

J. KNUDSEN.

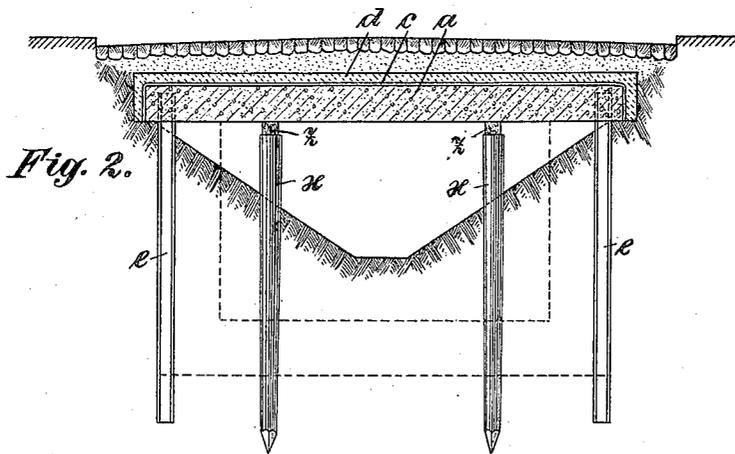
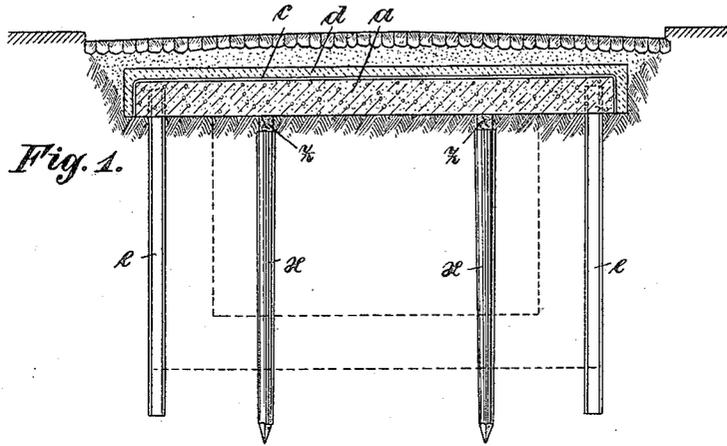
METHOD OF TUNNELING UNDER STREETS, ROADS, SQUARES, TRACKS, AND THE LIKE.

APPLICATION FILED JULY 2, 1908.

902,973.

Patented Nov. 3, 1908.

4 SHEETS—SHEET 1.



WITNESSES:

Edw. D. Spring

W. P. Burt

INVENTOR

Jens Knudsen
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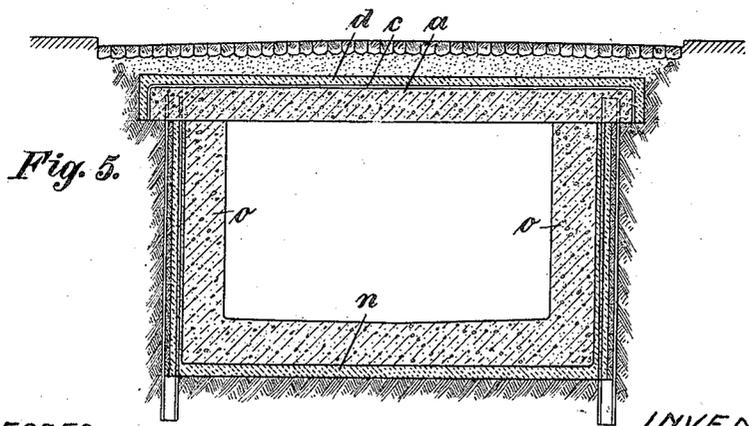
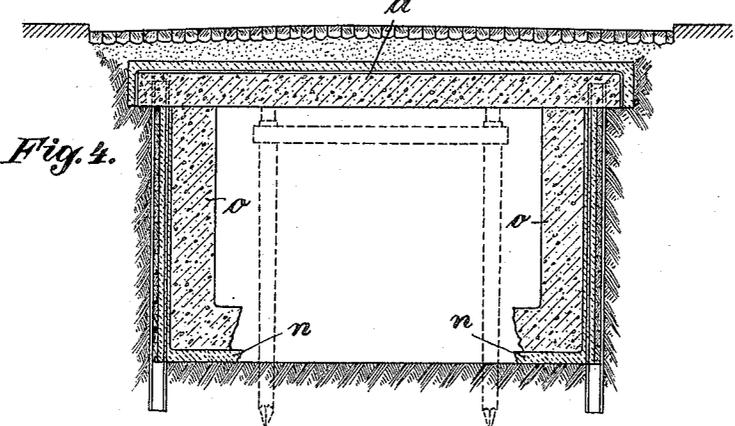
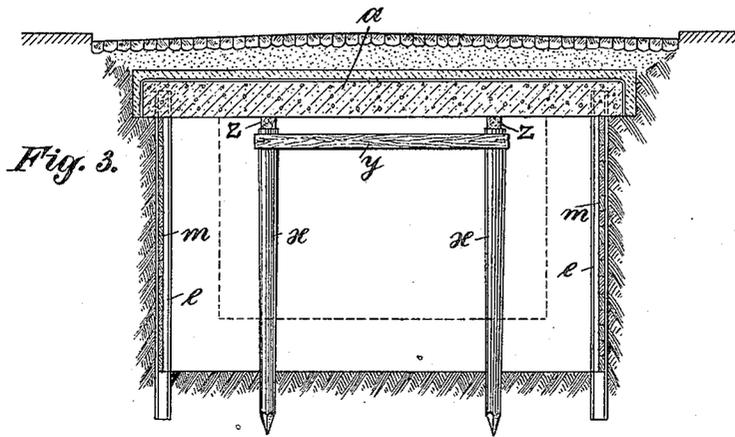
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4 SHEETS—SHEET 2.



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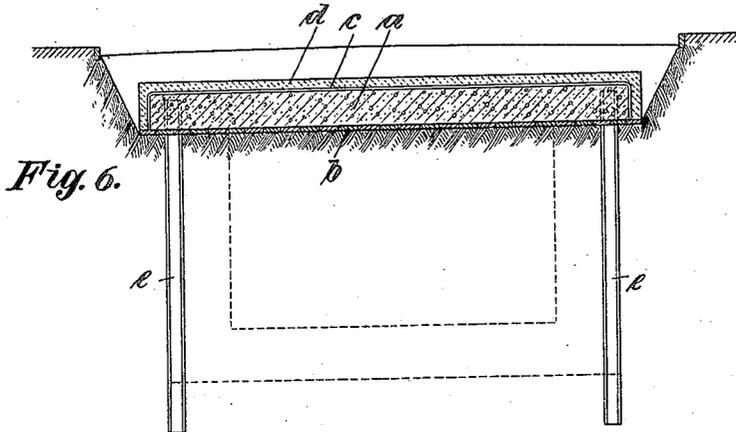


Fig. 6.

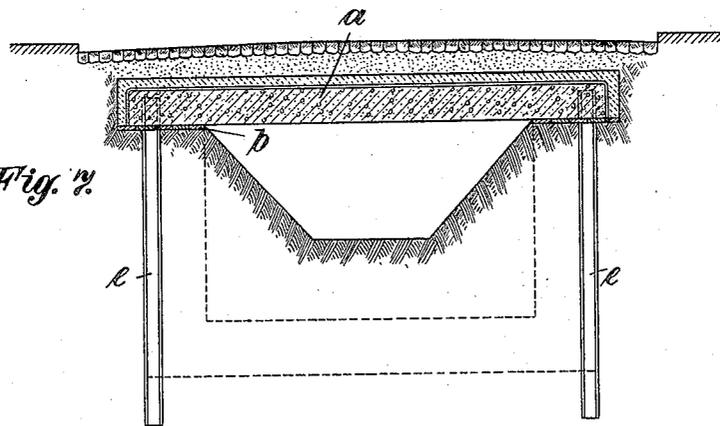


Fig. 7.

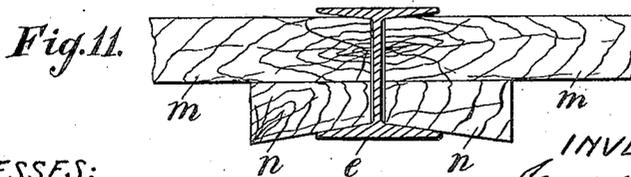


Fig. 11.

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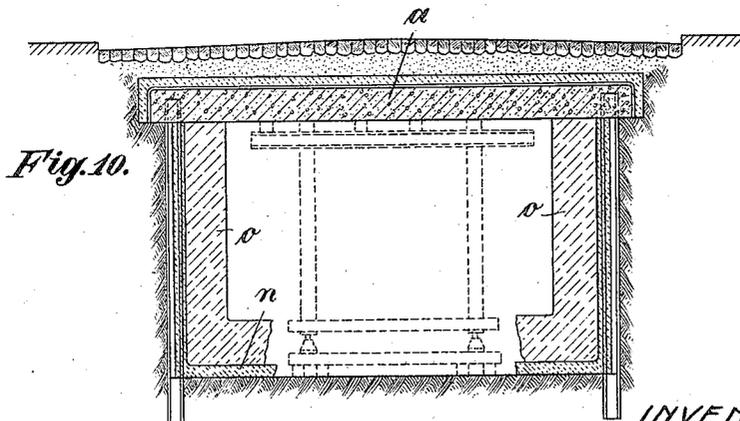
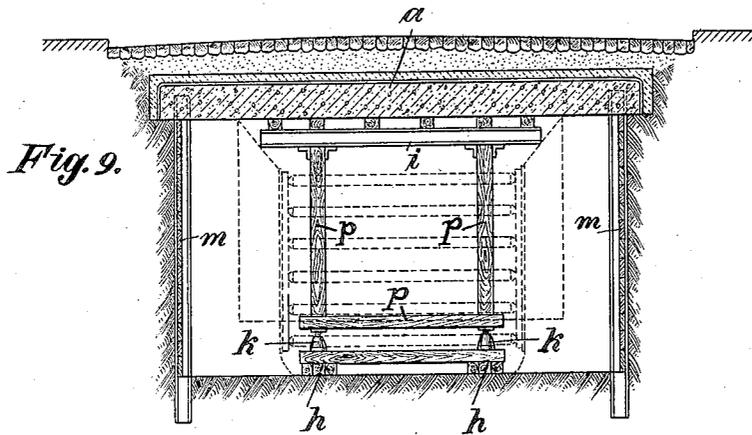
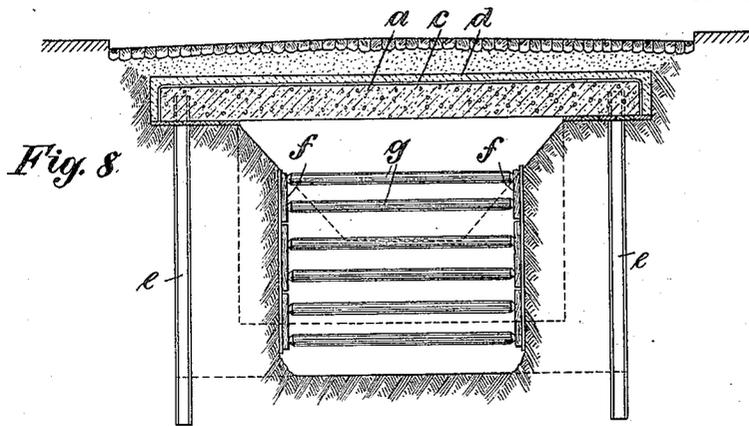
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APPLICATION FILED JULY 2, 1908.

902,973.

Patented Nov. 3, 1908.

4 SHEETS—SHEET 4.



WITNESSES:

Edward D. Spring
W. P. Burke

INVENTOR

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BY
Wm Wallace White
ATTY.

UNITED STATES PATENT OFFICE.

JENS KNUDSEN, OF BERLIN, GERMANY.

METHOD OF TUNNELING UNDER STREETS, ROADS, SQUARES, TRACKS, AND THE LIKE.

No. 902,973.

Specification of Letters Patent.

Patented Nov. 3, 1908.

Application filed July 2, 1908. Serial No. 441,712.

To all whom it may concern:

Be it known that I, JENS KNUDSEN, engineer, of 10-11 Pallasstrasse, Berlin, Germany, subject of Norway, residing at Berlin, aforesaid, have invented new and useful Improvements in Methods of Tunneling under Streets, Roads, Squares, Tracks, and the Like, of which the following is a specification.

The subject-matter of the present invention is a method of tunneling under streets, roads, squares, tracks and the like, particularly those with heavy traffic, without disturbing the traffic, for the purpose of making underground railways, footways for passengers and similar purposes.

In accordance with the invention, after the pavement of the part of the street or track has been taken up, under which the tunnel is to be made, the ground is first trenched only as deep as the underside of the finished roof of the tunnel, then a row of girders is driven in along each edge of the trench, and then the roof of I-girders and concrete, or of previously made Monier plates, is made on the bottom of the trench. Immediately after the roof is finished earth is again thrown over it, and the pavement or track is laid again so that the traffic can continue unimpeded, and the excavating and securing operations necessary for making the tunnel are then proceeded with below the concrete roof which is in the ground. Besides the girders driven in along the edges of the trench, it is preferable, before finishing the roof of the tunnel, to drive in a row of piles in the center of the tunnel, or still better two rows, each at a suitable distance from the center of the tunnel, and to place beams longitudinally on the heads of the piles in such manner that the top faces of the beams lie flush with the leveled ground; the piles and beams serve for supporting the roof during the excavating operations under it. The concrete or beton roof is to be made so strong that it can serve afterwards as the roof of the tunnel.

One condition for the possibility of executing the method is that explosions are not necessary for the purpose of opening out the tunnel. Also the ground must be dry down to the base of the tunnel; if necessary, the under-water must be removed before the ground is excavated by means of suitable operations, for example by sinking a

sump for the under-water, before the ground is removed.

In order that the invention may be clearly understood, reference is made to the accompanying drawings in which two different modes of construction are represented by way of example showing how an underground tunnel is made transversely of or along under a busy street when it is possible to temporarily entirely close the street for traffic.

In the drawings: Figures 1 to 5 are sectional elevations according to one mode of construction showing successive cross-sections through the street according to the different operations which take place in the execution of the method, whereas Figs. 6 to 10 are similar views according to the second mode of construction. Fig. 11 is a detail view.

Referring firstly to Figs. 1 to 5, Fig. 1 shows the concrete roof *a* arranged on the ground a little below the street level; the shape of the cross-section of the finished tunnel is indicated in dotted lines. When the pavement has been taken up and a trench has been made of sufficient depth, the ground at the bottom of the trench is made level or is given a slight curvature. Along the edges of the trench and at intervals of about 2 to 3 meters, figured-iron girders *e*, for example I-shaped girders, are driven into the ground, an operation which may also take place before the street is taken up. These I-shaped girders, the tops of which should project a certain amount above the leveled earth, afterwards serve for bounding and staying the excavation during the tunneling operations. Between the two rows of I-girders, as indicated above, two or more rows of piles *x* are driven into the ground, as clearly shown in Figs. 1 and 2, to such a depth that the same are able to carry the roof together with the traffic after the earth has been entirely excavated, the upper ends of each two piles situated in one and the same transverse plane being then preferably connected with one another by cross-pieces of timber *y*. The heads of the piles are cut off a little below the leveled earth, and for the purpose of distributing the pressure over the entire length of the roof, beams *z* are placed lengthwise over the heads of the piles.

Concrete for the roof is placed to a suitable thickness on the leveled earth in such man-

ner that it surrounds the heads of the I-girders which project into the trench. For the purpose of increasing the carrying power iron-work can be embedded in known manner in the concrete. In order to prevent water penetrating, the layer of concrete is covered with tarred felt or tar-roofing *c*, for example, and lastly a thin protecting layer of cement-concrete *d* is applied in known manner. After these operations are completed the street surface is finally made again, so that the regular traffic can proceed again without disturbance.

After the concrete has set perfectly, the real tunneling operations can be proceeded with under the roof quietly and without any danger to the traffic in the street. Firstly an adit or drift with considerably sloping sides is made from the head to about half way down the tunnel as clearly shown in Fig. 2, in such manner that the piles *x* for supporting the central part of the roof, and the longitudinal beams *z* become exposed.

After the cross-pieces *y* have been put in position, the entire quantity of earth which is situated in the cross-section within the outline of the tunnel indicated in Fig. 1 by the outside dotted lines is gradually removed. As soon as the I-girders *e* which were first driven into the ground are exposed at their upper ends, for preventing the earth sliding down from the sides planks *m* are inserted between the I girders in the longitudinal direction of the tunnel, and the ends of the planks are clamped by means of wooden wedges, *w*, between the flanges of the I-girders, as clearly shown in Figs. 3 and 11. As the excavation continues, plank-walls are produced in this manner extending down to the bottom of the tunnel and supporting the earth along the side-walls of the tunnel. The walls and bottom of the tunnel are first covered with a thin layer *n* of concrete, on which tar-roofing is placed in known manner (Fig. 4). The lateral concrete or brick walls *o* for supporting the roof are then made as clearly shown in Fig. 4. After the lateral walls have hardened sufficiently the piles and longitudinal beams are removed and the tunnel is completed by making the bottom or floor (Fig. 5).

The roof of the tunnel may also be provisionally supported in the manner represented in Figs. 6 to 10. After the required trench has been made in the earth the I-girders are driven in only at the longitudinal edges of the trench and the roof of the tunnel is made preferably on a layer of planks *b*. After the concrete has hardened, the ground is excavated under the center of the roof, to an extent as roughly indicated in Fig. 7. A drift reaching to the bottom of the tunnel is then excavated under the center of the roof, planks *f* which are reciprocally supported by struts or props *g* being put in place at the

same time, and scaffolds *p* are built in this drift on ground sills or sleepers *h*. Each scaffold has at the top an I-girder *i* extending over the entire width of the drift; on these I-girders long pieces of timber are placed at suitable intervals according to the length stretching from scaffold to scaffold. These scaffolds may preferably be provided with screw-spindles *k* which on the one hand enable the supporting scaffolds to be adjusted so that they support the roof uniformly, and which on the other hand also substantially facilitate the dismounting of the scaffolds.

As soon as the scaffolds *p*, *i* have been erected, the props *g* and planks *f* are removed, the earth at the sides is excavated, the planks *m* are placed in position between the I-girders *e* as the excavation proceeds, and the side-walls *a* of the tunnel are made. The scaffolds are then removed and the bottom of the tunnel is completed.

What I claim as my invention and desire to secure by Letters Patent is:

1. Method of making a tunnel under streets, roads, squares, tracks and like surfaces of the ground, consisting in excavating a trench in the ground only as deep as the under surface of the final roof of the tunnel which is to be made, in then driving in a row of girders along each edge of the trench, in making the roof of the tunnel on the bottom of the trench, in then at once restoring the surface of the ground for traffic on the roof, and in then excavating the ground under the finished roof.

2. Method of making a tunnel under streets, roads, squares, tracks and like surfaces of the ground, consisting in excavating a trench in the ground as deep as the under surface of the final roof of the tunnel which is to be made, in driving in a row of girders along each edge of the trench, in driving in rows of piles in the central part of the trench between the rows of girders for provisionally supporting the roof during the excavating operations, in constructing the roof of the tunnel on the bottom of the trench, in then at once re-making the surface of the ground for traffic on the roof, and in then excavating the ground under the finished roof.

3. Method of making a tunnel under streets, roads, squares, tracks and like surfaces of the ground, consisting in excavating a trench in the ground only as deep as the under surface of the final roof of the tunnel which is to be made, in then driving in a row of girders along each edge of the trench, in making the roof of the tunnel on the bottom of the trench, in then at once restoring the surface of the ground for traffic on the roof, in arranging provisional supports under the roof, in then completely excavating the tunnel under the roof, and in removing the provisional supports.

4. Method of making a tunnel under streets, 130

roads, squares, tracks and like surfaces of the
ground, consisting in excavating a trench in
the ground only as deep as the under surface
of the final roof of the tunnel which is to be
5 made, in then driving in a row of girders
along each edge of the trench, in making the
roof of the tunnel on the bottom of the
trench, in then at once restoring the surface
of the ground for traffic on the roof, in mak-
10 ing a drift under the center of the roof as deep
as the bottom of the tunnel which is to be

made, in erecting provisional supporting scaf-
folds for the roof in the drift, in then com-
pletely excavating the tunnel under the roof,
and in removing the scaffolds.

In testimony whereof I have signed my
name to this specification in the presence of
two subscribing witnesses.

JENS KNUDSEN.

Witnesses:

WOLDEMAR HAUPT,
HENRY HASPER.

15