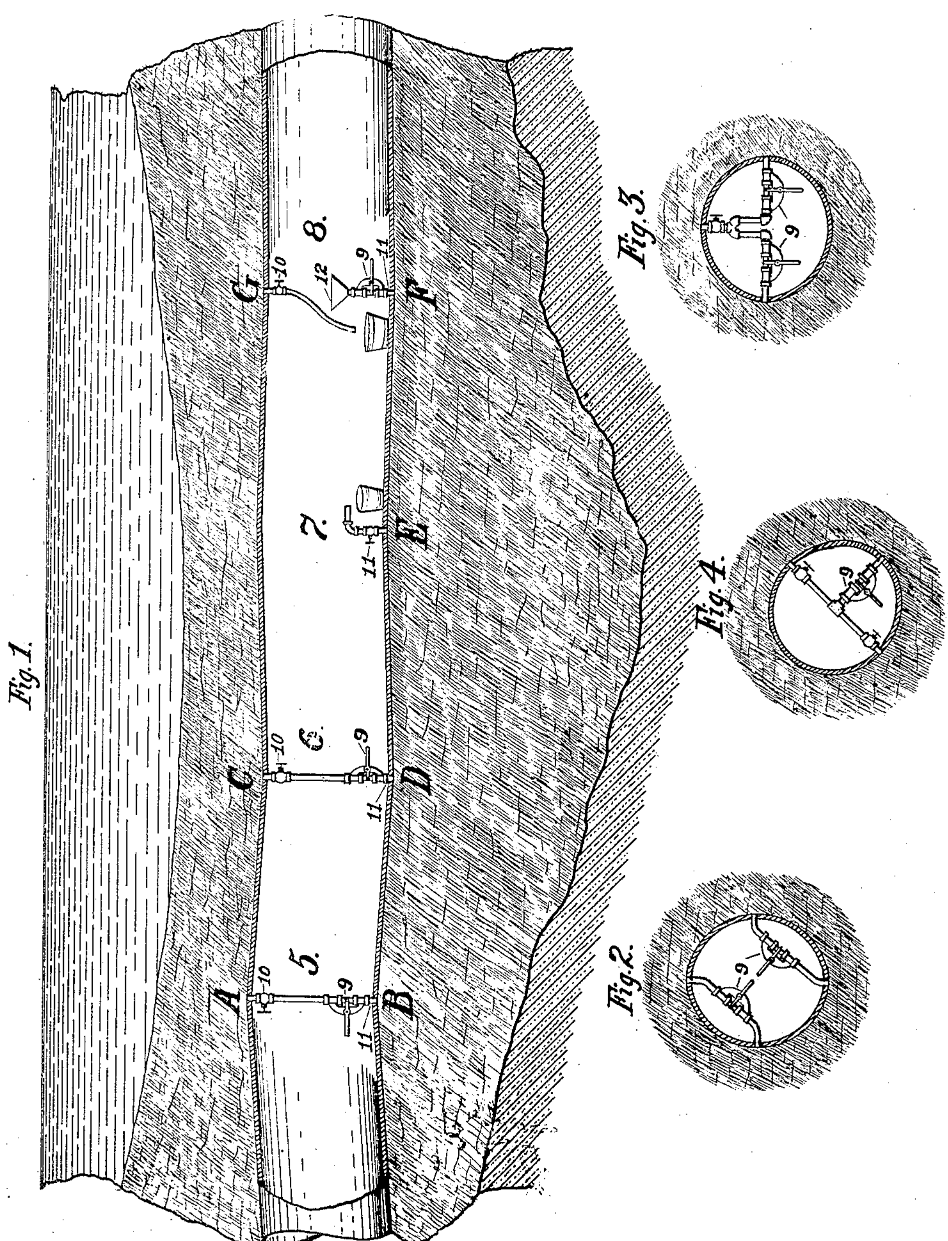
J. P. CONKLING.

ART OF TUNNEL CONSTRUCTION.

APPLICATION FILED NOV. 11, 1907.

956,627. Patented May 3, 1910.



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ART OF TUNNEL CONSTRUCTION.

956,627. Specification of Letters Patent. Patented May 3, 1910.

Application filed November 11, 1907. Serial No. 401,779.

To all whom it may concern:

Be it known that I, JOHN P. CONKLING, a citizen of the United States, residing at Manhattan borough, city, county, and State of New York, have invented new and useful Improvements in the Art of Tunnel Construction, of which the following is a specification.

This invention relates to the art of adjusting tunnel linings, and maintaining them in their theoretical position of center line, grade, and form.

It relates more particularly to subaqueous, segmental circular-ring, tube-tunnel linings, surrounded, or partly surrounded by detritus carrying more or less moisture, and has for its object to assure the usefulness of such tunnels for the purposes designed, when completed, and to render their construction more expeditious and less expensive.

In this specification the tunnel lining is referred to as a tube. Now, instead of depending solely upon driving the headings of these tubes through the earth at an estimated elevation sufficiently above theoretical grade to allow for the tube finally settling to the position of theoretical grade; after the tube is formed and the settlement has progressed sufficient to show the relative settlement of different portions of the tube, I employ a system of regulating the densities and pressures of the detritus surrounding the tube, so as to gradually bring all parts of the tube to theoretical line, grade, and form. This system consists in taking part of the surrounding ground into the tube, or forcing earthy material into the surrounding ground through openings in the wall of the tube. Where the densities and pressures of the material surrounding the tube are too heavy, I take into the tube through openings in the walls of the tube sufficient of the material surrounding the tube to reduce the densities and pressures at that place, to the point desired. Where the densities and pressures of the material surrounding the tube are too light, I force earthy material from within the tube, through openings in the wall of the tube and into the material surrounding the tube at that place, until the desired densities and pressures at that point are obtained.

By compressing such portions of the detritus surrounding the tube as are not sufficiently dense to support the tube at theoretical grade, and filling the space vacated with denser detritus, I build up foundations and buttresses of denser detritus within the mass of detritus where required to hold the tube in theoretical position. When necessary I continue the operation of compressing this light detritus and filling in the space vacated with denser detritus, until the tube has been elevated vertically or shoved horizontally into theoretical position or to the desired location.

While moving the tube vertically or horizontally by means of such pressure exerted from within the tube, and acting against the outside of the tube, I remove obstructions in the path of the tube, by taking the obstructions into the tube through openings in its walls.

To rectify distorted tubes, I employ the same methods. Where the diameter of the tube is greatest, I force earthy material from within the tube through openings in one or both of its opposite walls into the material outside of the tube, and I remove the surrounding detritus into the tube through openings in one or both of its opposite walls where the diameter of the tube is least. Thus, equalizing the pressures, and restoring the distorted sections of the tube to its theoretical form.

My invention may be more fully understood from the detailed description hereinafter presented with reference to the accompanying drawings, in which:

Figure 1 is a vertical cross-section of a portion of a river and its bed of rock and the detritus above the rock, a longitudinal vertical section of a portion of a tunnel being shown extending through the detritus. Inside of this tunnel are shown four systems, 5, 6, 7 and 8, for regulating the density and pressure of the detritus over and under the tunnel, by means of which the tunnel may be raised or lowered and adjusted vertically to the desired position. Fig. 2 is a vertical cross-section of a tunnel in detritus, showing a distortion of the tube in which the vertical diameter is greater than the horizontal diameter. A system consisting of an arrangement of pumps, valves and pipes for correcting this distortion are also shown within the tunnel. Fig. 3 is a vertical cross-section of a tunnel in detritus showing a distortion of the tube in which the vertical diameter is less than the horizontal diameter. A system consisting of an arrangement of pumps and valves and pipes for correcting this distortion is also shown within the tunnel. Fig. 4 is a vertical cross-section of a tunnel in detritus, showing a distortion of the tube in which the diagonal diameters are unequal. A system consisting of an arrangement of pump, valves, and pipes for correcting this distortion are also shown within the tunnel.

System 5 Fig. 1 is located at a point in the tunnel where the tunnel is too high. It is so arranged that the detritus may be pumped from under the outside of the tunnel at B, through the pump 9 and the pipe and valve 10 above it, and then be discharged above and around the outside of the tunnel at A. The removal of the denser detritus from under the tunnel at B will cause the tunnel to settle lower at that point, and by depositing the removed material above the tunnel at A, the general disturbance of the detritus above the tunnel will be avoided. In detail, this system consists of an opening through the bottom wall of the tunnel approximately in the center line of the tunnel at B and another similar opening in the top wall of the tunnel approximately diametrically opposite at A. These two openings are connected by a piping and pumping system extending vertically through the tunnel. In this line of piping there may be placed one or two gate valves, one 10, close to the top wall of the tunnel at A, and the other 11, when used, should be placed close to the bottom wall of the tunnel at B. These valves while not absolutely necessary, are inserted in this system to enable the operator to shut off the flow of detritus, in case of accident, or in case the system is to be disconnected for any purpose. The top valve 10 makes the operation of the system more convenient. A suction and force pump 9 is inserted in the line of piping at such elevation as is most convenient for operating, and this pump performs the functions of the lower valve 11. Intermediate openings, with valves for closing them may be inserted in the system at points desired for taking detritus into the tunnel, or for conducting it to other points of the periphery of the tunnel. The operation of this system consists in opening the upper valve 10 and the lower valve 11 when used, and then working the pump 9, until a sufficient amount of the material under the tunnel at B has been removed from under the tunnel and deposited above the tunnel at A to lower the tunnel to the point desired. The valves 10 and 11 may then be closed and the apparatus removed. The valves may be allowed to remain for future adjustments which may be required, or they may be removed, and the openings in the wall may be plugged.

The diameter of the pump and the piping through which the detritus is to be moved may be varied to accommodate the character of the detritus in each case. Pipes with internal diameters of one to two inches will answer for ordinary fine smooth silt, while coarser material such as sand and heavy gravel will require larger piping, even up to four, five, or six inches, or more. Where the tunnel deviates from grade to a considerable extent in any one direction, and this deviation exists for a considerable distance along the tunnel in a longitudinal direction, several of these systems similar to 5 may be established, spaced two, four, six, or eight feet apart along the center line of the tunnel, or they may be placed in groups as described, and the work of adjustment be greatly facilitated by operating all of the pumping systems at once. The extent of the error and the amount of the surrounding material to be moved will naturally govern the number of pumps to be employed.

System 6, Fig. 1, is located at a point in the tunnel where the tunnel is too low. This system 6 is arranged for pumping the detritus C from above the tunnel, into the detritus D under the tunnel, by means of which the density of the detritus D under the tunnel is increased, and the tunnel is gradually lifted, while at the same time the material C above the tunnel is removed from the path of the vertically upward moving tunnel. System 6 Fig. 1 is constructed exactly the same as system 5 Fig. 1, except that the pump 9 is connected up so as to force the detritus in the opposite direction, viz: under the tunnel instead of above the tunnel. The number of pumping systems employed to raise the tunnel may be governed like those used in lowering the tunnel, by the extent of the error and the distance it covers along the line of the tunnel.

System 7, Fig. 1, is located at a point where the tunnel is too high. This system consists of a vertical opening through the bottom wall of the tunnel, located about in the center line of the tunnel at E. Into or surrounding this opening is fixed vertically a pipe nipple about a foot long; on top of this nipple is fixed a straight-way valve (preferably a gate valve); on top of this valve is fixed vertically another nipple about a foot long; on top of this nipple is fixed a right angle elbow which looks out about parallel with the bottom of the tunnel, and to this elbow is fixed another nipple about a foot long which extends outward from the elbow in a direction parallel with the bottom of the tunnel and forms the outlet for the detritus. On the bottom of the tunnel under this outlet is placed a receptacle such as a tub, or box, or car to receive the material discharged from this system, which may be disposed of in the most convenient manner. When the valve 11 in this system is opened, the detritus E, propelled by the surrounding outside pressure will ooze through the opening in the wall of the tunnel and through this system of piping, and be deposited in the receiver under its discharge opening. The removal of this detritus from under the tunnel at E will decrease the density of the detritus remaining there and the tunnel will gradually settle to a lower level. As the tunnel settles to a lower lever the detritus above the tunnel will slowly follow it. In operating this system the arrangement of the entire body of detritus above the tunnel will be considerably disturbed, and care should be taken to conduct the work slowly so as to prevent the distortion of the tunnel, first by a too rapid decrease in the horizontal diameter at this point owing to excessive side pressures, and later by a decrease in the vertical diameter, due to an excessive weight of detritus on top of the tunnel owing to the arch of the detritus above the tunnel having been broken when the tunnel was lowered.

System 8, Fig. 1, is located at a point in the tunnel where the tunnel is too low. This system is exactly the same as system 6, except that it is disconnected at some convenient point between the pump 9 and the upper valve 10 in the pipe line. The detritus G above the tunnel may be taken into the tunnel through the opening in the top of the tunnel governed by the valve 10 and be discharged into some convenient receiver in the tunnel. It may be used again, if desired, by forcing it through the force pump 9 and under the tunnel at F to increase the density of the detritus there. A better material may be needed for this purpose, however, and in that case the detritus taken into the tunnel from G would be disposed of in the most convenient manner. The lower portion of system 8, Fig. 1, consists of a force pump 9 with some form of hopper 12 for holding and feeding to the pump 9 the earthy material to be forced under the tunnel at F by the force pump 9. As the earthy material is forced under the tunnel at F the density of the detritus at this point will be increased which will cause the tunnel to rise. At the same time the detritus at G which is in the path of the tunnel is removed into the tunnel through the opening governed by the valve 10 which makes this adjustment possible without distortion of the tube. Horizontal adjustments may be accomplished by the same apparatus set up in a horizontal position and extending diametrically across the tunnel from outside to outside, the apparatus being operated in practically the same manner as for the vertical adjustments. Distorted sections of a tunnel may be rectified by using a similar apparatus arranged to increase or decrease the density and pressure of the material surrounding the tunnel at points required to remedy the errors, as shown in Figs. 2, 3 and 4. To remedy distortion, however, only a comparatively small quantity of the volume of the material surrounding the tunnel need be removed or shifted to produce the desired result, while in rectifying alinement of grades it sometimes becomes necessary to move thousands of cubic feet of material to secure proper adjustment of the tunnel.

What I claim as new and desire to secure by Letters-Patent, is:

1. Adjusting tunnel linings by regulating the density and pressure of the ground surrounding the tunnel, by means of removing part of the surrounding ground from place where its density and pressure is too great, substantially as set forth.

2. Adjusting tunnel linings by regulating the density and pressure of the ground surrounding the tunnel, by means of injecting earthy material into the ground surrounding the tunnel where its density and pressure is too light, substantially as set forth.

3. Adjusting tunnel linings by regulating the density and pressure of the ground surrounding the tunnel by means of removing part of the surrounding ground from place where its density and pressure is too great, and injecting earthy material into the ground surrounding the tunnel where its density and pressure is too light, substantially as set forth.

4. Adjusting tunnel linings by increasing the pressure on the outside of that side of the tunnel opposite to the direction in which it is desired to move the tunnel, and decreasing the pressure on the outside of that side of the tunnel opposite, substantially as set forth.

5. Adjusting tunnel linings by means of moving part of the ground surrounding the tunnel lining, from the outside of one side of the tunnel to the outside of the opposite side of the tunnel, substantially as herein set forth.

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