No. 840,307. PATENTED JAN. 1, 1907.

# P. FORD.

# METHOD FOR TUNNELING THROUGH ROCKS.

APPLICATION FILED DEC. 26, 1905.

3 SHEETS—SHEET 1.

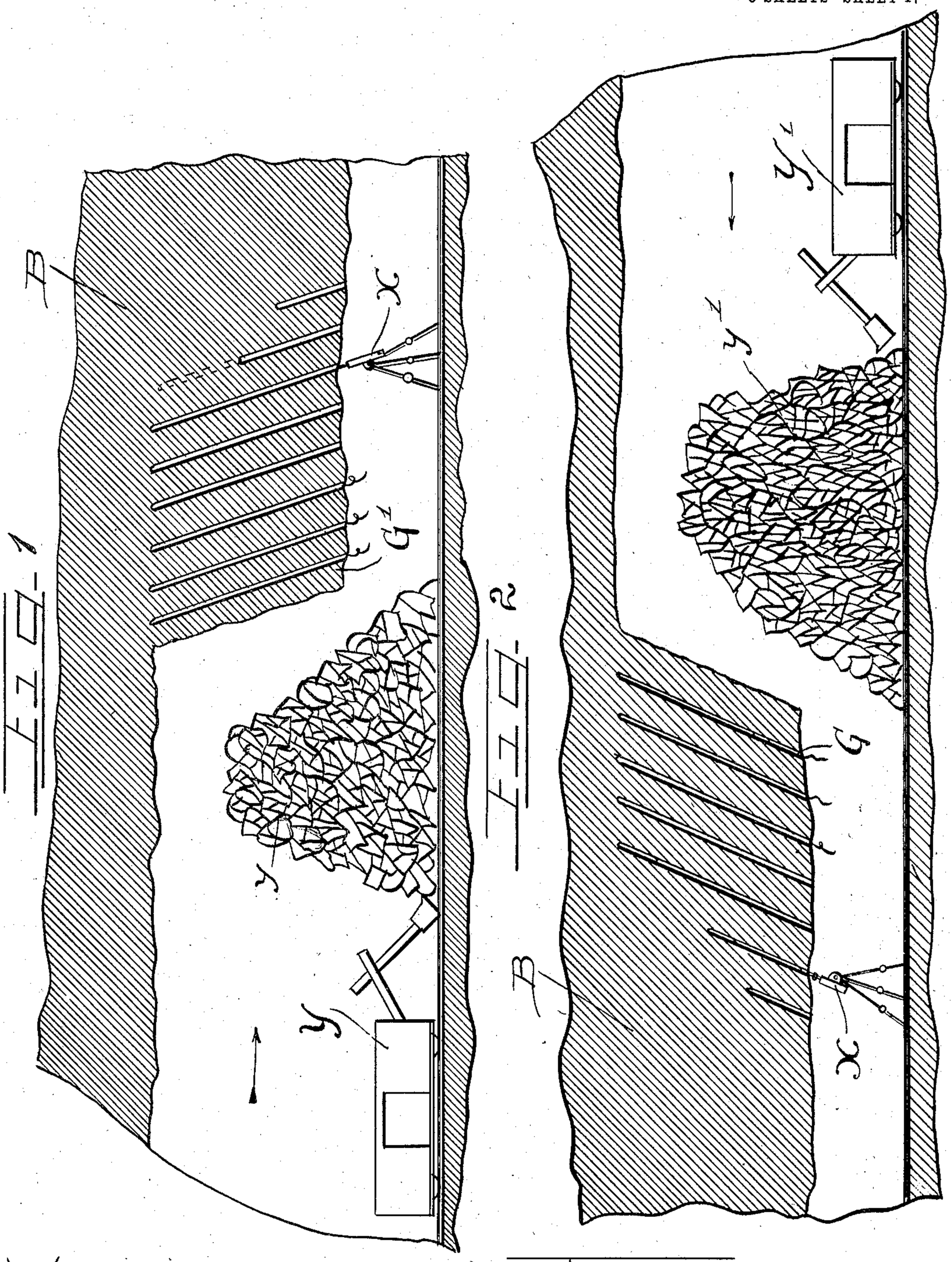


FIG. 1

FIG. 2

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3 SHEETS—SHEET 2.

Fig. 3

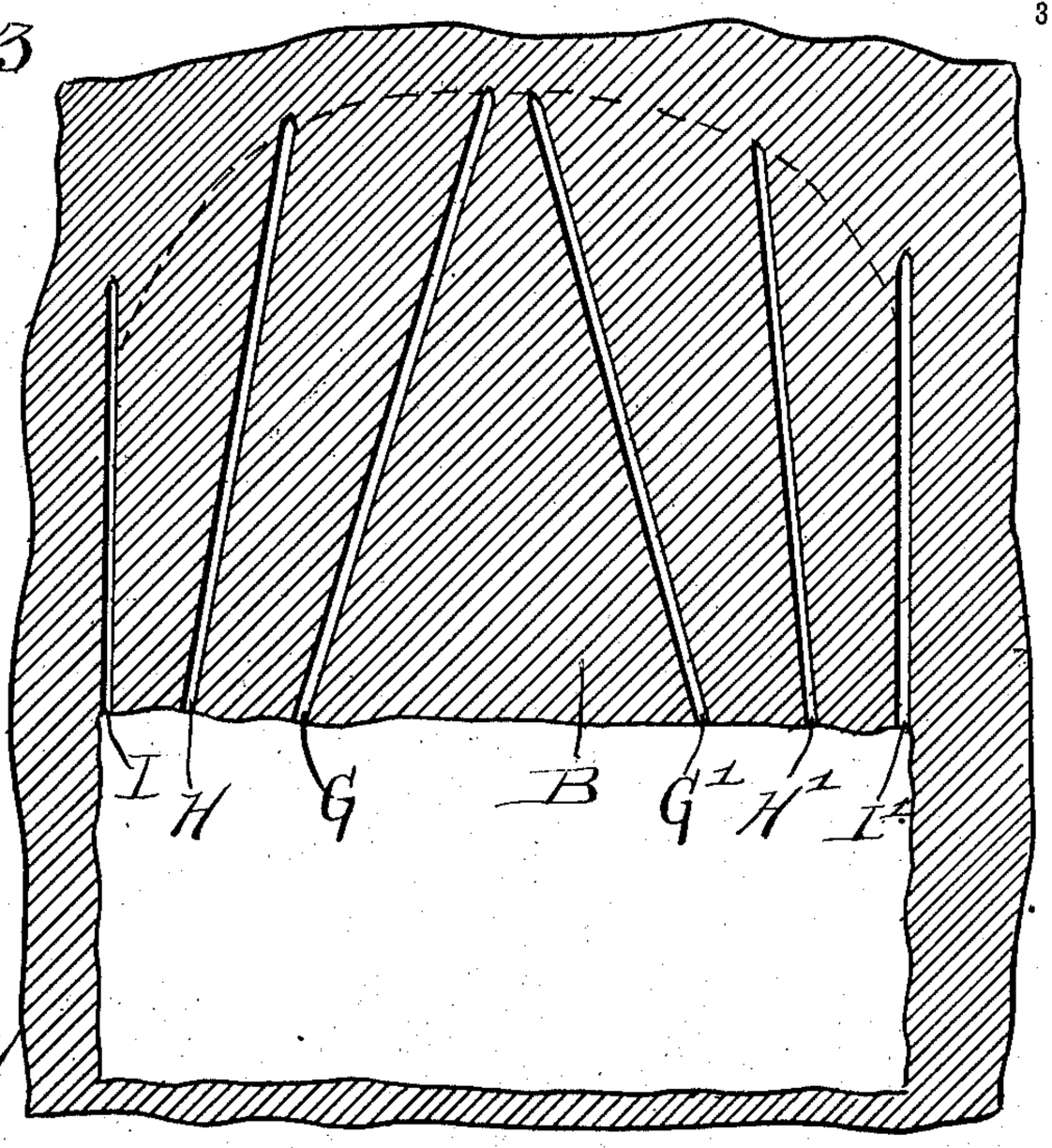
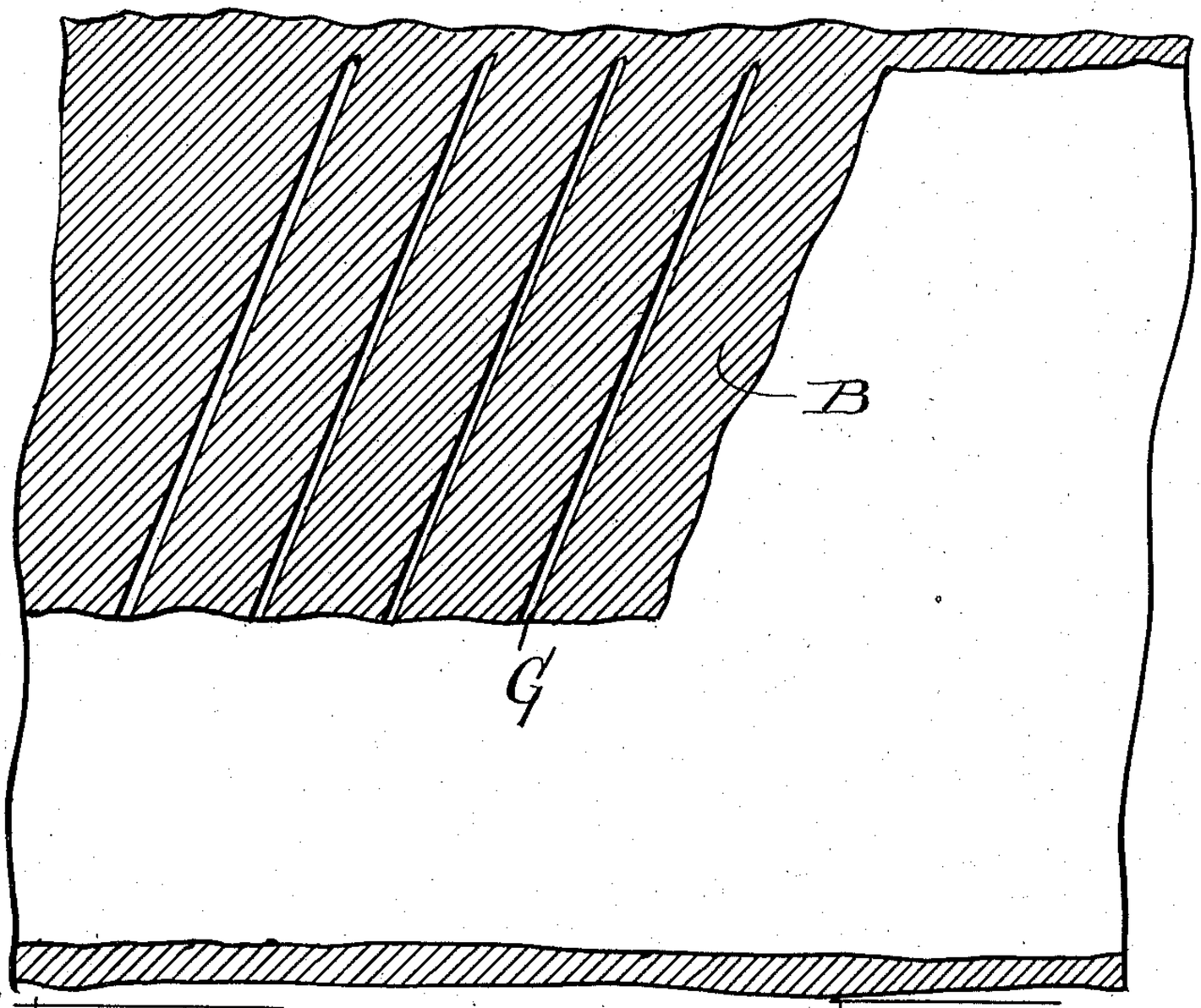



Fig. 4

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3 SHEETS—SHEET 3.

Fig. 5

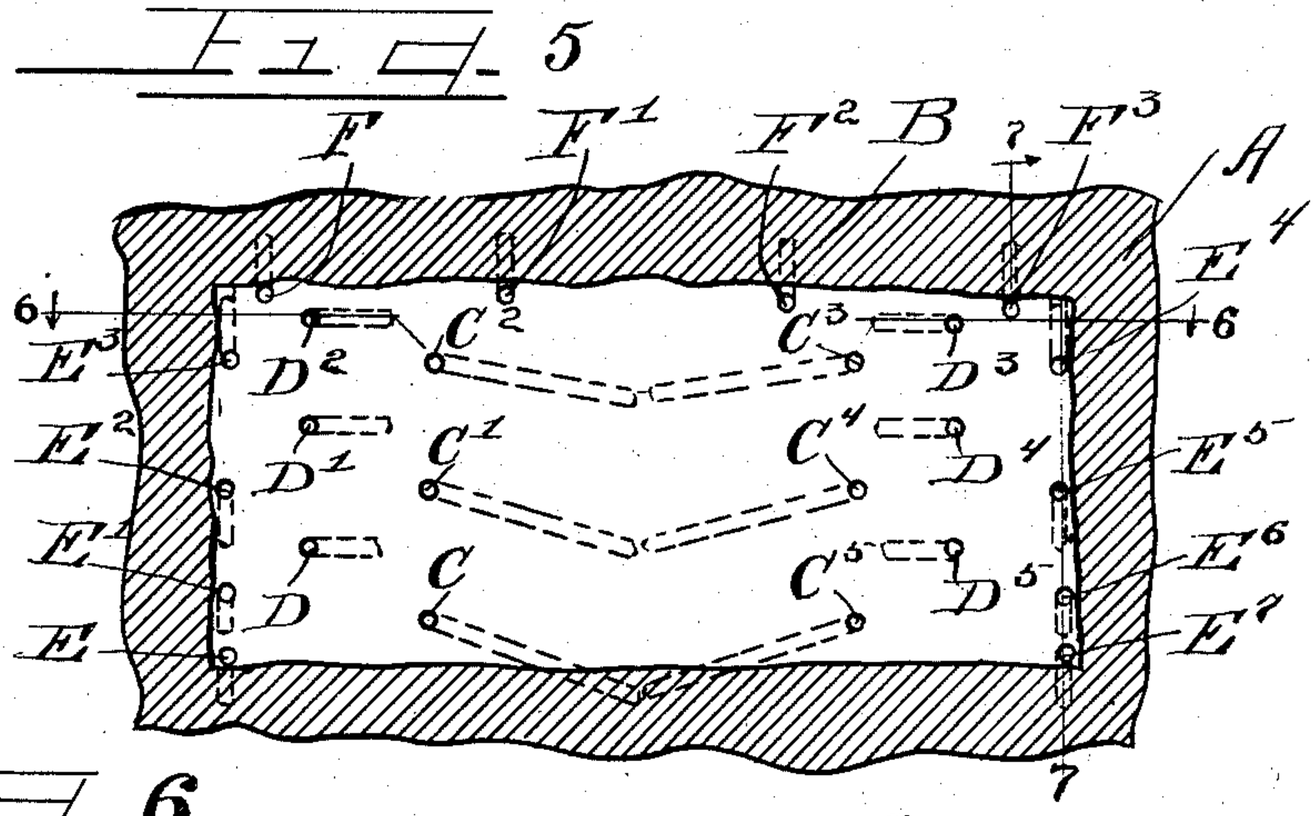



Fig. 6

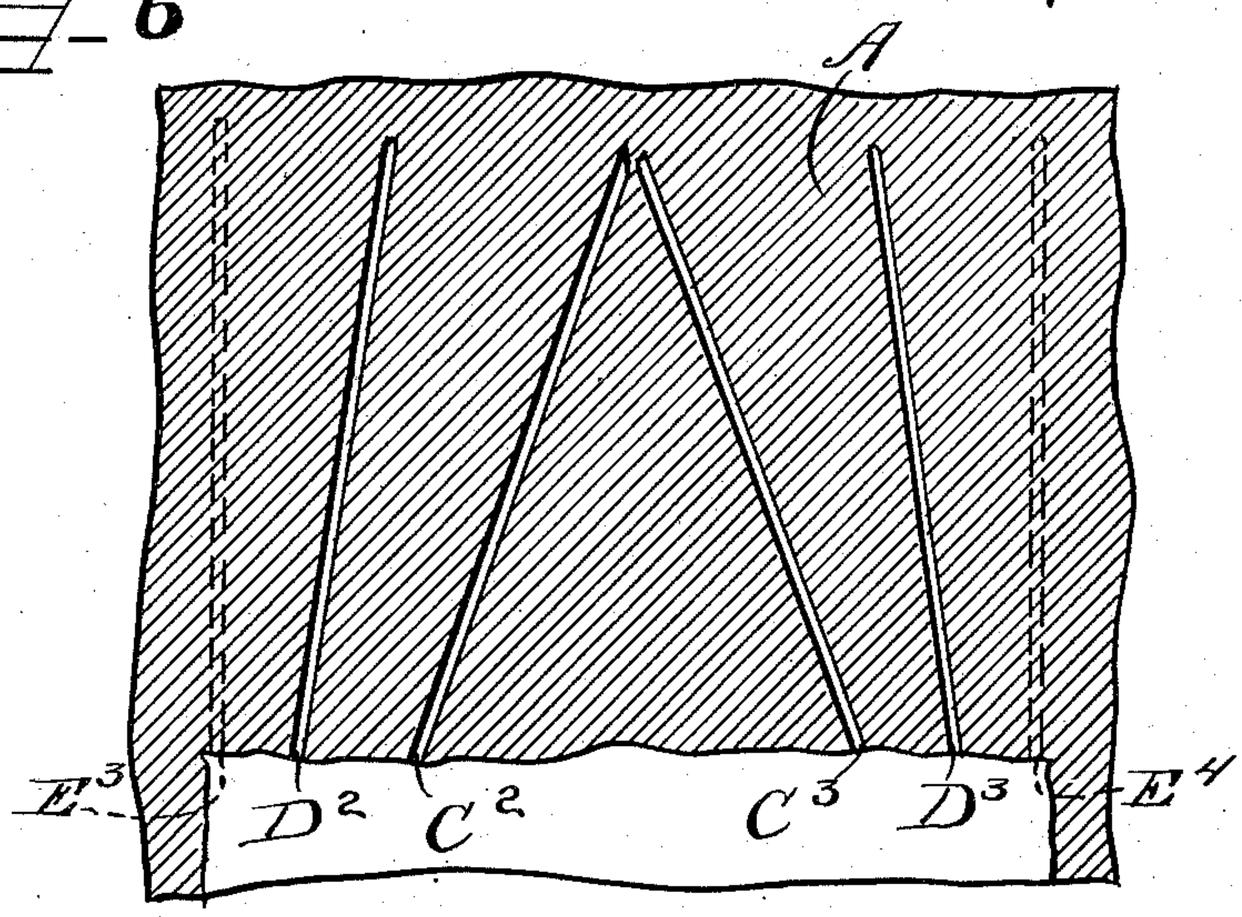
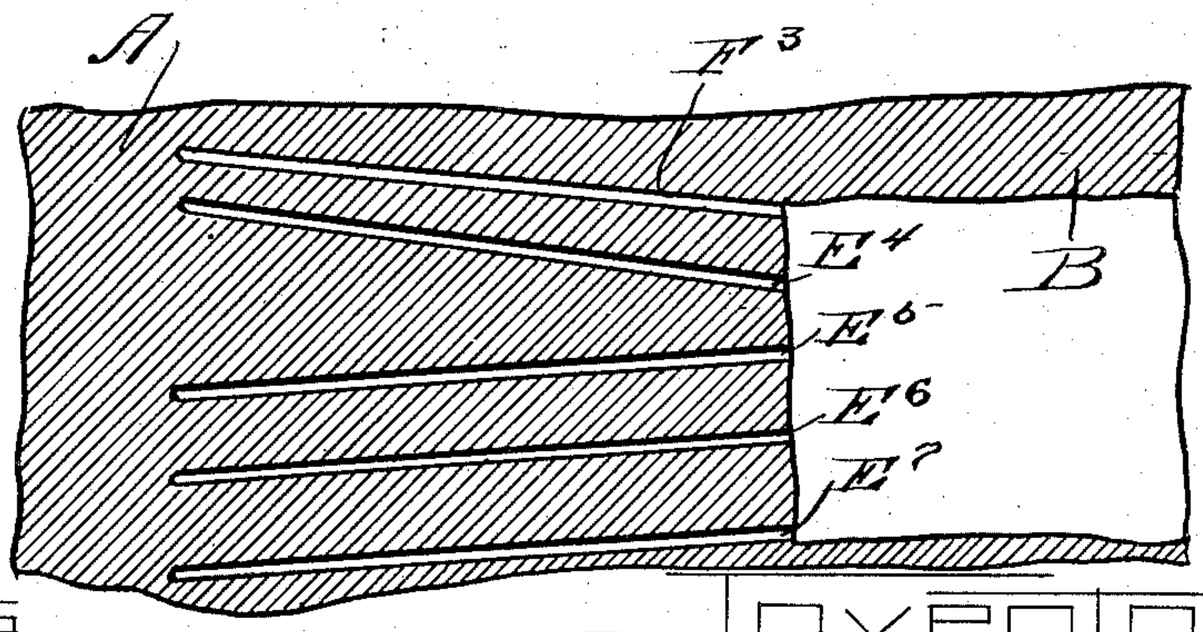



Fig. 7

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# UNITED STATES PATENT OFFICE.

PATRICK FORD, OF CHICAGO, ILLINOIS.

## METHOD FOR TUNNELING THROUGH ROCKS.

No. 840,307. Specification of Letters Patent. Patented Jan. 1, 1907.

Application filed December 26, 1905. Serial No. 293,432.

*To all whom it may concern:*

Be it known that I, PATRICK FORD, a citizen of the United States, and a resident of the city of Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Methods for Tunneling Through Rocks; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

Heretofore in tunneling through rock the operators have constructed a heading in the top of the tunnel, and then blasted out and removed the material in successive benches, thus working from the top downwardly. The material must thus all be lifted against gravity, and both in blasting and in removing the "muck" the work is necessarily slow and dangerous, inasmuch as the operators are forced to work in a confined space, usually with insufficient ventilation. Furthermore, in tunnels constructed in this manner it has been impossible to operate the crews to the best advantage, as the muckers or those working to remove the material loosened by the previous blasts cannot work during blasting and cannot resume work until the breast or heading has been cleared of smoke and gas. In this way one crew is always in the way of another, and the best that can be accomplished is either to work the crews alternately in shifts or to work the drillers and powder-men at night and the muckers or those removing material by day, and as crews of both kinds cannot be worked simultaneously and night and day the construction is slow and necessarily expensive.

The object of my improved method is to enable rock tunnels to be constructed very rapidly and cheaply and in such a manner that the work of one crew can never interfere with that of another, thus enabling the drilling and blasting and the removal of the debris or muck to continue night and day without interruption.

It is a further object of my invention to so construct the tunnel as to utilize the force of gravity as far as possible in economizing the labor in all respects and the explosives employed and to afford ultimately a natural draft, whereby the tunnel is at all times rendered clear from smoke and gas, enabling the operations of drilling, blasting, and removing the muck to continue without cessation, so far as interference of the work of one crew with that of another is concerned.

It is also an object of my invention to provide an improved method for blasting out and constructing an under heading at the bottom of the tunnel, whereby the maximum efficiency of each shot is secured.

The invention consists in the matters hereinafter described, and more fully pointed out and defined in the appended claims.

In the drawings, Figure 1 is a longitudinal central section illustrating the construction of a tunnel by my improved method. Fig. 2 is a similar view of the opposite end of the tunnel. Fig. 3 is a transverse section of the tunnel under construction and illustrates a convenient arrangement of the drill-holes to secure maximum efficiency at each shot. Fig. 4 is an enlarged longitudinal section thereof, showing the forward inclination of the drill-holes in the roof. Fig. 5 is a front elevation or fragmentary section, showing in front elevation the arrangement of the drill-holes in blasting out the under heading. Fig. 6 is a section taken on line 6 6 of Fig. 5. Fig. 7 is a section taken on line 7 7 of Fig. 5.

As shown in said drawings, A indicates the rock to be excavated at the heading, and B the material to be cast down from the roof after the heading is completed. In the construction of the tunnel an under heading is first constructed with its bottom or floor slightly below the grade of the tunnel and usually for the entire length and width of the tunnel and for a height sufficient to enable the workmen to work to an advantage to complete the tunnel. Usually the height of the under heading is about nine feet, though this of course may vary.

In constructing the heading the rock is drilled to the desired depth, as follows: Usually three holes (dependent on the nature of the rock) and indicated by C C′ $C^2$ $C^3$ $C^4$ $C^5$ are drilled on each side of the center and, as shown, approximately one-half the distance between the center and the rib or side of the tunnel and one above the other. The holes C to $C^5$, inclusive, as shown in dotted lines, all converge inwardly and incline downwardly at their inner ends or, in other words, are wet holes, and the lowermost holes C $C^5$ at the inner ends somewhat below the grade of the tunnel. Between the drill-holes thus formed are drilled other holes approximately half the distance between the same and the rib or wall of the tunnel, and these also con-

verge inwardly, though at a much less angle than the holes before described, as shown in Fig. 6, and said holes (indicated by D to $D^5$, inclusive) are arranged staggering with the holes C to $C^5$, inclusive. Eight holes, four on each side, are next drilled along the ribs or sides of the tunnel, (indicated by E to $E^7$.) All of these holes, as shown, extend inwardly parallel with and approximately at the rib-line of the tunnel, and, as shown, the three lower holes on each side of the tunnel are wet holes or inclined downwardly, as shown in Fig. 7 and in dotted lines in Fig. 5, the lowermost dipping below the grade-line, while the upper holes—namely, $E^3$ $E^4$—are dry holes and incline upwardly at their inner ends approximately to or above the roof-line of the heading.

At the top of the heading and, as shown, arranged staggering with the holes at the ribs and those intermediate the rib and the center are four dry roof-holes F to $F^3$, which incline upwardly above the roof-line of the heading.

Of course the number of holes required in each set of holes may vary somewhat with the nature of the rock, as will also the blasting charge.

In blasting the shots are first fired simultaneously in the central holes C to $C^5$, inclusive, thus drawing forward and outwardly the wedge-shaped mass included between said holes, which of course is completely shattered by the discharge. The holes D to $D^5$, inclusive, are next shot, then the rib-holes E to $E^7$, inclusive, after which the roof is shot down. Inasmuch as the holes E and $E^7$, C and $C^5$ incline downwardly below the grade-line, the heading is always constructed with its bottom slightly below grade, and owing to the converging and downward arrangement of the central intermediate and rib holes the outward downward force of the powder acts to break the rock into small pieces.

After constructing the heading for the entire length of the tunnel or to an air-shaft and slightly below the grade the work of removing the material above the heading, which constitutes the major portion of the material to be handled, is commenced, preferably, at both ends of the tunnel, and for this purpose, referring to Figs. 1 to 4, inclusive, the drill-columns X are arranged on the floor of the heading to provide drill-holes which incline forwardly at the top or toward the completed portion of the tunnel at an angle usually about twenty-two and one-half degrees and which, as shown, are arranged relatively of each other, as indicated in Fig. 3—namely, a line of drill-holes G and G′ are provided on each side of the center and approximately at their lower end half the distance between the center of the ribs or walls and converge upwardly until the inner ends thereof are close together and slightly above the roof-line. These holes are placed longitudinally of the tunnel, a distance apart depending upon the nature of the material to be operated upon and the condition and nature of the rock. Between said central holes and the ribs are provided intermediate holes H H′, which also converge toward the center, but at a much less angle of inclination than the central holes G and G′ and also incline forwardly at their inner ends and extend slightly above the line of the top of the tunnel when completed. Along each rib of the tunnel are provided also forwardly-inclined drill-holes I I′ and extended usually about one foot above the roof of the tunnel when completed. All of said holes are arranged a distance apart longitudinally of the tunnel, dependent on the nature of the rock, usually about nine feet in lime-rock or sandstone.

In blasting the first two holes G G′ are first simultaneously shot, and owing to the inclination of said holes the large central mass is thrown down from the roof. The intermediate holes H and H′ are next shot, simultaneously breaking away the intermediate portions of the roof to the top of the tunnel, and this is followed by the shots in the holes I and I′, which break the material out above the roof-line, as shown in Fig. 3. The mass of material thus thrown down at one round of charges is very great, and the muck-heap thus formed extends nearly to the top of the tunnel, and being shattered by the explosion and the fall can be rapidly removed by a steam-shovel Y Y′, suitably constructed for the purpose.

The operation is as follows: This muck-heap, extending to near the roof, affords adequate protection for the shovel-operators and pit-men at all succeeding blasts and enables the shovel to be continuously operated at the muck-heap independent of either the drilling or the blasting within the tunnel, and the same is true at the opposite end of the tunnel, each muck-heap *y y′* affording a shield to the operators at the shovel during blasting. Furthermore, as the heading extends the entire length of the tunnel a natural draft of air is afforded therethrough independent of the forced draft ordinarily provided in such cases, and in consequence the smoke of the blast curls upwardly over the muck-heap at each end and escapes from the tunneling along the roof and does not reach the shovel-operators at all. Furthermore, as but a very small amount of the explosive is required, gravity doing much of the work ordinarily done by the blast, but little smoke or gas as compared with bench-tunneling is formed. Owing to the heading being opened at each end, the drillers at each end thereof work independently of the conditions at the other end of the tunnel, and the drilling continues independently and well ahead of the blasting. The crew at each end of the tunnel, although at all times able to communicate

freely through the heading, work independently of each other, and the individual crews at each end perform their work continuously without reference to the work of the other crew at the same end of the tunnel. Thus none of the time of the men is wasted, though heretofore at least half of the time of each crew was wasted while the other crews repaired the work, the muck-men waiting for the drillers and the drillers waiting for the muck-men, and all waiting for the blast. In consequence, by the described method the work is accomplished much more rapidly and cheaply than heretofore by the older methods and gravity is utilized to the fullest extent possible in economizing the explosive. Furthermore, there is much less danger to the operators than by other methods, as no crew can endanger another, though a given work be accomplished in less time and at a mere fraction of the expense heretofore deemed necessary for constructions of this nature.

While I have described my method with reference to certain arrangements of drill-holes, it is to be understood that the number and arrangement of these drill-holes may be varied to suit the conditions present—as, for instance, cracks or fractures in the rock may render some holes unnecessary, and of course at times several lines of holes may be shot simultaneously—as, for instance, the rib-holes and the roof-holes in forming the heading. It is, of course, to be understood that the conditions present must determine the number and within reasonble limits arrangement and position and the amount of the charges and the order in which the same should be discharged or shot; but I do not purpose limiting this application for patent otherwise than necessitated by the prior art, as obviously there are many details capable of variation without departing from the principles of my invention.

I claim as my invention—

1. The method of excavating rock tunnels comprising first constructing an under heading for the length of the tunnel and then throwing down the material from the roof of said tunnel, into said heading and operating simultaneously at either or both ends of the tunnel.

2. The method of excavating rock tunnels comprising first constructing an under heading having its bottom slightly below grade for the length of the tunnel and then throwing down the material from the roof of said tunnel into said heading and operating simultaneously at either or both ends of the tunnel.

3. The method of constructing rock tunnels embracing first, constructing a heading of the width and length of the proposed tunnel and of a height convenient for the operation of the workmen then casting down the material from the top of the tunnel to the roof-line and removing the same by means of steam-shovels.

4. The method of constructing rock tunnels embracing first constructing a heading of the width and length of the proposed tunnel and of a height convenient for the operation of the workmen and having its bottom slightly below grade, then casting down the material to the roof-line from the top of the tunnel and removing the same by means of steam-shovels.

5. The method of constructing rock tunnels, embracing first constructing a heading for the entire length and width of the tunnel and of a height convenient for the operation of workmen then operating from one or both ends of the tunnel and throwing down into the heading by successive shots the superposed material to the roof-line and forming a muck-pile and utilizing the muck-pile thus formed as a guard for the muck-men, thereby enabling them to work continuously and independent of the operation of drilling and blasting crews.

6. The method of constructing rock tunnels, embracing first the constructing of a heading of the desired width and the length of the tunnel and with its bottom slightly below grade-line, then drilling the superposed material approximately in one plane transversely with the drill-holes inclined forwardly at the top and the central drill-holes converging inwardly, then shooting the blast to throw the material forwardly and downwardly forming a muck-pile thus affording a shield for the muck-men and shovels during successive shots and whereby the drillers at all times are unimpeded by the accumulation of muck.

7. The method of constructing rock tunnels consisting in first blasting a heading open at both ends and having the bottom thereof sightly below grade and wherein successive shots are arranged to throw the material outwardly affording clean or true rib-walls and roof, next beginning at each end of said heading at the extremities of the tunnel and drilling the superposed rock to slightly above the roof-line, said holes inclining forwardly and the central holes converging at their inner ends and then blasting and removing the superposed rock.

8. The method of constructing rock tunnels comprising first constructing an under heading open at both ends, then throwing down the remainder to the roof-line thereby forming a muck-pile and utilizing the muck-pile as a shield to protect the mucking-crew and utilizing steam-shovels to remove the muck.

9. The method of constructing rock tunnels by first constructing a heading with its bottom below grade and for the length of the tunnel and drilling therefor several converging wet holes on each side of the center, the lower of which extend below grade, intermediate holes also converging inwardly, rib-holes in line and parallel with the ribs and

dry roof-holes and shooting the same, the central holes first then the intermediate next the rib, then the roof-holes and later after completing the heading for the entire length blasting down to the tunnel-roof line in successive charges each charge including all material from the heading to the tunnel-roof.

10. The method of constructing rock tunnels comprising first constructing an under heading the length and width of the tunnel, then drilling the roof from the heading to slightly above the tunnel-roof line to afford central converging holes, intermediate holes of less convergence extending above the roof and non-converging rib-holes, all of said holes inclining forwardly at their tops and a distance from the front of the mass dependent on the nature of the rock, shooting said holes in the order before named, and removing the muck by means of steam-shovels.

11. The method of constructing tunnels comprising constructing an under heading on a level with the bottom of the tunnel, drilling a plurality of forwardly and inwardly inclined holes in the superposed material and shooting the charge in said holes thereby throwing the material down to form a muck-pile between the drillers and the mouth of the tunnel.

12. The method of constructing tunnels comprising forming an under head for the drillers then throwing down the superposed material and forming a muck-pile between the drillers and the muck-men.

13. The method of constructing tunnels comprising forming an under heading drilling the superposed rock from the mouth of the tunnel inwardly then blasting to throw down the superposed material between the drillers and the mouth of the tunnel and forwardly of the muck-men.

14. The method of tunneling comprising forming an under heading for the drillers, and blasting down the superposed rock to form a muck-pile between the drillers and the muck-men.

15. The method of tunneling through rock comprising first forming an under heading inwardly to air and approximately the width of the tunnel and to bottom grade then utilizing gravity by drilling the superposed material to cast the same down and forwardly in blasting, thereby economizing in labor and explosives.

In testimony whereof I have hereunto subscribed my name in the presence of two subscribing witnesses.

PATRICK FORD.

Witnesses:
C. W. HILLS,
WM. C. SMITH.