UNITED STATES PATENT OFFICE.

JOHN C. GOODRIDGE, JR., OF NEW YORK, N. Y.

PROCESS OF AND DEVICE FOR THE CONSTRUCTION AND REPAIR OF TUNNELS AND SHAFTS.

SPECIFICATION forming part of Letters Patent No. 303,506, dated August 12, 1884.

Application filed January 2, 1884. (No model.)

To all whom it may concern:

Be it known that I, JOHN C. GOODRIDGE, Jr., of the city, county, and State of New York, have invented a new and useful Improvement in the Construction and Repair of Tunnels and Shafts, of which the following is a specification, reference being had to the accompanying drawings.

The construction, maintenance, and repair of railway-tunnels and other like structures is seriously embarrassed by water percolating through fissures in the mass overhead and escaping under more or less pressure into the tunnel or structure itself.

As the water enters a tunnel it spreads in a thin sheet over the sides thereof, if near or below the spring of the arch, while if near or at the crown of the arch it drips or falls in a stream, as the water is present in less or in greater quantity. In cold weather the thin sheet of water aforesaid is speedily chilled to the freezing-point and congeals into ice, rapidly increasing in thickness. Soon it reaches the floor of the tunnel and assumes the form of a buttress, with its base on said floor, which continually encroaches on the space reserved for and onto the tracks themselves. A mass is thus formed, in a time incredibly brief to one unfamiliar with the subject, which would instantly derail a passing train. Constant vigilance and free use of the ax are therefore required to contend with it. Again, if the water percolates through and emerges from the crown of the arch, it quickly forms icicles of great size and weight, and it becomes necessary, and it is the practice, frequently to send men through the tunnel armed with poles to break down the icicles and remove them. Furthermore, the freezing of the water in the fissures of the hanging rock forming the roof of the tunnel disintegrates it, so that at all times, summer and winter, there is danger lest passing engines encounter fallen fragments of rocks and serious accident result. So well is this danger recognized that it is the practice to employ watchmen for the express purpose of giving timely warning of such contingencies. This constant deterioration soon renders it necessary to line the tunnel with masonry or beton, either throughout or at least in those portions where the water shows itself most freely. Then a fresh difficulty appears. The water flowing over the sides, as well as that issuing from lateral fissures, being under greater or less pressure, locally forces out the cement in which the masonry is laid before it has time to set, and not only weakens the structure, but as the overhead drip is in a measure shut off, such water passes downward between the rock and the masonry, escapes through the apertures formed as aforesaid, and the formation of ice in the manner first above named is aggravated. Difficulties of a like nature, though of varying character, occur in analogous constructions, such as shafts and the like. The process hereinafter described is intended to meet and overcome these difficulties.

In the drawings forming part of this specification, Figure 1 shows my process of lining a tunnel with beton. Fig. 2 is a transverse section of a mold for forming a longitudinal depression in the interior surface of the beton lining to serve as a water-bar. Fig. 3 shows my process as applied to lining a tunnel with masonry. Fig. 4 shows a metal water-bar as applied to a masonry lining. Fig. 5 is a sectional elevation, showing my method as applied to the construction or repair of a railway air-shaft.

In lining such tunnels it has been the practice first to erect "centers" of timber at intervals, then to cover the upper surfaces of these centers with planks, termed "lagging," and to build the masonry on the latter as a support until the arch is completed and self-sustaining. Then the lagging is removed. This lagging, with a view to economy in the quantity of material employed and for the purpose of observing the work, is placed with intervals between the edges of the planks.

My process consists, first, in so placing the lagging F, Fig. 1, between which and the natural rock A the tunnel-lining C is to be built, that the edges of the planks forming the same are in contact. If the seams so made are not water-tight, I make them so by calking, or in any desired way. As I work upward I continue the lagging also upward, always keeping the same water-tight. Thus the water is prevented from forcing its way through the cement in which the masonry is laid, or through the beton, if that is employed, until it has had time to set. Such water as is not shut



(No Model.) 2 Sheets—Sheet 2.

J. C. GOODRIDGE, Jr.

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out encounters the upper edge of the growing work, and is there turned off laterally by and flows gently along it until it escapes at some convenient point of discharge prepared for that purpose; but should water issue locally in quantity and under pressure it will be better to insert a discharge-pipe opening through the lagging, as hereinafter described. Having reached at or near the point shown at D, Fig. 1, or at any other point where the drip will cause least inconvenience, I proceed as follows: If the lining is of beton, I place upon the lagging molding-strips of wood, E, of substantially such a cross-section as is shown in Fig. 2. This strip may extend the length of the work, and over and around it the beton is rammed, so that when the beton is set and the lagging, with the strips E, is removed, a longitudinal depression or groove will be formed in the beton and running the entire length of the lining. The molding-strips E may be laid parallel with the axis of the tunnel, and at an equal height from the floor thereof; or they may be laid with a slope, or in a zigzag manner, so as to conduct the drip to one or more selected points of final discharge. More than two such depressions may be employed, if desired, but two located as shown will generally suffice. It will be seen that at these grooves all drip must accumulate, and that they act as water-bars, since water will not voluntarily run up hill. Thus, therefore, the buttress formation of ice is prevented, while since the water falls from the grooves so much sooner after infiltration and in so much larger mass, the greater part, if not all, drips before it has time to chill to the freezing-point, and consequently the formation of icicles is prevented or much lessened. Should a beton lining be employed, since it is supported by the water-tight lagging until it sets into a single homogeneous monolith, when completed, it is impervious to water and shuts out infiltration altogether; but if the rock overhead is seamy this may merely turn the water into other seams and remove the infiltrations to a fresh point. To obviate this, I embed two or more pipes in the beton, as shown at D, Fig. 1, leaving a shallow basin at that end of the pipe nearly in contact with the rock. These basins may be readily formed by simply wrapping around the inner end of the pipe any material pervious to water which will form a backing for the beton, &c.—such as strips from an old gunny-bag—and then packing the beton around it. The mouth of the pipe should not be covered. The other end of the pipe I lead to any convenient place of discharge, packing it to prevent freezing, if necessary. Thus the various seams of the rock through which the water formerly percolated fill up to the level of the pipe, and then the water escapes through the pipes into the ditch alongside or between the tracks, and thereby the water still follows its old course through the rock, and all trouble and danger from ice within the tunnel are obviated. It will thus be seen that by inserting the discharge-pipe at or above the point of infiltration, the water will accumulate below and rise or back up until it reaches one of these drains, through which it escapes. The danger of the choking up of the drain is thereby avoided, as the excess of water over that escaping through seams in the rock is taken off from the top of the accumulated body, and the sand and dirt sink to the bottom. Indeed, the discharge-pipes may be advantageously used anywhere in the course of the work where the water appears locally in large quantity and under pressure, placing one end of the pipe, wrapped as aforesaid, nearly against the seam, leading the other through the lagging, and packing the beton around the pipe and wrapper.

Masonry, whether of brick or stone, is not in itself perfectly water-tight, because of the porous nature of the former and imperfections in the latter. Still, if laid upon the support of water-tight lagging, as hereinbefore described, and the said lagging is allowed to remain until the cement between the bricks or stones is perfectly set, it will confine infiltration mainly to the crown of the arch. A depression, E, as shown in Fig. 1, will serve as a water-bar and act as described in the case of beton; but this is expensive in construction compared to the following equally efficient method. When the masonry has reached to or about the point at E^2, Fig. 3, I place a strip of sheet copper, lead, or other similar material parallel with the axis of the tunnel, and so that one edge will be confined for about half the width of the strip—say three or four inches—in the joint formed between the course last laid before the strip is placed in position and the next following course. The other edge is bent over, so as to rest upon the inner surface of the lagging, so that the following course of masonry rests in part upon it. (See E^2, Figs. 3 and 4.) When the lagging is removed, the edge last named is bent downward, so that the whole strip lies in one plane, as shown at E^2, Fig. 4, by the dotted lines. Thus cheap and efficient water-bars are formed, acting as hereinbefore described in reference to the same feature of the beton lining.

Discharge-pipes, as hereinbefore described, may be also introduced through suitable holes in the masonry, packing the same well with beton, concrete, or cement, so as to prevent leakage around the pipe. Since a shaft is nothing but a tunnel set on end, it is clear that my method is equally applicable to that form of construction. Waste-water pipes D, Fig. 5, are inserted whenever, through meeting a fissure or from accumulation, the water becomes troublesome. These project through the lagging, and may be led to a convenient place of discharge, and may be packed to prevent freezing; or, as in the cases hereinbefore described, they may be plugged after the lagging is removed, and the water shut out altogether, as the nature of the material through which the shaft is driven renders advisable.

I am aware that it has been proposed to relieve tunnels of infiltrated water by the running of adits or other nearly horizontal passages through the walls of the tunnel connected with conducting-flues; but in systems heretofore proposed or employed for this purpose liability to choke by silt or freezing has existed to a highly injurious and often fatal extent, owing to the sluggish passage of the water or the existence of dead-points in the conduit. By my plan I despense with horizontal or nearly horizontal adits, and with long conducting-flues, and employ straight discharge-pipes, vertical, or nearly so, and as short as possible. These pipes discharge a more or less solid stream directly into the tunnel, dispensing entirely with crooked or lengthened flues. My system is thus essentially different from those heretofore adopted, the theory of which is that water should be discharged at the lowest point. My short straight discharge-pipes have little or no liability to choke, or if they should become choked from any cause may be readily freed and cleaned.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The within-described process of lining tunnels and shafts with beton or masonry in the presence of infiltrating water, consisting of erecting a water-tight lagging within the tunnel or shaft, substantially parallel to and at any desired distance from the interior thereof, filling the space so formed with beton or masonry, allowing said lagging to remain in position until said beton or the cement in which the masonry is laid has set, and then removing said lagging.

2. The combination, with a tunnel or shaft lining, of one or more water-bars for the purpose of controlling and localizing the discharge of infiltrating water, substantially as described.

3. The combination, with a tunnel or shaft lining, of one or more waste-water discharge-pipes inserted through said lining at the point of infiltration, or above that point, for the purpose of controlling or leading away infiltrating water, substantially as described.

4. The combination, with a tunnel or shaft lining, of one or more waste-water discharge-pipes inserted through said lining at the point of infiltration, and above one or more water-bars, substantially as and for the purpose set forth.

5. The within-described method of embedding pipes for the discharge of infiltrating water in beton or masonry structures, consisting of wrapping pervious material around one end of said pipe, placing the pipe in such position that that end may be nearly in contact with the orifice through which the water enters, while the other or discharge end projects through the work, and then packing beton or other suitable material around said pipe and pervious material, substantially as described.

In testimony that I claim the foregoing improvement in the construction of tunnels and shafts, as above described, I have hereunto set my hand this 28th day of December, 1883.

JOHN C. GOODRIDGE, JR.

Witnesses:
HENRY P. WELLS,
CHAS. G. KOSS.