No. 836,215. PATENTED NOV. 20, 1906.

J. W. RENO.

TUNNEL CONSTRUCTION AND METHOD AND APPARATUS FOR FORMING THE SAME.

APPLICATION FILED MAR. 5, 1906.

2 SHEETS—SHEET 1.

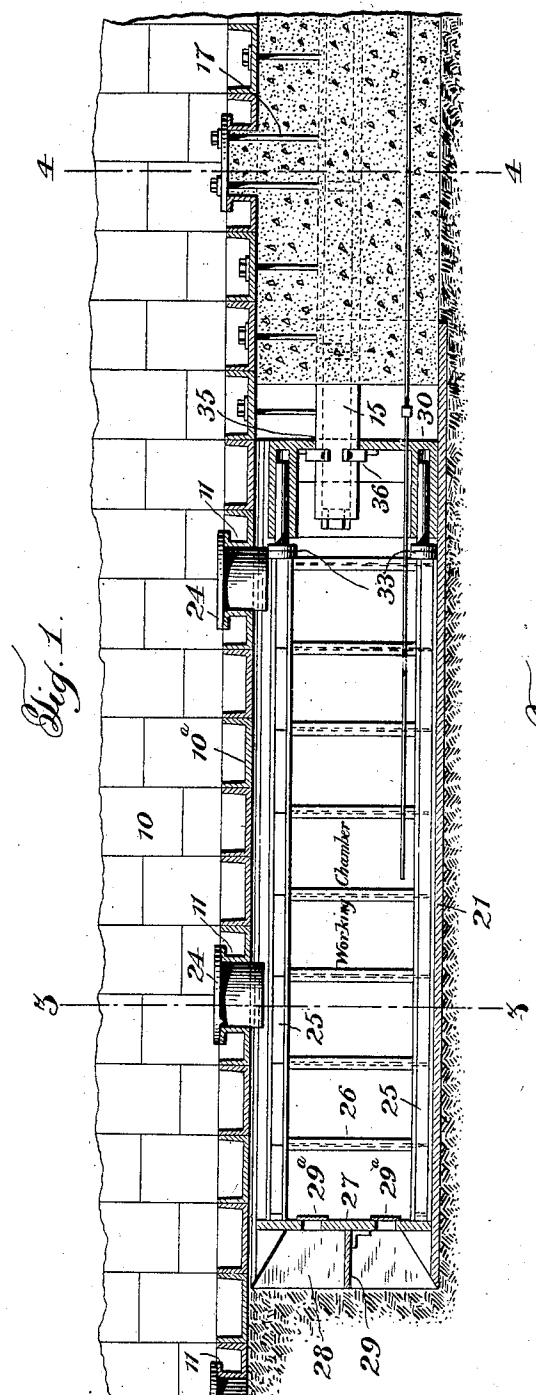


Fig. 1.

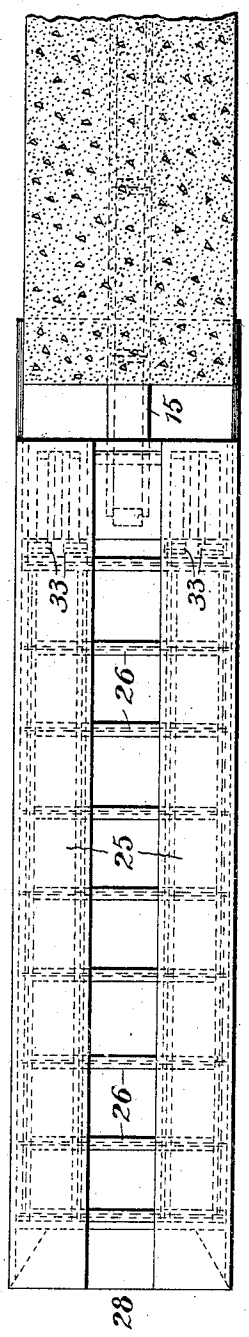


Fig. 2.

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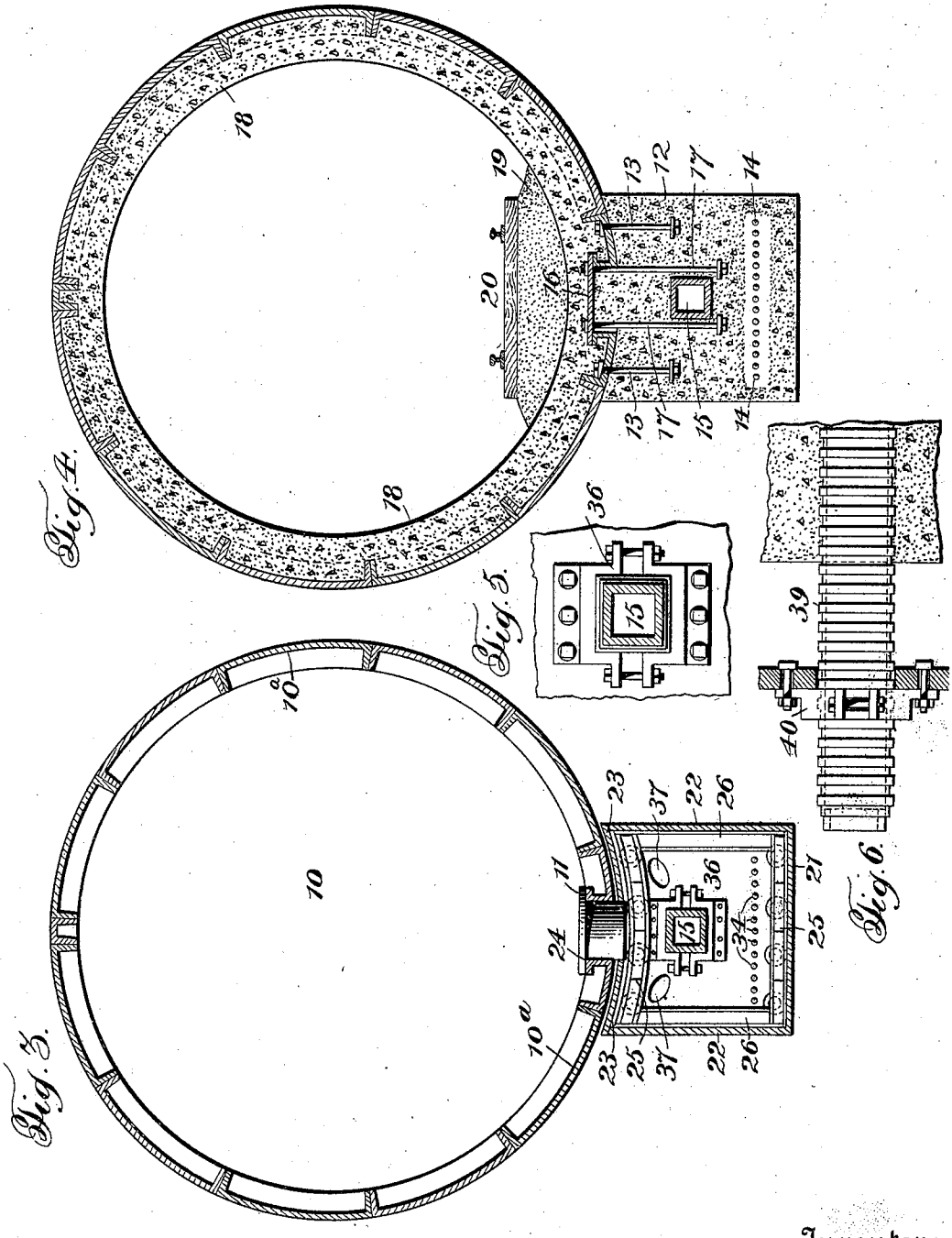
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UNITED STATES PATENT OFFICE.

JESSE W. RENO, OF NEW YORK, N. Y.

TUNNEL CONSTRUCTION AND METHOD AND APPARATUS FOR FORMING THE SAME.

No. 836,215. Specification of Letters Patent. Patented Nov. 20, 1906.

Application filed March 5, 1906. Serial No. 304,310.

To all whom it may concern:

Be it known that I, JESSE W. RENO, of New York, in the county of New York and in the State of New York, have invented a certain new and useful Improvement in Tunnel Construction and Method and Apparatus for Forming the Same; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, in which—

Figure 1 is a partial vertical longitudinal section illustrating a tunnel provided with my reinforcing-girder and also illustrating an apparatus for the practice of my method of constructing said girder. Fig. 2 is a horizontal sectional view taken in the plane of the bottom of the tunnel as illustrated in Fig. 1, the positions of the manholes being indicated by dotted circles. Figs. 3 and 4 are vertical sectional views taken, respectively, on the lines 3 3 and 4 4 of Fig. 1; and Figs. 5 and 6 are detail views.

The objects of my invention have been to provide an improved tunnel construction embodying the generic idea in tunnel constructions which is covered by the Letters Patent granted to me March 24, 1903, No. 723,307, but illustrating a different specific embodiment of said generic idea, to provide an improved method of forming such tunnel constructions, and to provide improved apparatus for practicing said method; and to such ends my invention consists in the tunnel construction and method and apparatus for forming the same, substantially as hereinafter specified.

In carrying my said invention into practice as illustrated in the said drawings I provide a tunnel 10, placed in position in any desired manner and having any desired construction, except that it is provided with manholes 11 or other form of opening for a purpose to be explained. I prefer to have the tunnel formed of metal plates 10^a and to have it form a complete circle, so that the strength of the tunnel is not impaired in any way. Beneath the tunnel is a reinforcing-girder 12, which, as stated in my said patent, is provided to give the tunnel strength longitudinally, so that it can bear the concentrated weight of a locomotive or the distributed weight of a train without bending, even though the earth through which it is driven may not afford a good support. Said girder is also for the purpose of giving weight to the tunnel, so that it will not tend to rise or float in soft material in which it may be embedded. Said girder also serves the purpose of absorbing the shock and vibration of passing trains, and thus avoids their transmission to the surrounding earth and the harmful loosening effect that would follow.

The girder 12 consists of a body formed of concrete or other similar material which fits the bottom of the tunnel and is secured thereto by bolts 13, such bolts passing through such bottom and having heads or nuts on the upper side thereof and also having heads or nuts that are embedded in the concrete. In the lower portion of the body of concrete longitudinal metal rods 14 are embedded, this being the portion of the girder which is subjected to tensile strains by weight in the tunnel. Embedded in the body of the girder is a preferably rectangular pipe 15, which may serve as a drain. In the completed tunnel the manholes 11 are preferably covered by plates 16, that are secured in place by bolts 17, anchored in the body of the girder. The completed tunnel is also provided with a cement lining 18 and with a road-bed 19 and track 20.

In constructing the above illustrated tunnel by the practice of my method I preferably use my improved apparatus for the purpose, which comprises what I shall term a "working chamber." Such chamber consists of a sheet-metal bottom 21, sheet-metal sides 22, and top plates 23, which extend from the side plates inward, the adjacent edges of said plates being separated a distance preferably equal to diameter of the manholes in order that the working chamber may be guided on flanged rings 24, that are temporarily seated in the manholes and project sufficiently below the tunnel to engage and guide the adjacent edges of the top plates.

The working chamber is preferably braced by longitudinal **I**-beams 25 on the bottom and top plates and by cross **I**-beams 26 on the sides, top, and bottom; but any other form of bracing can be used. The working chamber is provided with an excavating-head 27 of any construction, but preferably one suitable for being forced into the material beneath the tunnel in order that the material ahead of such chamber may be excavated. Such head may have the usual cut-

ting edges 28 and a shelf 29 to direct a portion of the material displaced into the upper manholes 29ª.

At the rear end the bottom and side plates extend some distance beyond the bracing; but the top plates terminate farther forward for a purpose to be explained.

A bulkhead 30 closes the space between the bottom of the tunnel and the bottom and side plates of the working chamber, and such bulkhead has formed in or attached to it a number of cylinders which are preferably arranged four at the bottom of the bulkhead and four at its top. If the pistons do not come in line with the I-beams 25, a cross plate or frame 33 may be provided for the pistons to bear against. Means are provided to produce pressure, preferably by means of water, in the cylinders to force out the pistons.

The bulkhead is provided with holes 34, through which the rods 14 may be passed, and with an opening 35, by which the sections of the pipe 15 may be set into place. A clamp 36 is secured to the bulkhead in order that the latter may be secured to the pipe 15 for a purpose to be explained. The bulkhead is also provided with manholes 37, by which a man may pass to a space back of the bulkhead and by which concrete may be introduced into such space.

In the practice of my method of forming a strengthening-girder under a tunnel, as illustrated in the formation of the above-illustrated girder, using the above-illustrated apparatus the working chamber is gotten into position under one end of the tunnel by making a suitable excavation or in any other desired manner. A partition having an air-lock is preferably located in the tunnel at a point nearer the open end of the tunnel than the manholes 11, giving access to the working chamber. The rods 14, bolts 13, and pipe 15 having been placed in position, the space back of the bulkhead is filled with concrete or other suitable material. For the purpose of placing said rods and bolts and said pipe in position and of distributing and tamping said concrete a man preferably gets behind the bulkhead. When such material has set, the water-pressure may be turned into the cylinders 26 and the working chamber forced ahead, its movement being guided by the action of the top plates against the flanged rings 24 in the manholes. After sufficient length of the pipe 15 has been set in the concrete to firmly support such pipe the bulkhead, without waiting for the concrete to set, may be clamped to the said pipe by the clamp 36 and the working chamber then forced ahead. The projecting rear ends of the side and bottom plates are supported against the external pressure by the concrete and by the bulkhead. After the working chamber has been forced forward the bulkhead is drawn forward (as by creating a vacuum in the cylinder) to afford the space for working behind it. The sections of the pipe 15 fit into each other, and the adjacent ends of the rods 14 are screwed into sleeves to make, in effect, one continuous rod. The working chamber preferably has a groove 38 formed in its top to permit it to pass the flanged ring 24 without the removal of the latter. After my girder is formed the manhole-covers are bolted on, the tunnel is lined, and the road-bed 19 is put in.

It is obvious that various changes can be made in the above-illustrated constructions and method without departure from the spirit of my invention, and I desire not to be limited beyond the terms of my claims and the requirements of the prior art. For instance, the pipe 15 may, as illustrated in Figs. 5 and 6, be provided with corrugations 39, and the clamp 40 may be complementally formed so that the pipe will be more firmly anchored in the cement, and the clamp will get a firmer hold on the pipe.

The above-described method of and apparatus for forming tunnel constructions are of course applicable to the formation of other tunnel constructions than that illustrated herein. For instance, they can be used in forming such a tunnel construction as illustrated in my said Patent No. 723,307.

I claim—

1. In a tunnel structure, the combination of a metal shell forming a complete circle, a concrete girder beneath said shell and extending longitudinally thereof, bolts embedded in said girder and secured to said shell, and tension-rods embedded longitudinally in said girder.

2. In an apparatus of the class described, the combination of a working chamber having an excavating-head at one end and a bulkhead at the opposite end of said chamber, said working chamber having its top shaped to fit the under side of a tunnel-shell.

3. In an apparatus of the class described the combination of a working chamber having an excavating-head at one end, a bulkhead at the other end, and means for moving said chamber relative to said bulkhead.

4. In an apparatus of the class described, the combination of a working chamber having an excavating-head at one end, a bulkhead at the other end, means for moving said chamber relative to said bulkhead, and means for guiding said working chamber on a tunnel-shell.

5. In an apparatus of the class described, the combination of a working chamber having an excavating-head at one end, a bulkhead at the other end, and means for moving said chamber relative to said bulkhead, said bulkhead having an opening therein for the passage of material.

6. In an apparatus of the class described, the combination of a working chamber hav-

ing an excavating-head at one end, a bulkhead at the other end, means for moving said chamber relative to said bulkhead, and means for guiding said working chamber on a tunnel-shell, said bulkhead having an opening therethrough, and a clamp about said opening.

7. In an apparatus of the class described, the combination of a tunnel-shell having manholes in its bottom, tubes seated in said manholes, a working chamber having an excavating-head at one end, and a bulkhead at the opposite end, means for moving said working chamber and bulkhead relative to each other, and guides on said working chamber adapted to engage said tubes.

8. In an apparatus of the class described, the combination of a tunnel-shell having manholes in its bottom, tubes seated in said manholes, a working chamber having an excavating-head at one end, and a bulkhead at the opposite end, means for moving said working chamber and bulkhead relative to each other, and guides adapted to engage said tubes, said guides being formed by the adjacent edges of the top plates of said working chamber.

9. In an apparatus of the class described, the combination of a working chamber, an excavating-head at one end of said working chamber, a bulkhead at the opposite end of said chamber, and means for moving said bulkhead and chamber relative to each other, said bulkhead having holes for the passage of rods therethrough.

10. In an apparatus of the class described, the combination of a working chamber having an excavating-head at one end thereof, a bulkhead at the opposite end thereof, and means for moving said working chamber and bulkhead relative to each other, said bulkhead having a manhole therein for affording access to its outer side.

11. In an apparatus of the class described, the combination of a working chamber having an excavating-head at one end, a bulkhead at the opposite end, means for causing a relative movement of said working chamber and bulkhead, said bulkhead having a central opening therethrough, and a clamp surrounding said opening.

12. In an apparatus of the class described, the combination of a tunnel-shell, a concrete girder secured to the bottom of said shell, and extending longitudinally thereof, a sectional pipe or rod extending through the center of said girder and projecting from its front face, a working chamber beneath said shell and having an excavating-head at its forward end, a bulkhead, at the rear end of said working chamber, means for causing a relative movement of said working chamber and bulkhead, said bulkhead having a central opening, and a clamp about said opening and adapted to engage said pipe.

13. In an apparatus of the class described, the combination of a tunnel-shell, a concrete girder secured to the bottom of said shell, and extending longitudinally thereof, a sectional pipe or rod extending through the center of said girder and projecting from its front face, a working-chamber beneath said shell and having an excavating-head at its forward end, a bulkhead, at the rear end of said working chamber, means for causing a relative movement of said working chamber and bulkhead, said bulkhead having a central opening, and a clamp about said opening and adapted to engage said pipe, said pipe being corrugated.

14. In an apparatus of the class described, the combination of a tunnel-shell, a concrete girder secured to the bottom of said shell, and extending longitudinally thereof, a sectional pipe or rod extending through the center of said girder and projecting from its front face, a working chamber beneath said shell and having an excavating-head at its forward end, a bulkhead, at the rear end of said working chamber, means for causing a relative movement of said working chamber and bulkhead, said bulkhead having a central opening, and a clamp about said opening and adapted to engage said pipe, said pipe and clamp being corrugated.

15. In an apparatus of the class described, the combination of a tunnel-shell, a concrete girder extending longitudinally of and secured to the outside of said shell, a working chamber beneath said shell, said working chamber having an excavating-head at its forward end, a bulkhead at the rear end of said working chamber, and means for causing a relative movement of said working chamber and bulkhead, said working chamber comprising side and bottom plates which extend beneath said bulkhead and are adapted to embrace the forward end of said concrete girder.

16. In an apparatus of the class described, the combination of a tunnel-shell, a concrete girder extending longitudinally of and secured to the outside of said shell, a working chamber beneath said shell, said working chamber having an excavating-head at its forward end, a bulkhead at the rear end of said working chamber, and means for causing a relative movement of said working chamber and bulkhead, said working chamber comprising side and bottom plates which extend beneath said bulkhead and are adapted to embrace the forward end of said concrete girder, said working chamber also having top plates, whose adjacent edges are separated from each other, and projections on said tunnel-shell that are adapted to be engaged between said top plates to guide the working chamber.

17. The method of constructing reinforcements for tunnels, which consists of partially

forming a reinforced member, providing said member with a central rod or pipe, clamping an excavating apparatus to said pipe, and forcing said excavating apparatus ahead, using said pipe as an abutment.

18. The method of constructing reinforcements for tunnels, which consists in forming a reinforcing member for a portion of the length of the tunnel-shell, inclosing the forward end of said member in a thin mold, filling said mold with material for forming said reinforcing member, and forcing said mold forward by pressing backward on said reinforcing member.

19. The method of constructing reinforcements for tunnels, which consists in forming a reinforcing member along a portion of the length of a tunnel-shell, inclosing the forward end of said member by the thin walls of a forwardly-extending chamber having a movable bulkhead at its rearward end, filling the space between said bulkhead and said member with material for forming said member, and forcing said chamber forward by forcing said bulkhead against said material.

20. The method of constructing reinforcements for tunnels, which consists in forming a reinforcing member for a portion of the length of a tunnel-shell embedding in said member a rod or pipe projecting from the forward end thereof, inclosing the forward end of said member in the walls of a working chamber having an excavating-head at its opposite end, filling the mold formed by said inclosing walls with material for forming said member, securing a clamp to said projecting rod or tube, and exerting pressure between said clamp and said working chamber, to force said working chamber forward.

In testimony that I claim the foregoing I have hereunto set my hand.

JESSE W. RENO.

Witnesses:

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EDWIN J. PRINDLE.