enlargement, and eventually incorporating said beams in the permanent structure so that the overlying load which they carry is transferred from the tube shells.

5. A method of constructing a station between two previously driven tunnel tubes, which comprises placing temporary supports in the interior of the tube shells, tunneling between and above the tubes, progressively placing plates and arch rings to carry the overlying load and applying the end reactions of said rings to the tops of the tube shells, completing the excavation for the station under the protection of said rings, laying a floor slab, removing the inner sections of the tube shells down to the floor slab, constructing the station structure on said floor slab, and eventually transferring the reaction of the load on the top portions of the arch-rings from the tube shells to said station structure.

6. A method of constructing a station between two previously driven tunnel tubes, which comprises placing temporary supports in the interior of the tube shells, driving an arch tunnel between and above the shells, placing arches to carry the overlying load and to apply their end reactions to the tops of the tube shells, completing the excavation for the station under the protection of said arches, removing the adjacent portions of the tube shells, constructing a foundation and a permanent station structure in the excavation thus protected, stressing the station structure to a degree corresponding to its expected final load by jacking between the structure and the arches, and making a closure between the station structure and the arches while this stress is maintained.

7. A method of constructing a station between two previously driven tunnel tubes, which comprises tunneling the station under the protection of arches, causing said arches to bear upon the tops of the shells of the tubes, and supporting the shells in turn by temporary internal struts, thereafter taking out the adjacent portions of the shells, laying a foundation for the station at the bottom of the excavation between the tubes, erecting a permanent framework thereon, stressing said framework to a degree corresponding to the expected final load, and while said stress is maintained making closures between the framework of the station and the arches.

8. A method of constructing a station between two previously driven tunnel tubes, which comprises tunneling the station under the protection of arches, causing said arches to bear upon the tops of the shells of the tubes, and supporting the shells in turn by temporary internal struts, thereafter taking out the adjacent portions of the shells, laying a foundation for the station at the bottom of the excavation between the tubes, erecting a permanent framework thereon, stressing said framework to a degree corresponding to the expected final load, and while said stress is maintained making closures between the framework of the station and the arches and between the framework and the shells of the tubes.

9. In the construction of an island station in soft ground, the combination with two previously driven tunnel tubes, of temporary supports in said tubes, tunnel plates and arch-rings carrying the load overlying an arch tunnel driven between and above said tubes, the ends of said arch-rings bearing on the tops of the tube shells so as to transmit the roof load to the temporary supports within the tubes, and the top portions of the arch rings being constructed so as to form roof beams of the station.

10. In the construction of an island station in soft ground, the combination with two previously driven tunnel tubes, of temporary supports in said tubes, tunnel plates and arch-rings carrying the load overlying an arch tunnel driven between and above said tubes, the ends of said arch-rings bearing on the tops of the tube shells so as to transmit the roof load to the temporary supports within the tubes, and the top portions of the arch rings being constructed so as to form roof beams of the station, and means for relieving the supports within the tubes of the roof load and transferring it to a permanent structural framework resting upon foundations between the tubes.

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