No. 820,747. PATENTED MAY 15, 1906.

R. F. TUCKER.

METHOD OF AND APPARATUS FOR LINING TUNNELS WITH CONCRETE.

APPLICATION FILED JULY 8, 1904.

2 SHEETS--SHEET 1.

Fig.1

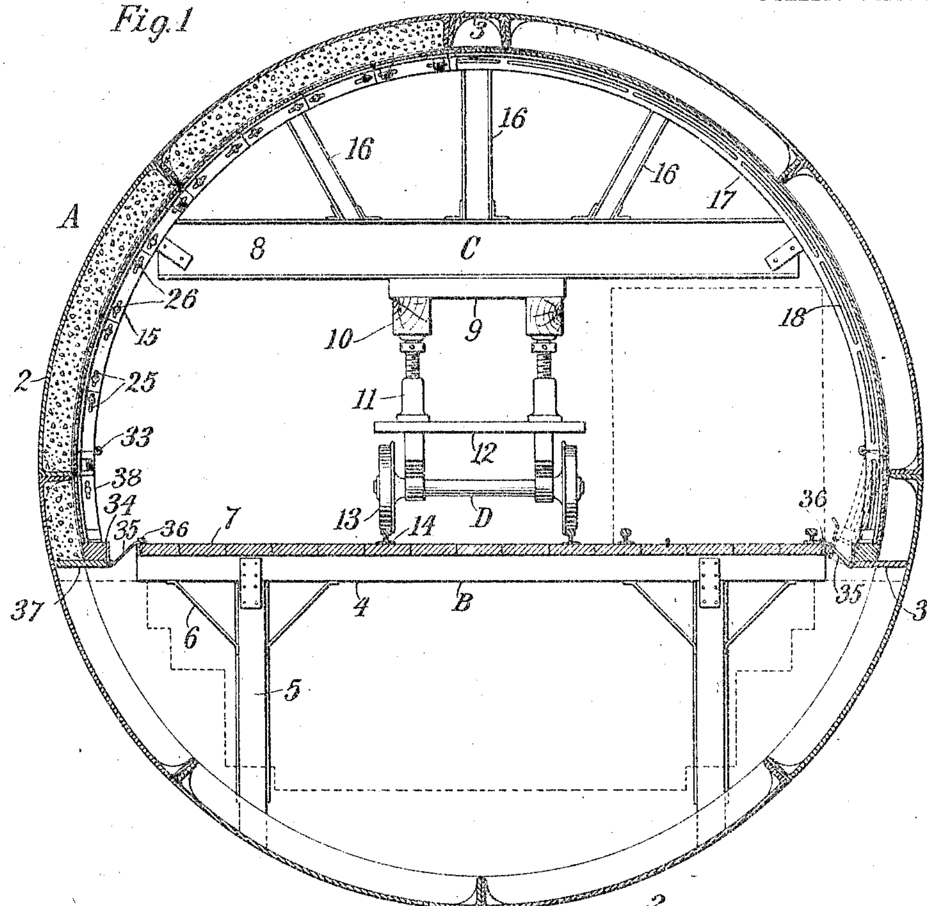


Fig.4

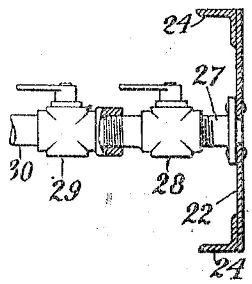
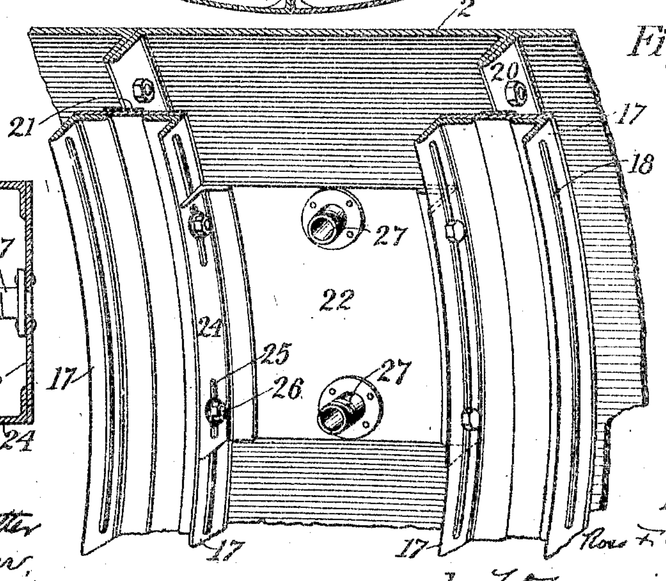


Fig.3



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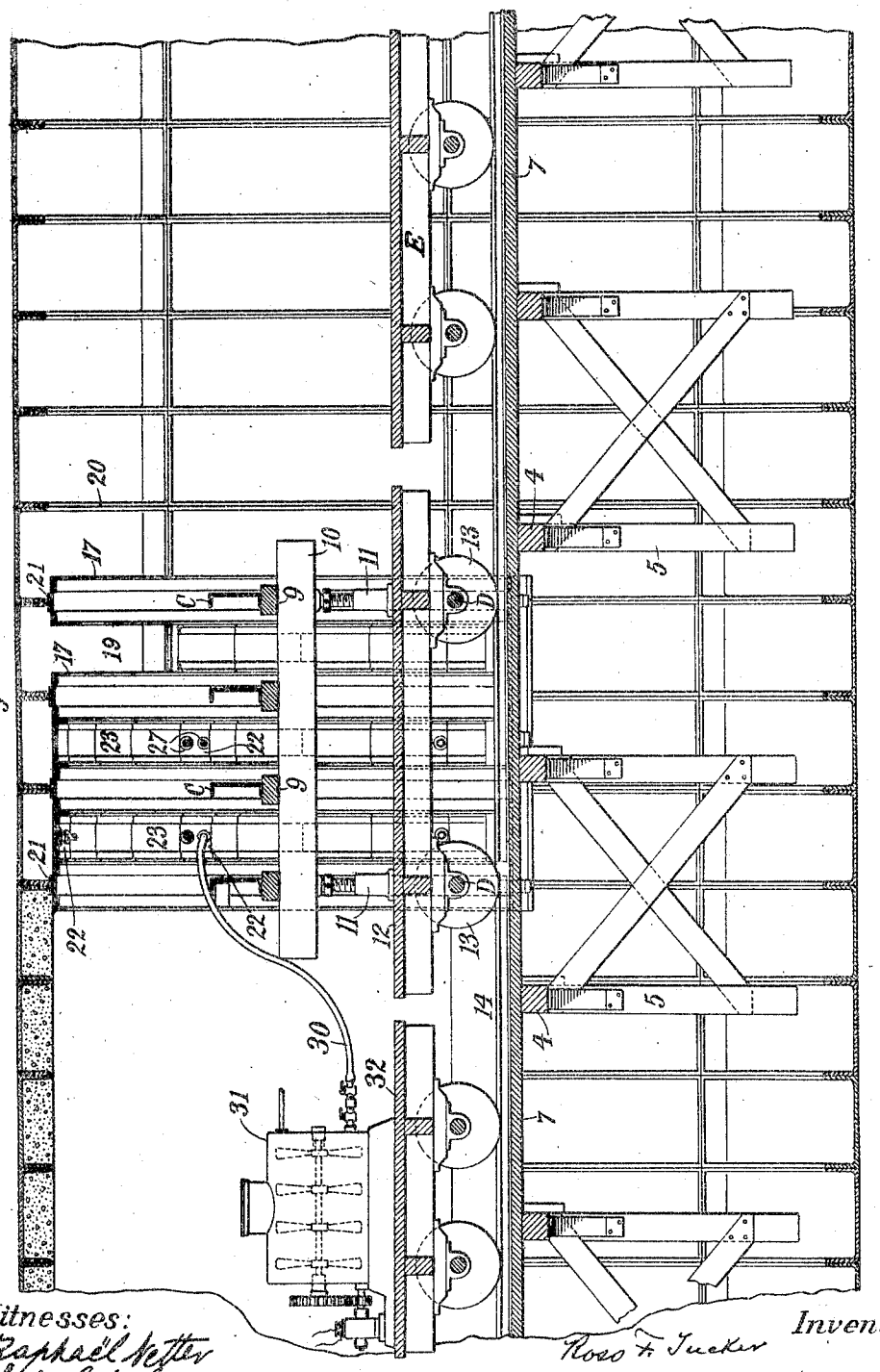
2 SHEETS—SHEET 2.

Fig. 2



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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR LINING TUNNELS WITH CONCRETE.

No. 820,747. Specification of Letters Patent. Patented May 15, 1906.

Application filed July 8, 1904. Serial No. 215,731.

To all whom it may concern:

Be it known that I, ROSS F. TUCKER, a citizen of the United States, residing at 156 Fifth avenue, New York city, State of New York, have invented a new and useful Method of and Apparatus for Lining Tunnels with Concrete, of which the following is a specification.

My invention relates to improvements in methods and apparatus for the lining of tunnels, particularly with concrete, its object being to carry on simultaneously the two sets of operations of driving the tunnel-heading and finishing the interior of the tunnel-tube in the rear of the heading; and it consists in the methods and features of construction hereinafter particularly described and claimed.

In the accompanying drawings, forming part of this specification, Figure 1 is a cross-section of a metallic tunnel-tube in which my improvements are shown. Fig. 2 is a longitudinal section of the same. Fig. 3 is a perspective sectional detail of the tunnel-tube and the shield-segments in place thereon, with one of the closure-sections secured in place; and Fig. 4 is a detail showing the coupling for a hose connection between a grout-pump and one of the closure-sections.

In the drawings, A represents a metallic tube adapted to be erected within the bore of the tunnel, made up of flanged segments 2 and 3.

B is a temporary frame or platform arranged longitudinally in the completed portion of the tunnel-tube, extending, preferably, from the tunnel-entrance to close proximity to the heading and being arranged, preferably, near, but a little below, the horizontal diameter of the tube, leaving space underneath for the running of cars to and from the heading. This platform is made up of the cross-timbers 4, the standards 5, having proper braces 6, and preferably covered with a floor of planks 7. The platform is slightly narrower than the diameter of the tube, as shown, for reasons hereinafter pointed out.

C is the shield or center, by means of which the concrete is applied to the tunnel-arch and held in place until it has set. This is made up of series of channel-girders 8, extending transversely of the tunnel-arch and supported upon the timbers 9, carried by the stringers 10. These stringers are mounted upon jacks 11, which in turn are set upon the platform 12 of the truck D, the carrying-wheels 13 of which run upon tracks 14 on the platform B. The shield itself is made up of series of flanged cylindrical segments 15, secured to the girders 8 and supported also by the struts 16. The webs of the flanges 17 of the cylindrical segments are provided with longitudinal slots 18 and are uniformly interspaced from each other, as shown best in Figs. 2 and 3, so as to leave an intermediate opening or slot 19 between each pair of segments.

In operations, such as are illustrated in the drawings, where the lining is to be flush with the flanges of the tube the cylindrical segments of the shield are arranged to be seated upon the circumferential flanges 20 of the tube, as shown in Figs. 2 and 3, in which case rubber or other compressible gaskets 21 are arranged on the outer face of the cylindrical segments to secure an air-tight joint between the segments and the flanges.

Fitted to the space or slot between the cylindrical segments are closure-sections 22 and 23. These are provided with side flanges 24, having slotted openings 25, through which, and through the slots 18 of the flanges 17 of the cylindrical segments, bolts 26 are passed to secure the sections in place, as shown in Fig. 3. The sections 22 are provided with pipe couplings or nibs 27, one near the bottom and the other near the top edge or margin. The sections 23 are not necessarily provided with such couplings or nibs. These nibs are designed one to receive a valved coupling 28, to which may be secured a similar coupling 29, connected to a hose 30, leading to a grout-mixer and pump 31, mounted upon a truck 32, which runs upon the tracks 14 in the rear of the truck carrying the shield or center, as shown in Fig. 2, and the other to serve as a vent. The cylindrical segments of the shield are a little less than an arc of one hundred and eighty degrees, and therefore terminate a little above the horizontal diameter of the tube when the shield is seated upon the flanges of the tube. In order to extend the center or shield below the diameter of the tube, and thus to permit the concreting of the arch below the center, I provide depending extension pieces or sections 38, secured to the lower end of the cylindrical segments by hinges 33. The lower ends of the extension-sections are preferably provided with blocks 34, to which are hinged braces 35, the outer ends of which are connected, as by means of bolts 36, to the platform B, thus holding the segment extensions firmly against the flanges

of the tube. Between the flanges of the tube and below the edge of the shield are preferably arranged filler-boards 37 to close the space intermediate of the circumferential flanges of the tube and below the shield, as shown in Fig. 1.

In use the apparatus is handled and operated as follows: The tunnel-heading having been driven a sufficient distance to give working space within the tube between the heading and entrance, the platform B is erected from the entrance to close proximity to the heading. Tracks are laid thereon to carry the shield-trucks and material-cars. The shield being brought into proper position in the tunnel, the jacks are turned to force the shield firmly against the arch of the tunnel with sufficient pressure to cause the gaskets upon the periphery of the shield to hermetically seal the joints between the shield-segments and the tube-flanges. The extension-sections of the shield are then forced out against the flanges of the tube and secured in place. The spaces between the shield-segments are then gradually closed from the bottom upward by means of the sections 22 and 23. If the lining is to be made with ordinary concrete, then the blank-sections 23 are used to close the space between segments until near a longitudinal flange of the tube, which space will be closed by a section 22, having nibs for the hose-coupling. If, on the other hand, the lining is to be made of broken stone and grout, a section 22 is placed at the bottom, as well as at the top of the space between the flanges of a tube-segment. As the sections are put in place the closed space back of them is filled in with concrete or broken stone, as the case may be, as far as it is possible to do so, leaving only a small pocket or open space at the top of the chamber. This, then, is closed by a section 22. The hose of the grout-pump is then connected to the lower nib of the section at the bottom of the chamber if the whole chamber is to be filled with grout or to the bottom nib of the section which is placed at the top of the chamber for the purpose of merely filling the unoccupied remaining space. Grout is then forced in until the chamber is thoroughly filled, when the valve is closed and the hose uncoupled. In this manner the spaces between the cylindrical shield-segments are gradually closed from the bottom up by means of the sections 22 and 23, and the chambers formed by the shield and the flanges and wall of the tube are filled with the concreting material. After all of these chambers thus formed back of the shield are filled with concrete the shield is allowed to remain in place until the material has thoroughly hardened or set, after which the braces of the extension-pieces of the shield and the jack-screws supporting the shield itself are loosened, the extension-pieces being swung inwardly on their hinges and the shield bodily lowered from the arch of the tunnel, after which the truck can be moved forward in the tunnel and the shield again jacked up against the flanges of the tube in advance and the operation repeated, the platform being forward as the heading advances. During the progress of these operations concreting material and supplies can be brought in upon cars running on the tracks alongside of the shield, and the materials placed in a mixing-car E, which stands on the track in advance of the shield, as shown in Fig. 2. During all of these operations it is obvious that the space beneath the platform is left free for cars to be operated therethrough between the entrance and heading in the ordinary manner. After the lining of the arch of the tunnel has thus been entirely completed or carried to any desired distance the material-cars for the heading may be transferred to the tracks upon the platform B and the invert of the tunnel concreted and all of the permanent fittings thereof put in place without interfering with the traffic upon and over the platform.

It is apparent from the foregoing description that by thus lining the tube in longitudinal sections—such as, first, the arch and then the invert—it is possible to carry on this work simultaneously with the driving of the heading and the operating of cars to and from the heading adjacent the wall of the section of the tube opposite that upon which the lining is being applied.

I claim—

1. The method of lining the interior of a tunnel while the heading is being driven and without interfering therewith, consisting in applying the lining along a longitudinal section of the wall in one set of operations while maintaining a way for transporting material to and from the heading adjacent the opposite section, and then lining said opposite section and maintaining the way for transporting material to and from the heading adjacent the first section.

2. The method of applying a concrete lining to a tunnel without interference with the driving of the heading, consisting in lining the arch and invert in separate operations, transporting materials to and from the heading along the bottom of the tunnel while the arch is being lined and concreting materials transported along elevated ways from entrance to the point of work, and transporting materials to and from the heading along elevated paths while the invert is being lined and material therefor transported along the bottom of the tunnel.

3. The method of lining and equipping the interior of a tunnel without interference with the driving of the heading, consisting in arranging an elevated platform in the tunnel, carrying on the lining operations of the arch upon and over said platform and simultane-

ously utilizing the space beneath for a way for material-carriers to and from the heading, then operating said material-carriers upon said platform and lining and equipping the tunnel-invert.

4. The method of applying a concrete lining to a tunnel-tube, consisting in progressively erecting a substantially diametric platform behind the heading, transporting material to and from the heading underneath said platform and at the same time applying the concrete lining to the tunnel-arch and transporting materials to the point of work along the platform from the entrance, then transporting materials along the platform to and from the heading and applying the concrete lining to the tunnel-invert and transporting materials underneath the platform from entrance to point of work, whereby both sets of operations are carried on simultaneously.

5. In tunnel construction, means for lining the arch of the tunnel simultaneously with the driving of the heading, consisting of a frame or platform sufficiently elevated to permit free passage of material-cars underneath to and from heading, a center or shield for holding the concrete in place until set, a truck for carrying the same and tracks upon the platform for supporting said truck and for carrying material-cars along the tunnel above the cars running to the heading.

6. The method of applying a concrete lining to the arch of a tunnel-tube, consisting in inclosing successive or contiguous spaces thereon to form temporary chambers having circumferentially-disposed openings thereinto, then progressively filling said chambers from the bottom upward and closing said openings as the filling advances, and then removing the inclosing walls.

7. In tunnel construction, the method of simultaneously carrying on operations at the heading and upon the arch in the rear of the heading, and transporting materials to and from the heading along a path in the lower section of the tunnel, and transporting, along a path in the upper section of the tunnel, material from the entrance to the scene of work upon the arch.

8. In tunnel construction, the method which consists in arranging a substantially diametric, horizontal partition in the tunnel between entrance and heading, utilizing the lower section of the tunnel as a way for transporting materials to and from the heading and the upper section for carrying on building operations upon the tunnel-arch and as a way for the transportation of material from the entrance to the scene of arch operations.

9. In tunnel construction, the method which consists in transporting materials to and from the heading along paths in the bottom section of the tunnel, and at the same time carrying on work upon the arch of the tunnel and transporting materials from the entrance to the point of such work along paths in the upper section of the tunnel.

10. In tunnel construction, the method which consists in transporting material to and from the heading in the lower segment of the tunnel and at the same time transporting materials toward and from the entrance and carrying on work upon the walls in the upper segment of the tunnel.

11. In tunnel construction, the method which consists in transporting material toward and from the heading along a path at or near the bottom of the tunnel and at the same time applying a concrete lining to the walls of the tunnel above said path.

12. A shield or center of the class described having a circumferential slot and removable sections for closing said slot.

13. Apparatus for applying a concrete lining to tunnel-tubes having interior ribs or flanges, consisting of a shield or center conforming to the arch of the tube, having means for adjusting its position along the tube and toward and from its arch, and provided with circumferential slots and removable sections for closing such slots.

14. A shield or center of the class described, comprising two or more similar cylindrical segments, uniformly interspaced to form intermediate slots, and having common support adjustable axially and radially, and removable closures for said slots for the purpose specified.

15. A shield or center of the class described, comprising in combination a series of similar cylindrical segments in normal or working position concentric with the tunnel-tube, uniformly interspaced to form intermediate openings or slots, and series of cylindrical segments for each slot serving as removable closures therefor.

16. A shield or center for the purpose specified, comprising in combination a series of similar cylindrical segments having a common support provided with means for adjusting the position of the shield lengthwise of the tunnel and radially toward and from the arch of the tunnel, said segments being uniformly interspaced, and series of sections for closing said spaces, certain of said sections having pipe or hose couplings.

17. The method of applying a concrete lining to a metallic tunnel-tube having inner circumferential ribs or flanges, consisting in first partially inclosing the spaces between said ribs to form chambers with circumferentially-slotted openings, then progressively closing said slots from the bottom upwardly and progressively filling the closed portions of the said chambers with concreting material.

18. The method of applying a concrete lining to a metallic tube, consisting in first partially inclosing a space thereon to form a temporary chamber with circumferentially-slot-

ted opening, the tube constituting the outer wall of the chamber, then progressively closing said opening from the bottom upwardly and filling the closed portion of the chamber with concreting material, and then removing the inclosing walls of the chamber.

19. The method of applying a concrete lining to the arch of a tunnel-tube, consisting in partially inclosing spaces upon the walls of the tube to form series of circumferentially-extended, temporary chambers having circumferentially-slotted openings, then gradually closing said openings from the bottom upward, and filling the closed space with concreting material.

20. The method of applying a concrete lining to the arch of a tunnel-tube, consisting in first inclosing a space upon said arch to constitute a chamber having a circumferential slot or opening, then progressively closing said slot from the bottom upward and progressively charging the closed portions with concrete material, and then forcing grout into said chamber to complete the filling thereof.

21. The method of applying a concrete lining to the arch of a tunnel-tube, consisting in first inclosing successive or contiguous spaces thereon to form temporary chambers with circumferentially-disposed openings thereinto, then filling said chambers from the bottom upward with gravel or broken stone and closing said openings as such filling progresses, then forcing grout into said chambers to fill the interstices, and then removing the inclosing walls.

22. The method of applying a concrete lining to the arch of a tunnel-tube, consisting in first arranging a series of interspaced circumferential cylindrical segments concentric with and spaced from the arch a distance equal to the required thickness of such lining, then progressively closing the openings between segments and filling the space between segments and arch with concrete, and then removing said segments.

23. Apparatus for applying concrete lining to a circumferentially-ribbed tube, consisting of a series of interspaced cylindrical segments adapted to be seated severally upon the ribs of the tube, gaskets interposed between said segments and ribs, and sections for closing the spaces between segments.

24. A shield of the class described, having series of cylindrical segments with intermediate slots, and closures therefor, and extension-segments for the lower ends of said cylindrical segments, and means for seating them against the tube.

25. A shield of the class described, having interspaced cylindrical segments, longitudinally-slotted flanges upon the edges thereof, closure-sections having flanged edges and securing-bolts arranged through said slots and section-flanges.

26. A shield or center for the purpose specified, comprising in combination a supporting and carrying truck, a series of interspaced cylindrical segments mounted thereon, and depending extension-pieces hinged to said segments.

27. A center of the class described, having depending extension-pieces hinged to the lower edges thereof, and means for raising and lowering said center and for forcing said extension-pieces outwardly.

In witness whereof I have hereunto set my hand, at the city of New York, this 7th day of July, 1904.

ROSS F. TUCKER.

Witnesses:
J. T. CRANE,
T. D. MERWIN.