

No. 786,382.

PATENTED APR. 4, 1905.

J. W. RENO.  
METHOD OF SUBWAY CONSTRUCTION.

APPLICATION FILED FEB. 6, 1905.

2 SHEETS—SHEET 1.

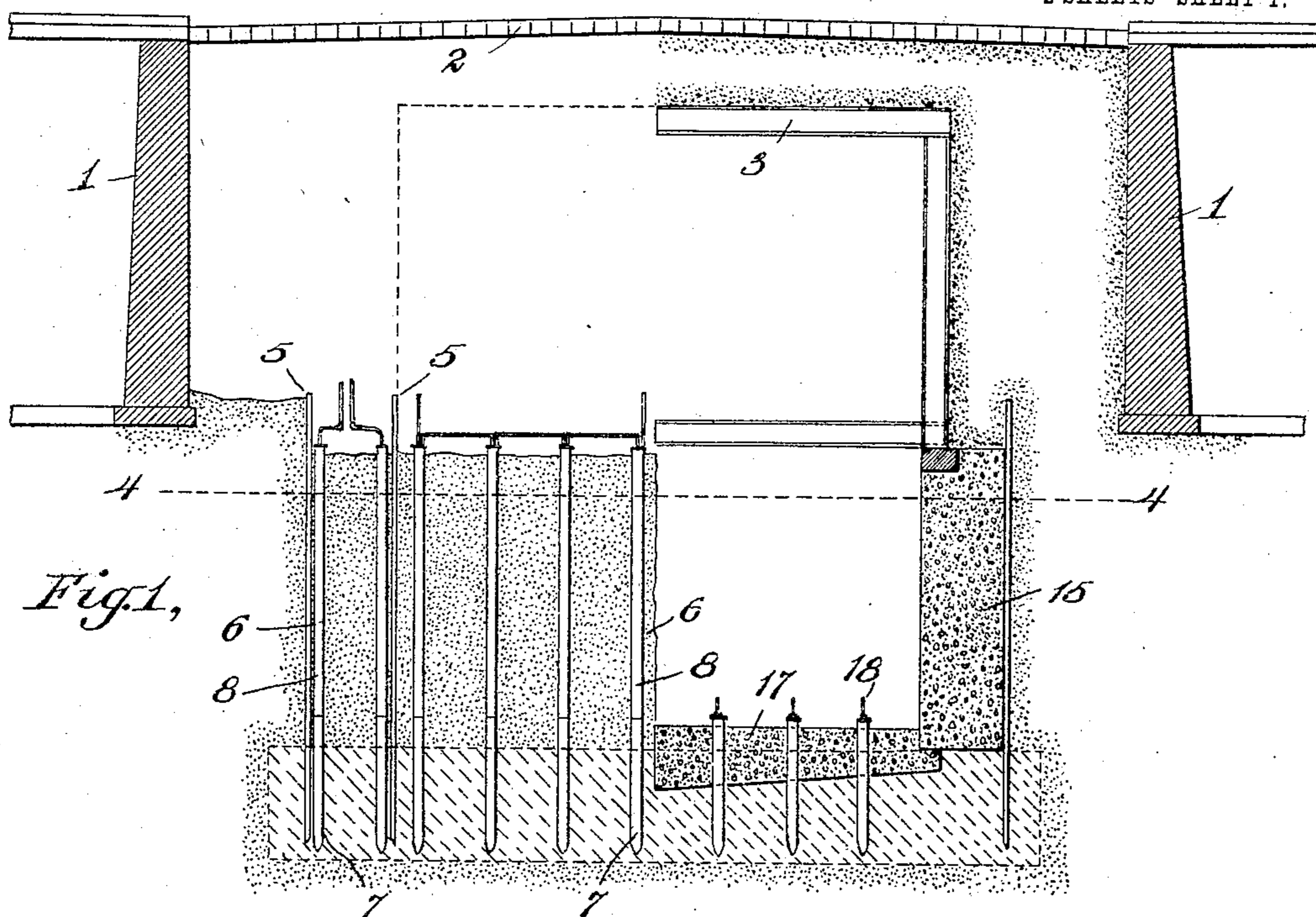


Fig. 3,

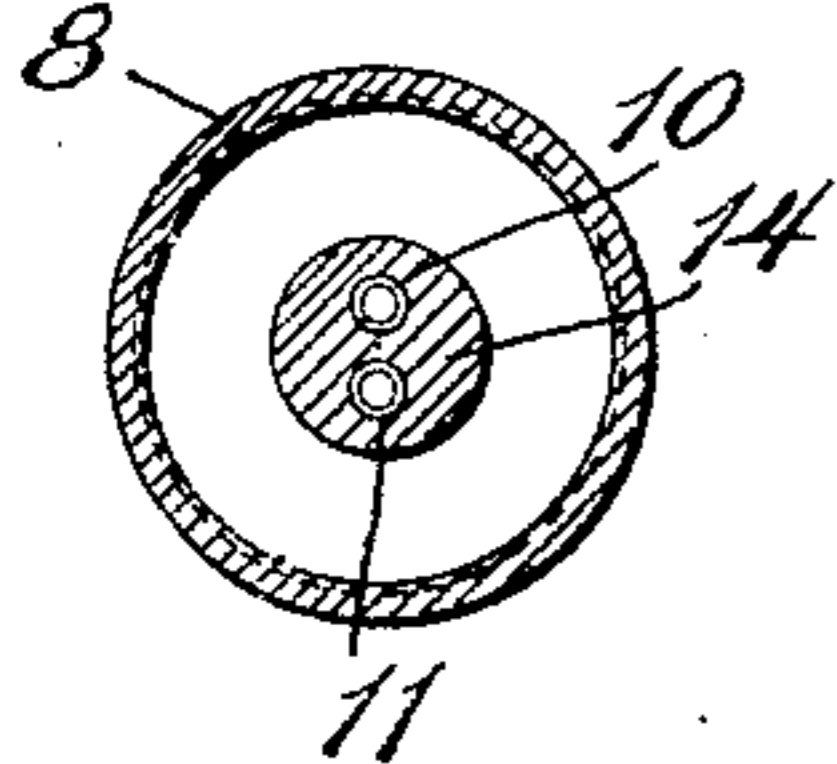


Fig. 2,

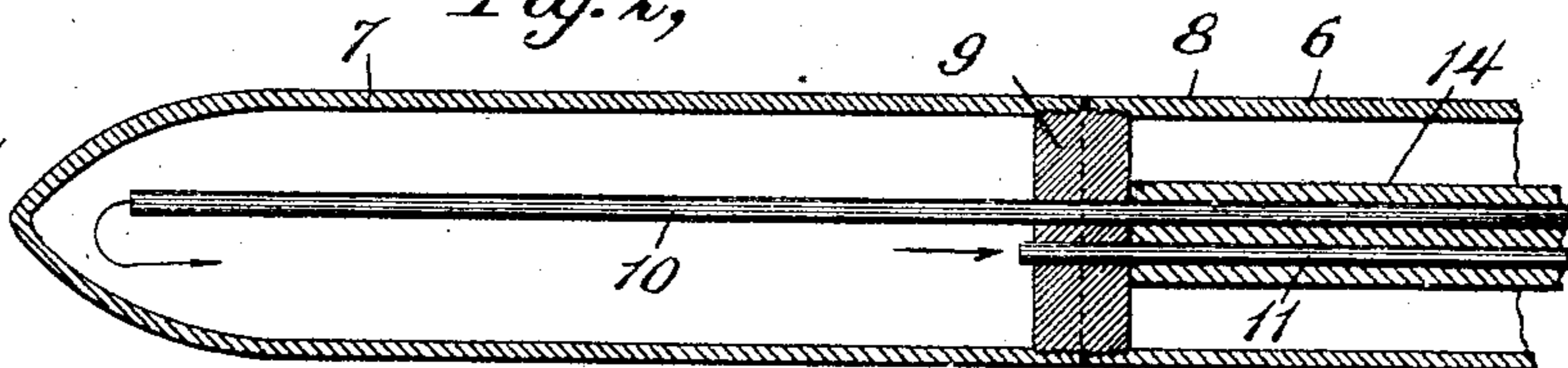
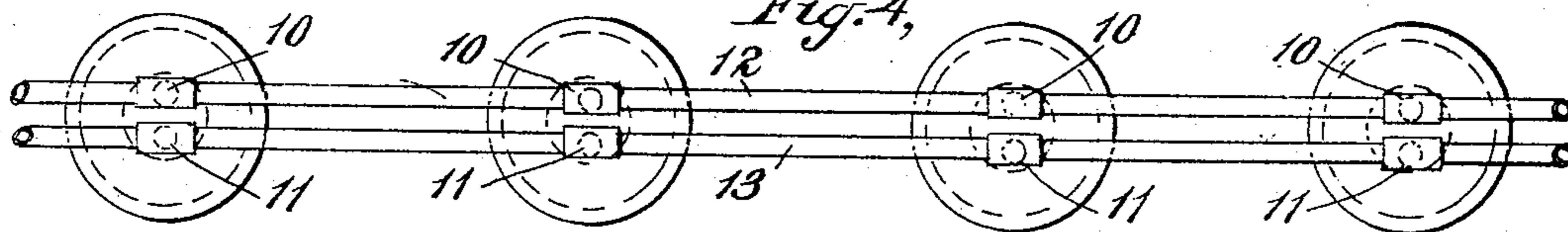


Fig. 4,



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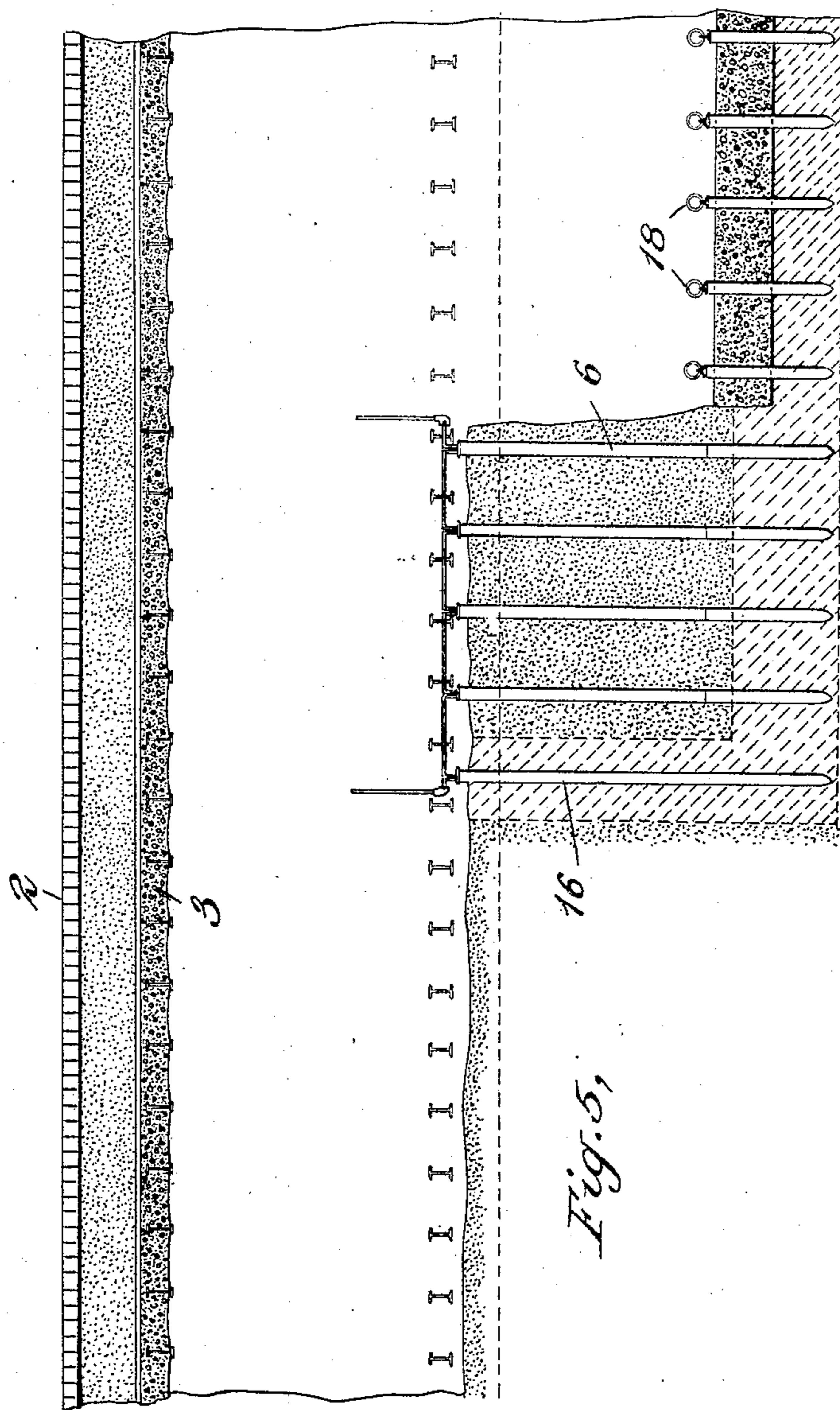
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2 SHEETS—SHEET 2.



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# UNITED STATES PATENT OFFICE.

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## METHOD OF SUBWAY CONSTRUCTION.

SPECIFICATION forming part of Letters Patent No. 786,382, dated April 4, 1905.

Application filed February 6, 1905. Serial No. 244,262.

*To all whom it may concern:*

Be it known that I, JESSE WILFORD RENO, a citizen of the United States of America, and a resident of the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Subway Construction, of which the following is a specification.

My invention relates to a method for tunnel or subway construction.

The object of my invention is to provide a method for constructing subways or tunnels in soft wet ground under city streets or elsewhere where it is necessary on account of the character of the earth to provide against the earth caving in or running into the excavation from the sides, bottom, or heading during the construction of the tunnel or subway.

My invention consists in performing the operations of excavating for and building longitudinal side retaining-walls, in forming a transverse bulkhead or wall of frozen material to guard against the entrance of material from the heading or advance end of the excavation, in forming a horizontal stratum of frozen material beneath the space to be occupied by the floor or invert of the subway, excavating the material inclosed between the side walls down to the proper depth, and forming a concrete or other suitable invert or floor and in other novel features to be hereinafter more particularly described.

Where tunnels or subways are to be driven through the streets of cities which are bounded on either sides by buildings and where the earth through which the tunnel is to be driven is wet and soft or of the nature of quicksand, great care must be used to prevent the entrance of water or earth into the excavation from the space adjacent to the line of the tunnel, as this would result not only in delaying and hampering the work of the construction of the tunnel, but would undermine the foundations of buildings, with serious or disastrous results, as is well known.

In the drawings accompanying and forming part of this specification, Figure 1 is a transverse section representing a portion of a city street in which a tunnel or subway is being constructed by means of my improved method.

The right-hand half of the figure represents the structure practically completed, while the left-hand portion represents one of the intermediate stages of the construction. Figs. 2 and 3 represent, respectively, longitudinal and transverse sections of the freezing-tubes. Fig. 4 represents a plan showing a number of tubes and the manner in which the tubes are connected to pipes conveying the freezing medium. Fig. 5 represents a longitudinal section of a subway, showing different stages of the process or method.

The reference characters are used in the same sense throughout the drawings and specification.

The particular type of subway or tunnel illustrated in Figs. 1 and 5 is what is known as a "double-deck" tunnel and is similar to that described in my former patent, No. 466,046.

Numerals 1 represents the vault-walls, such as usually occur under the outer edge of the sidewalks.

2 represents the street-surface, and 3 the permanent roof of the tunnel.

The line 4 4 indicates the height to which water rises, and the excavation down approximately to this line may ordinarily be made in the usual manner without taking extra precautions against caving in. After the excavation has been made down to the soft or wet material two rows of sheet-piling 5 are driven down to a depth some feet below the proposed base of the side walls, along the line of the side walls of the subway. Then the freezing-tubes 6 are driven down in rows just inside of the sheet-piling. These freezing-tubes consist of a pointed end 7, connected to the upper portions 8 by means of a threaded plug 9. They are also provided with circulating-pipes 10 for the induction of the freezing medium and pipes 11 for the eduction of the same. These tubes, with their inclosed pipes, extend up to the surface of the excavation, and they are connected to transverse pipes 12 and 13, respectively, which latter are connected with any convenient source capable of supplying cold brine or other refrigerating medium.

The circulating-pipes 10 and 11 are provided with an insulating material 14 in the tubes 8,

which, in connection with the air-space surrounding the pipes, prevents the portions 8 of the tubes above the freezing end 7 from absorbing heat from the earth surrounding those portions, while the freezing medium is allowed to enter the freezing end 7, and thus absorb heat from the earth surrounding said end and freeze it. As will be obvious, therefore, when the freezing-tubes are driven to the proper depths between the rows of sheet-piling for the side walls and a freezing medium is made to circulate through the pipes that portion of the earth which surrounds the end 7 will become frozen. When this has taken place, the earth between the piling is excavated and the wall 15, of concrete or other suitable material, is constructed. After the side walls have been formed for a convenient distance, as above described, other freezing-tubes are driven down through the earth between the side walls, as indicated in Figs. 1 and 5. These tubes should be placed in longitudinal and transverse rows and spaced from two to three feet apart at a convenient distance ahead toward the direction in which the work is advancing. A row of tubes 16 is driven across the end of the line of the excavation. These tubes differ from the tubes 6 in that the plug 9 is omitted, so that they will freeze the earth surrounding them for their entire lengths, and thus forming a transverse retaining-wall of frozen earth.

After the freezing operation has been carried on for a sufficient length of time it will be seen that that portion of the tunnel which is to be excavated is surrounded and protected on the sides by the permanent side walls and on the bottom and advance end by walls of frozen earth, which will effectually prevent the entrance of material during the operation of excavating. The next step in the process is to excavate the unfrozen material between the side walls. In order to facilitate this, the upper portions 8 of the freezing-tubes may be unscrewed from the freezing end 7 and withdrawn. After the material has been excavated a concrete base or invert 17 is formed in the usual manner. The freezing ends 7 are preferably left in place during the formation of the invert 17, so that at any time it is desired the freezing medium may be again connected to the freezing end and the freezing operation carried on, so as to maintain the strength of the frozen stratum beneath the invert while it is being constructed and until it has sufficiently set. After the floor or invert 17 has been completed the freezing ends 7 are withdrawn by means of strong eyes 18, which are screwed into the ends of the freezing ends, and the holes remaining are rammed with sand and concrete.

I am aware that shafts have been sunk and that it has been proposed to construct tunnels before my invention by means of freezing earth; but in all of the methods heretofore in

use the entire mass of earth to be excavated was frozen, thus requiring much greater time and expense for the freezing operation, as well as greatly increasing the difficulty of the operation of excavating. It has, in fact, frequently been necessary to blast the frozen earth in order to excavate it. It will be seen that by employing my method practically all of the material to be excavated is unfrozen, and therefore much more easily excavated, and that the amount of earth which is required to be frozen is merely a wall or stratum of sufficient thickness to protect the excavation.

Having thus described my invention, what I claim is—

1. The method of constructing subways which consists in driving double rows of sheet-piling along the lines of the side walls of the subway, freezing the earth below the line of the base of the said side walls, excavating the unfrozen earth between the rows of sheet-piling above the frozen base and constructing walls in the excavations thus made.

2. The method of constructing subways which consists in driving double rows of sheet-piling along the lines of the side walls of the subway, freezing the earth below the line of the base of the said side walls, excavating the unfrozen earth between the rows of sheet-piling above the frozen base, constructing walls in the excavations thus made, freezing a horizontal stratum of earth beneath the space to be occupied by the tunnel-invert, excavating the earth between the side walls above said frozen stratum and forming a subway-invert upon said frozen stratum.

3. The herein-described method of constructing a subway-invert which consists in freezing a horizontal stratum below the position to be occupied by said invert after the side walls have been constructed and forming a concrete invert upon said frozen stratum.

4. The herein-described method of constructing a subway-floor which consists in constructing side walls, conveying a freezing medium to the earth beneath the position to be occupied by the subway-floor and insulating the freezing medium from the surrounding earth above the position of said floor.

5. The herein-described method of constructing subways which consists in constructing subway side walls by driving two parallel rows of sheet-piling for each side wall, conveying a freezing medium to the earth below the proposed line of the base of said side walls, insulating said freezing medium above said base excavating the unfrozen earth between said rows of sheet-piling, forming walls in the excavation thus made, conveying a freezing medium to the earth beneath the proposed base of the subway-invert, insulating said freezing medium above said proposed base, excavating the unfrozen earth between said side walls and forming a concrete invert upon said frozen base between said side walls.

6. The herein-described method of constructing subways in wet ground which consists in constructing the subway side walls by driving two parallel rows of sheet-piling for  
5 each side wall, conveying a freezing medium to the earth below the proposed line of the base of said side walls, insulating said freezing medium above said base, excavating the unfrozen earth between said rows of sheet-  
10 piling, forming side walls in the excavation thus made, freezing a transverse stratum connecting the advance ends of said side walls to form a dam for the advance end of the excavation to be made, conveying a freezing medium

to the earth beneath the proposed line of the subway-invert, insulating said freezing medium above said proposed line, excavating the unfrozen earth between said side walls and forming a concrete invert upon said frozen stratum between said side walls. 15 20

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

JESSE W. RENO.

Witnesses:

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