

(No Model.)

3 Sheets—Sheet 1.

J. W. RENO.

METHOD OF AND APPARATUS FOR CONSTRUCTING TUNNELS.

No. 466,046.

Patented Dec. 29, 1891.

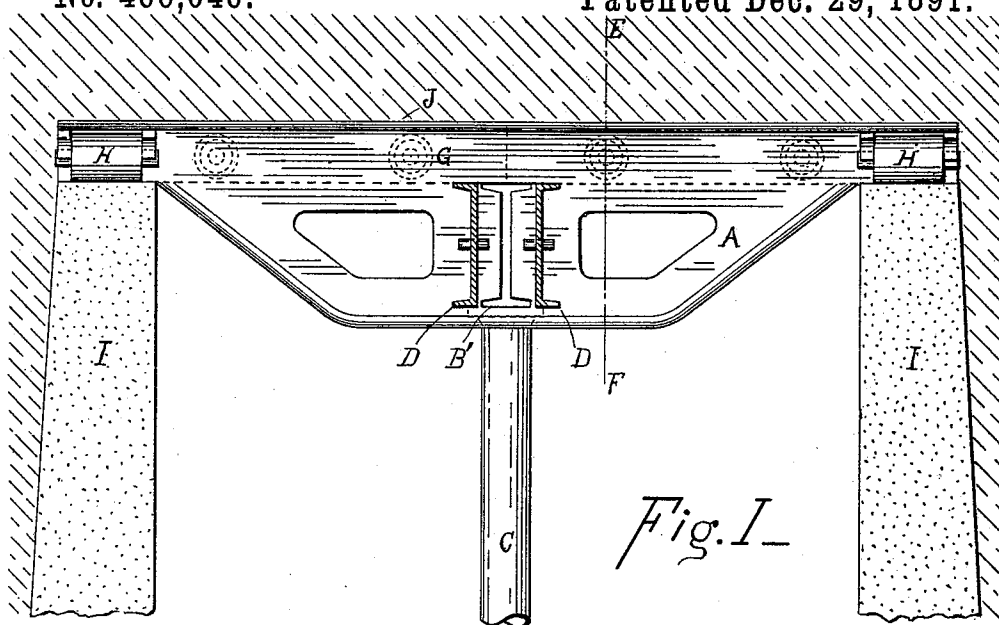


Fig. 1-

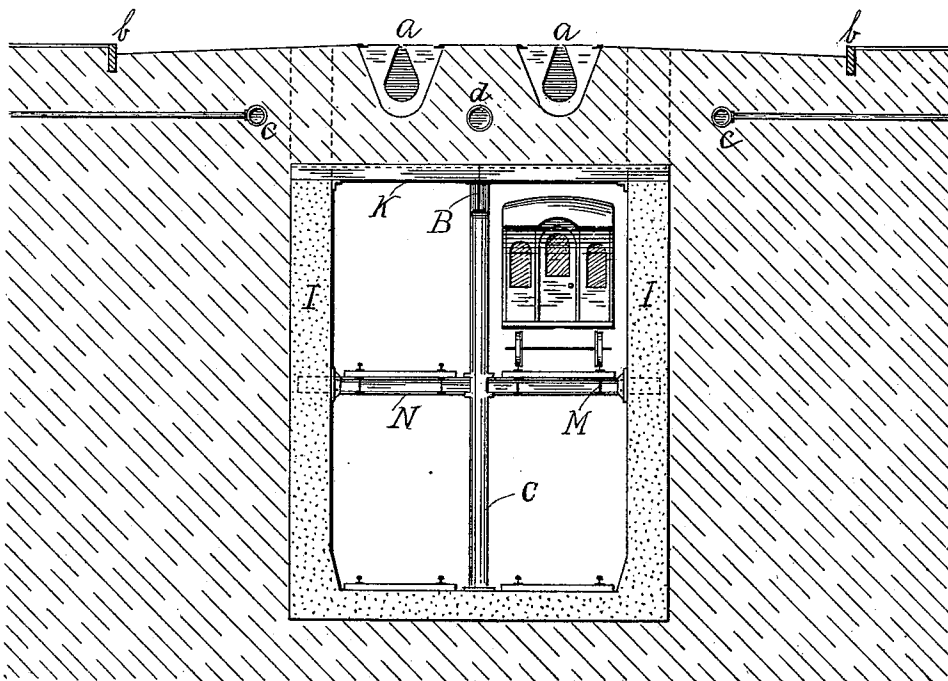


Fig. 2-

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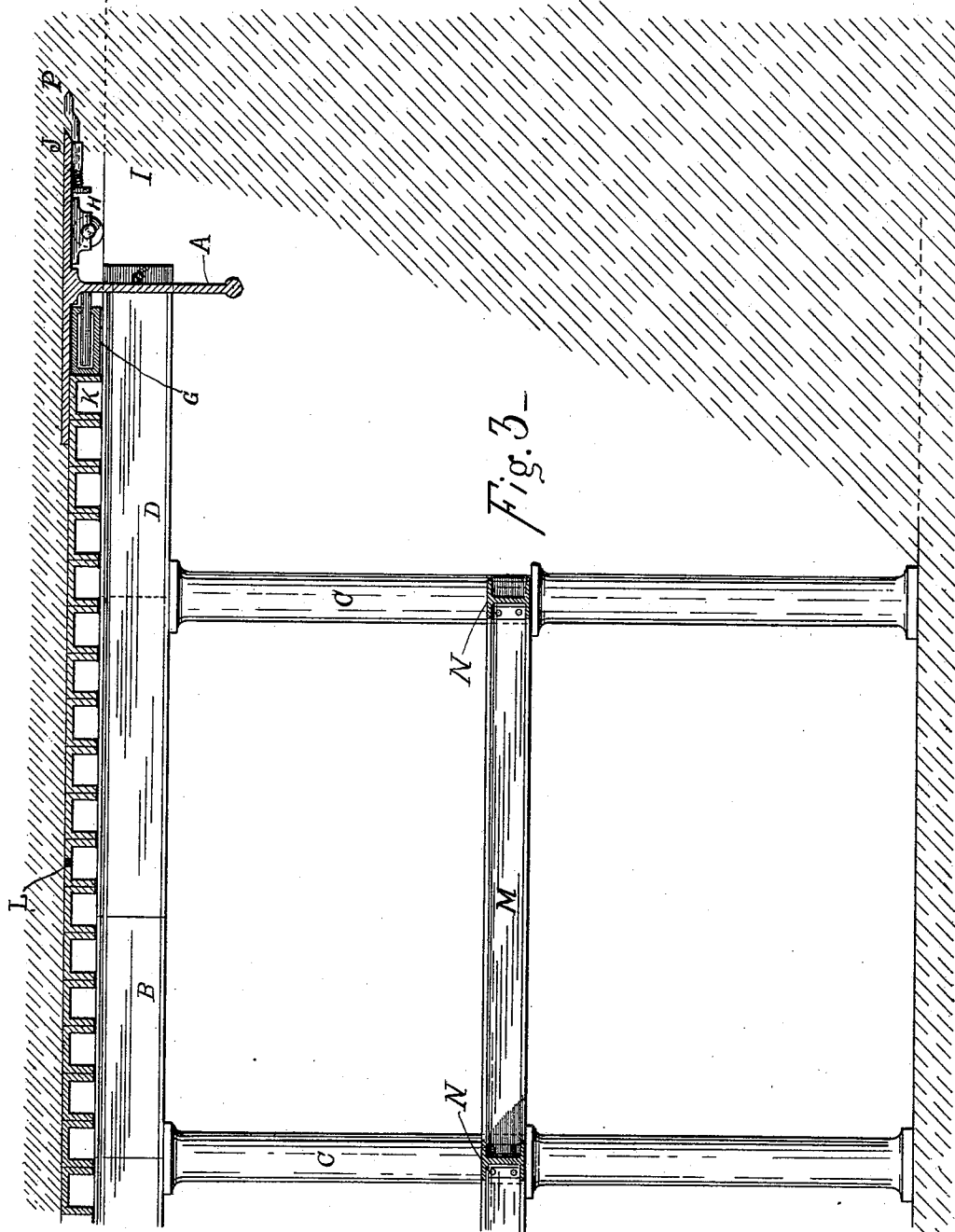
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3 Sheets—Sheet 3.

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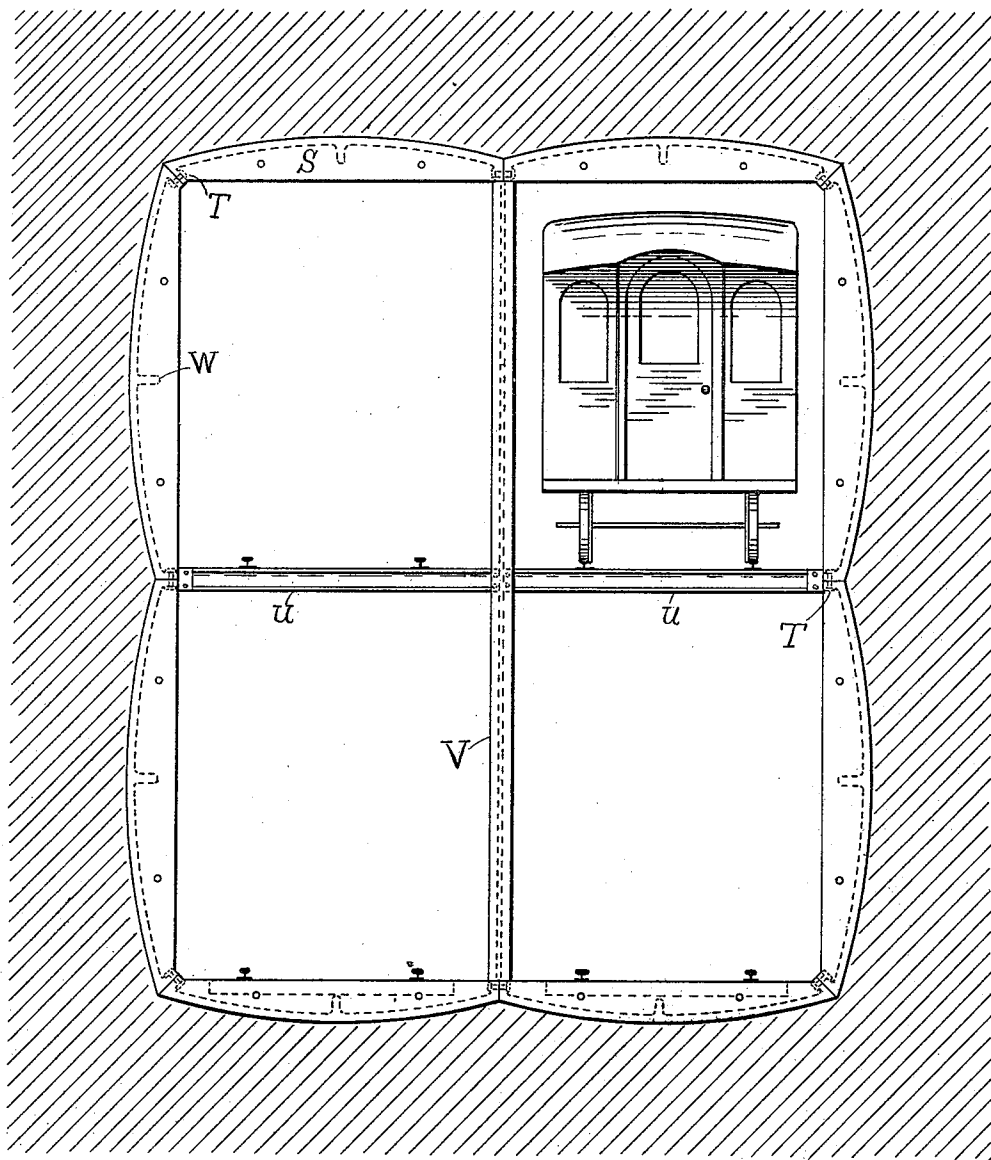


Fig. 4—

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METHOD OF AND APPARATUS FOR CONSTRUCTING TUNNELS.

SPECIFICATION forming part of Letters Patent No. 466,046, dated December 29, 1891.

Application filed May 21, 1891. Serial No. 393,542. (No model.)

To all whom it may concern:

Be it known that I, JESSE W. RENO, of the city of New York, in the county and State of New York, have invented a new and useful
5 Method of and Apparatus for Constructing Subterranean Railway Structures and Tunnels, which invention is fully set forth and illustrated in the following specification and accompanying drawings.

10 The object of this invention is to provide an improved method of and apparatus for constructing and driving tunnels under ground, in particular where it is desired to drive the tunnel comparatively near the sur-
15 face of the ground, without disturbing the main body of the ground above the roof or top line of the tunnel. The invention is therefore particularly applicable in situations where it is advisable to have the roof of the
20 tunnel as near as possible to the surface of a street or avenue and yet below such existing obstructions as gas, water, and steam pipes, cable-road beds, &c.

The method and the apparatus described are
25 particularly adapted for use in ground consisting of mixed sand and bowlders, and also where the soil is wet or marshy or of rolling or quicksand formation. The shape of tunnel to which this invention is specially adapted
30 is rectangular in cross-section. Such shape of tunnel is particularly desirable as a railway-tunnel because of the usual standard and almost necessarily rectangular outline of railway-cars. Where the tunnel is near the
35 surface of the ground, there will be of course comparatively little outside pressure upon the tunnel walls or roof. Hence in such location the rectangular periphery of tunnel is preferable.

40 In the accompanying drawings, Figure 1 shows in cross-section the side walls of a tunnel with one form of cutting-shield mounted thereon in position to be forced ahead in the proposed roof-line. Fig. 2 shows in cross-
45 section, on a smaller scale, a completed tunnel divided by columns or girders into four compartments, each forming a separate rail-
way, with a car mounted on a track in one of said railways *a, b, c,* and *d*, showing cable rail-
50 ways, street-curbs, and gas and water pipes, respectively. Fig. 3 is a longitudinal vertical section taken at the line E F of Fig. 1, show-

ing some of the roof-sections of the tunnel in place, roof-girders supporting the same and resting on central columns, horizontal, longi- 55 tudinal, and transverse beams, and the shield in section, ready for cutting or entering the ground in advance of the roof-sections already in place. Fig. 4 shows a tunnel in cross-section divided into four compartments 60 or railways having a car mounted on a track in one of said ways. This figure illustrates a modification of the method of constructing the walls of the tunnel suited for wet ground or quicksand, the details of which modifica- 65 tion will be hereinafter described.

In said figures the several parts are indicated by reference-letters, like parts in each figure being indicated by like letters.

Referring now to Figs. 1, 2, and 3, the method 70 of constructing the tunnel, the construction of the shield and its adjuncts, and the operation of the same are as follows: The side walls I of the tunnel may be built one at a time, if preferred, by digging an open trench from the sur- 75 face to the required depth below the ground and bracing said trench with a plank lining, after which the wall is constructed by filling in the lined trench, which thus serves as a mold, with concrete to the required height of the 80 tunnel, and then filling in the open space remaining with earth and restoring the surface of the ground to its previous condition, as shown in Fig. 2. The other tunnel-wall may then be similarly constructed and covered in. 85 These trenches for the tunnel-walls being narrow can be easily lined and braced, thus preventing any slipping of the ground between the trenches and the foundations of buildings in proximity. The walls of the tunnel being thus completed, the ground between 90 them is then excavated, while the earth or material over the line of the tunnel is supported by a cutting-edge or roof-shield J, strengthened by a girder-piece A, Fig. 1, resting at each end on rollers H upon the com- 95 pleted walls I.

The roof of the tunnel, with the aid of the shield, is constructed in the manner now to be described. An opening is made to permit 100 the placing of two roof-shields back to back upon the tops of the walls I, with the cutting-edges of the shields pointing in opposite directions. The shields are then forced apart

by their several hydraulic pistons G a distance sufficient to admit one of the channel steel sections K, Fig. 3, of which the roof of the tunnel consists, to be put in place. The ground between the two side walls and under the roof-shield is then cut down or excavated by picks and shovels or by blasting, if necessary. The hydraulic pistons G then force the shields ahead for another "cut" in each direction, when another channel-steel roof-section K is put in in rear of the hydraulic pistons, and these operations are continued or repeated until a distance of about twelve feet is attained, when a pair of central iron columns C are erected, and the permanent girder B, supporting the roof-section K in the center of the tunnel, is slid into place through the opening B' in the girder A, Fig. 1. The pair of working girders D are used to support the roof-sections at the center of their span until the advancing shield has been moved a distance sufficient to place a permanent girder B in position. It will be observed that the roof-shield J extends back over an adjacent roof-section K, so that after the shield has been advanced one cut and the hydraulic pistons are placed for their next strokes there is sufficient space to insert an additional roof-section. The roof-sections are divided at the center in order to facilitate their being placed in position. Where the ground to be tunneled carries bowlders, the shield is to be provided with steel feelers or indicator-bars P, held in slides or guides and backed with stiff springs, preferably coiled, Fig. 3, so that when an obstruction is encountered one or more of the bars P will be forced back, and thus indicate to the workmen at the "heading" the presence of something requiring to be removed before forcing the shield farther ahead. The cutting-edge of the shield will thus be preserved from injury.

Among other advantages inherent in this invention the construction of the side walls first and in the manner above described perfect familiarity with the ground to be excavated is first obtained, and any sewers or pipes which may be encountered in digging the trenches for the side walls may be altered or changed in position before the walls are laid. The walls also will have had sufficient time to set and season before being subjected to any pressure. The invention also admits of the application in tunneling of the principle of the girder-roof span, instead of that of the masonry arch, the former having recognized advantages over the latter.

As the main feature in tunneling is the support of the roof, this invention provides (with a minimum roof-span) for a tunnel having a capacity sufficient for four tracks, with one pair over the other pair, the upper tracks supported upon transverse girders N, Figs. 2 and 3. These girders N rest at each end in sockets molded into the concrete side walls I of the tunnel and in the center upon the iron columns C, which, together with longitudinal

girders B, divide the span of the roof. The horizontal girders N, besides supporting the pair of upper tracks, resist the inward pressure of the tunnel's side walls, while the row of vertical iron columns C throughout the center line of the tunnel similarly brace the tunnel-roof along the vertical plane. This arrangement of a four-track tunnel permits of easy access to the car-platforms of all trains, which would not be the case were the four tracks on a level, while the iron structure in the tunnel permits through circulation of air for ventilation in all four compartments, and the area of the boring containing all the tracks is utilized for the easy lateral displacement of the air in front of rapidly-moving trains. Any suitable number of fan-blowers or other ventilating devices may be employed at suitable intervals at the passenger-stations or elsewhere in the line, as may be desired.

In Fig. 4 a modification of this invention is shown, which will now be described as follows: This modification may be used in ground in which the pressure of water, quicksands, or swelling clay is encountered. The arrangement provides for a tunnel the sides, floor, and roof of which are formed of hollow cast-iron "girder-panels" S, bolted together, as shown at T, built in immediately in the rear or an advancing shield, which in this modification is used to separately cut portions of the entire periphery instead of the roof portion alone, as described in relation to Figs. 1, 2, and 3. The iron girder-panels S, which may conveniently have a width of about two feet (that is their dimension parallel with the axis of the tunnel) are provided with strengthening-flanges W, and at their points of common intersection are braced by the horizontal and vertical members U and V, respectively. As the transverse girders U will be only about two feet apart, they will serve directly for support of the rails of the upper tracks, thus obviating the use of cross-ties for the rails and diminishing the required dimensions of the tunnel. The ties of the lower tracks may be embedded in a concrete filling between the flanges of the girder-panels which form the floor of the tunnel. This construction being thus internally braced will be stronger than a circular tunnel of the same capacity and will also have less sectional area. A tunnel or section of a tunnel constructed in accordance with this arrangement of the invention herein described and claimed, being made of iron or steel panels bolted together at their flanges, will have a lining impervious to water. A tunnel of this description may be driven without disturbing the surface at all by having a girder-cutting shield in front of each of the panels S, Fig. 4, which upon being separately forced ahead would collectively cut out the whole periphery of the tunnel, when the placing in position of the panels S and the horizontal and vertical members U V would immediately follow. The cutting-edges of the girder-shields in this description.

of work are the same as that shown in Fig. 2 for the roof-shield, except that the plates may be carried to the outline of the steel panels instead of forming a straight line.

5 The roof-sections in the side-wall tunnels and the panel-sections in the tunnel shown in Fig. 4 may be provided with holes L at suitable intervals, through which grout or cement may be driven by a pump, as is commonly done
10 where required with masonry-work. This grout will fill-up any cavities outside the bounding walls of the tunnel and will also fill up the space left vacant by the cutting-plate of the shield where the earth does not
15 fill in behind it.

It is obvious that the same advantages for lateral displacement of air in front of moving trains and facility for ventilating by means of fans or blowers exist in either form of tunnel, whether having the concrete walls or
20 metal panel-walls.

I claim—

1. The method of tunnel construction, consisting in first building side walls in trenches
25 cut down from the surface of the ground, then at or about the distance of the tunnel-roof below said surface forcing a cutting-shield horizontally in advance of the plane of the roof and removing the ground between said
30 walls, and then placing roof-sections in the rear of the advancing shield, substantially as set forth.

2. A subterranean rectangular railway structure composed of two side walls, a roof,

and floor, the roof consisting of transverse 35 girders supported by said walls and by central columns supporting longitudinal girders, the side walls being braced laterally by transverse girders in a plane at or near the center of the height of the structure, the whole interior space of the structure being thus taken
40 up and divided into two upper and two lower railway-compartments of substantially equal area, whereby provision is made for the entire rectangular area of the structure to be
45 occupied by four railway-trains, for the purposes set forth.

3. A cutting-shield adapted to cut the line of the roof of a tunnel for railway or other purposes, consisting of a cutting plate or
50 plates and a strengthening-girder, said girder provided with means for sustaining the ends of temporary roof-girders until the advance of the shield far enough to admit of the insertion of permanent roof-girders, substan-
55 tially as set forth.

4. An apparatus for use in the construction of tunnels for railway and other purposes, consisting of a girder-shield provided with projecting bars or feelers and yielding springs
60 for said bars, whereby the presence of rock or other obstructive matter may be indicated before contact of the shield therewith.

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