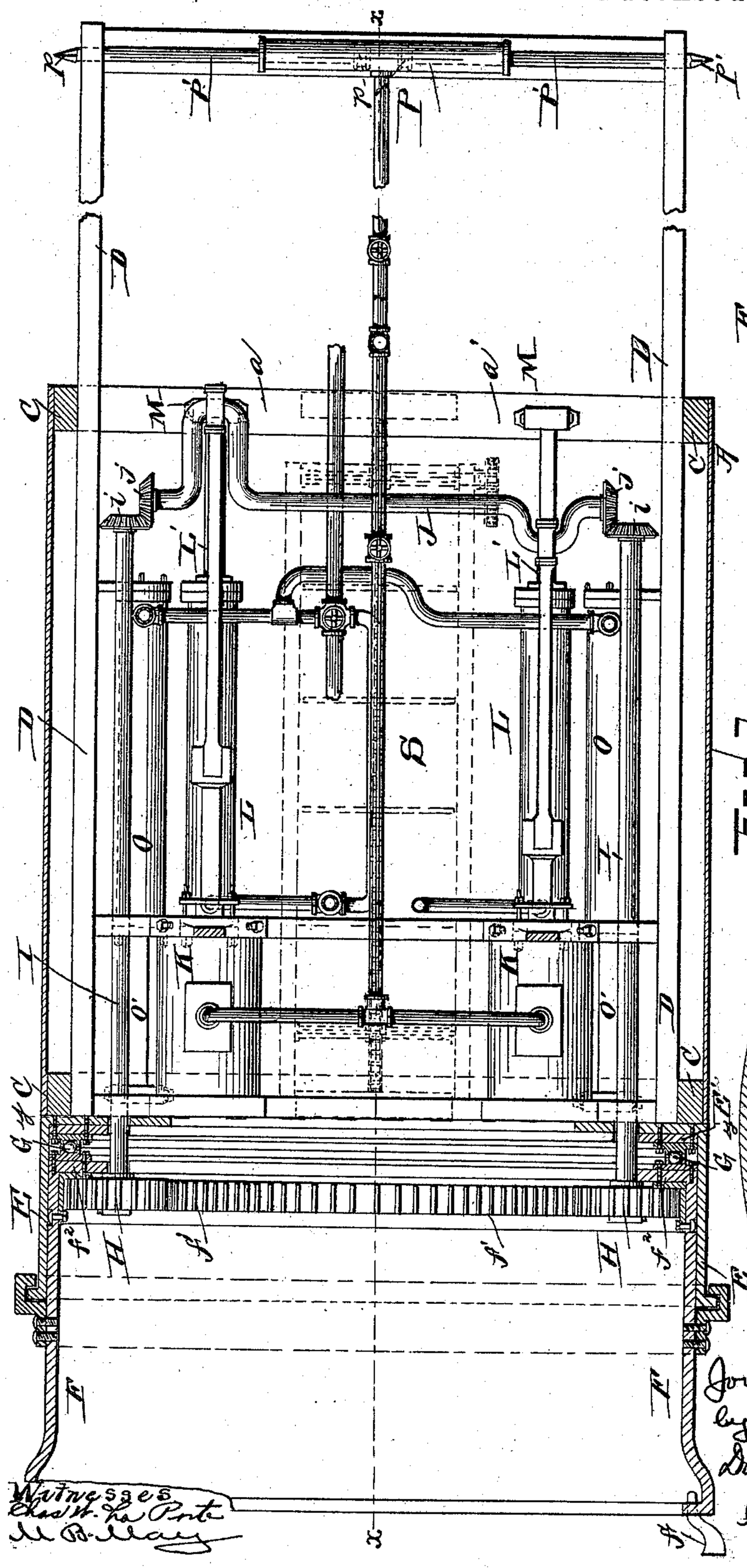
(No Model.) 3 Sheets—Sheet 1.

J. L. MITCHELL.

TUNNELING MACHINE.

No. 537,899. Patented Apr. 23, 1895.



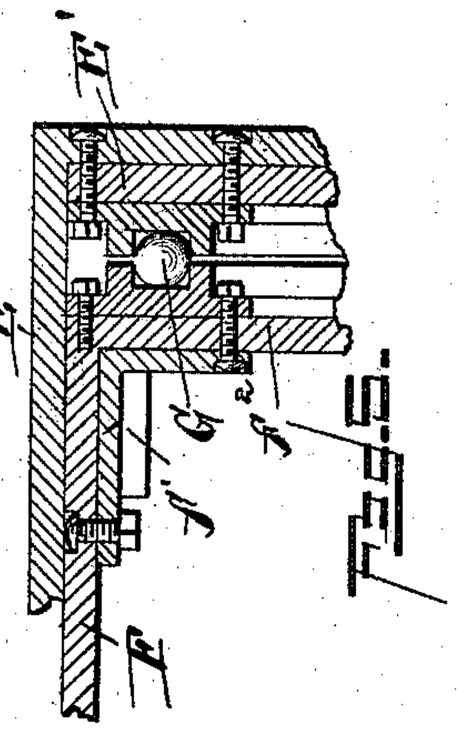


FIG. 5.

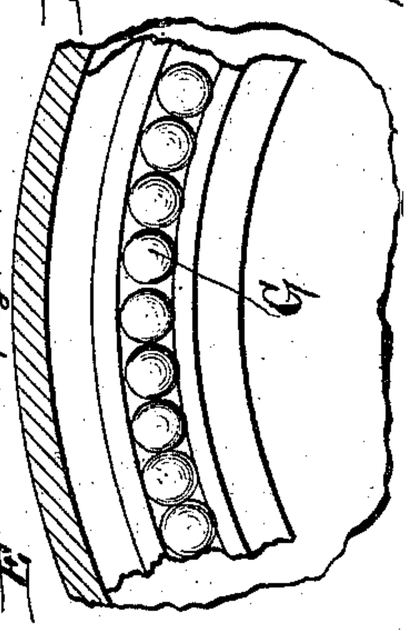


FIG. 6.

FIG. 7.

Witnesses
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(No Model.) 3 Sheets—Sheet 2.

J. L. MITCHELL.

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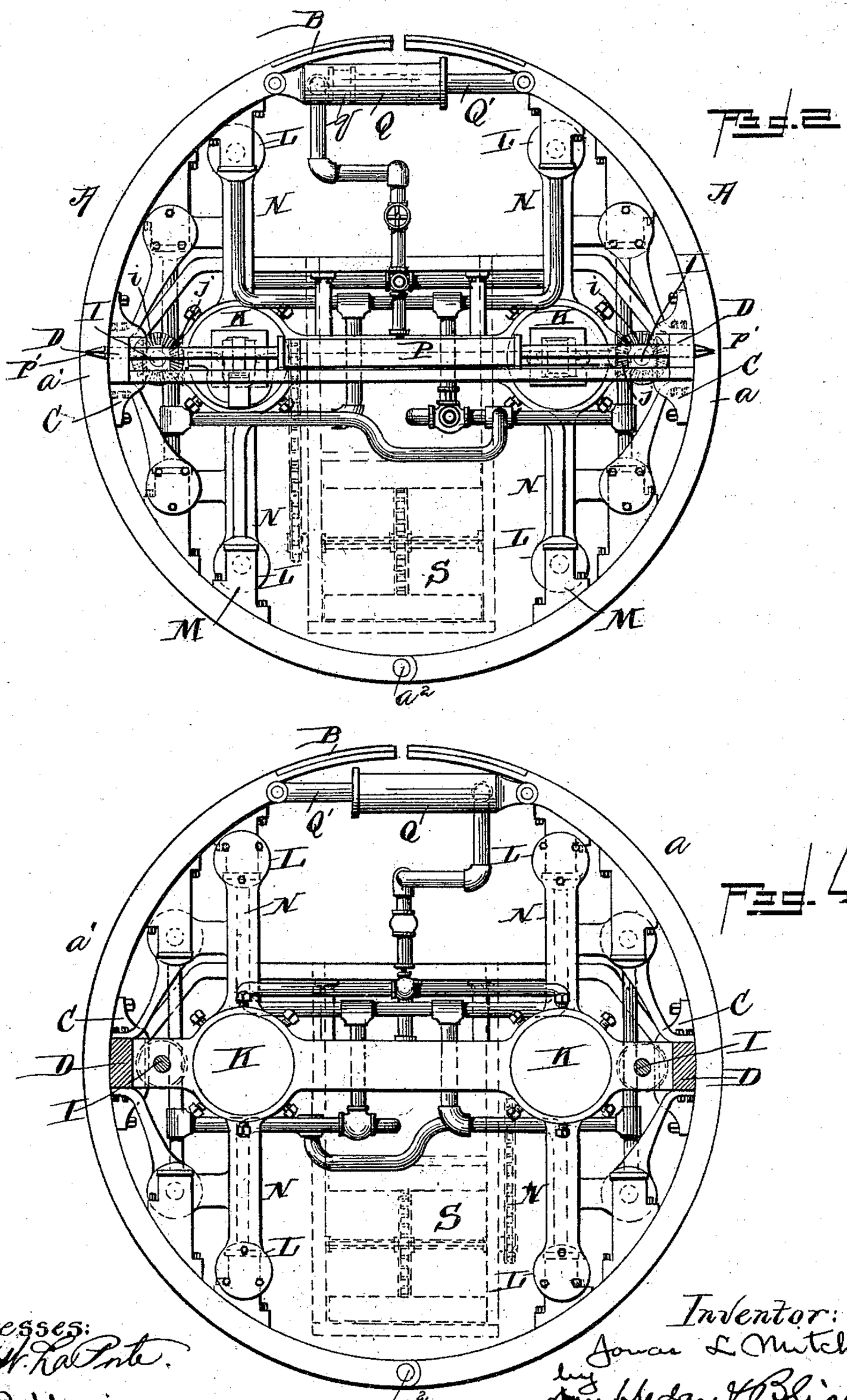

Fig. 2

Fig. 4

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(No Model.)

3 Sheets—Sheet 3.

J. L. MITCHELL.

TUNNELING MACHINE.

No. 537,899. Patented Apr. 23, 1895.

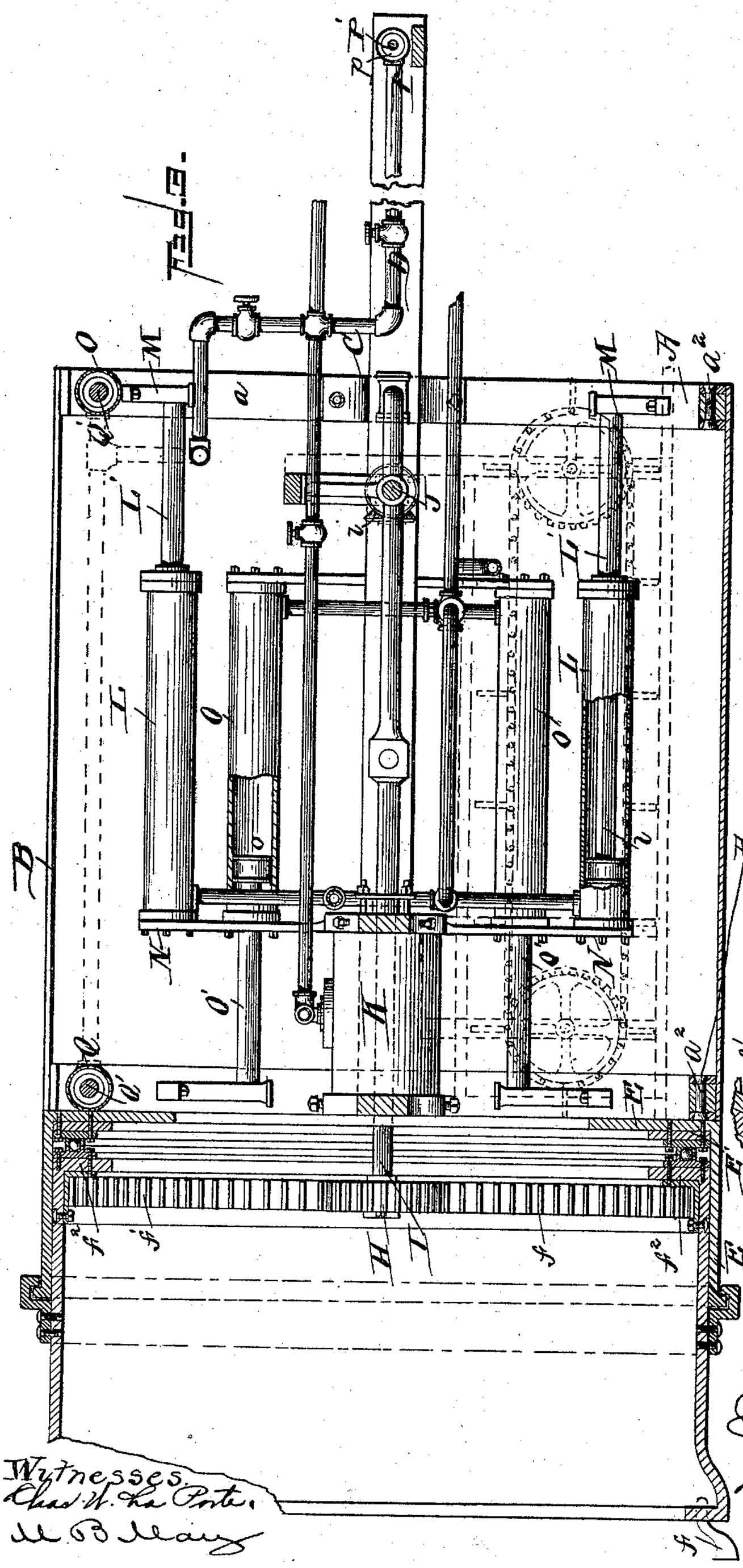

Fig. 1.

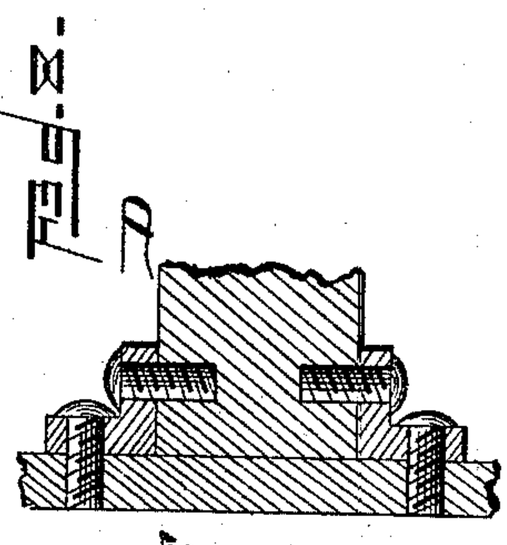

Fig. 2.

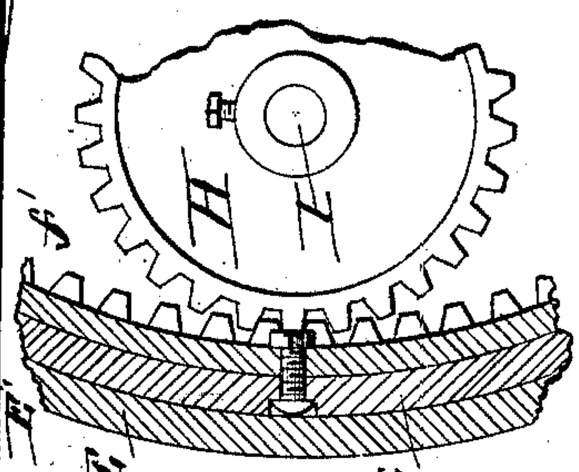

Fig. 3.

Fig. 4.

Witnesses.
Chas. H. La Porte.
H. B. Mays

Inventor.
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UNITED STATES PATENT OFFICE.

JONAS L. MITCHELL, OF CHICAGO, ILLINOIS.

TUNNELING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 537,899, dated April 23, 1895.

Application filed April 3, 1893. Serial No. 468,909. (No model.)

To all whom it may concern:

Be it known that I, JONAS L. MITCHELL, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Tunneling-Machines, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to improvements in tunneling machines, that is to say, machines intended to cut an aperture in coal or rock of such nature that the entire machine can be propelled through it.

Figure 1 is a longitudinal, horizontal section of a machine embodying my improvements. Fig. 2 is a rear view. Fig. 3 is a vertical transverse section on the line *x*—*x*, Fig. 1. Fig. 4 is a vertical transverse section on the line *y*—*y* of Fig. 1. Fig. 5 shows an enlarged section of the tubular support, and the adjacent parts. Fig. 6 shows in detail the anti-friction bearing for the cutter head. Fig. 7 shows in section a portion of the tubular cutter head with the internal gearing. Fig. 8 shows in detail the manner of securing the tubular support to the carriage bars.

The frame work of the machine comprises two parts, one being the main frame or bed, and the other being the cutter support or frame. In respect to either of these parts there can be numerous modifications without departing from the essential features of the invention.

As shown in the drawings, the bed-frame contains parts A A each of which is preferably formed of two curved metallic bars *a a'* hinged together at a^2, and at their upper ends adapted to approach and recede from each other somewhat for a purpose to be described. These ring-like frame-supports are preferably arranged one at the forward end and the other at the rear end of the bed, and they are connected together by means of any suitable longitudinal girts or bars, and have sheets B of sheet metal secured thereto for the purpose pose of inclosing the operative parts and of obtaining an extended frictional surface of contact with the wall of the tunnel. The upper part and the lower part of each ring section may be connected by vertical bars or uprights for supporting portions of the operative parts of the machine, as will be described.

At C C there are guides carried by the bed frame which are for the purpose of guiding the cutter carrier or supporting it in its movements relatively to the bed.

The cutter frame or support comprises longitudinally arranged bars or carriers D which are fitted in the above described guides at C. At their forward ends these carrier bars carry a short tube E of large diameter, and to which they may be secured by means of plates at E'. This plate may be made integral with the tube E or may be rigidly secured thereto. At the rear ends and at intermediate points the sliding carriers may be connected by any suitable girts.

The cutter-head proper consists of a tube F which at its rear end fits in the tube E, but projects forward considerably beyond it. At the front edge it is formed or provided with sockets for receiving the cutters *f*, and at the rear end it is formed with gear teeth *f'*, and with a bearing flange f^2. The cutters *f* can be adjusted so that one shall attack the material along one circle of rotation, and another on another circle, and they are so disposed that they will form an aperture of a diameter greater than that of the machine.

The cutter head F can be rotated within the stationary tube E, and the back pressure from the cutters is received upon a series of anti-friction balls or rollers at G placed between the bearing flange f^2 and the flange or plate E'. As the tube E is supported upon the carriers D, and the tube F is in turn supported in the tube E, it will be seen that the latter will be advanced with the carriers D as they are forced forward.

Power for rotating the revolving cutter-head or tube F is imparted to its gear *f'* by pinions H. The latter are secured to longitudinally arranged shafts I which are mounted in bearings carried by the cutter-supporting frame. At the rear ends these shafts have beveled wheels *i* which mesh with beveled pinions *j* on the crank shaft J, which shaft is also mounted in suitable bearings secured to the cutter carriage. The shaft is rotated by engines whose cylinders are shown at K, and which are adapted to be actuated by steam, compressed air, water or other driving agent. The engines are arranged horizontally and are so placed as to leave as large an opening as possible on the central longitudinal lines of the machine and extending through it.

It will be seen that when the engines are

in operation the rotation of the cutter head F will be caused through the crank shaft J, beveled wheels *i* and *j*, shafts I, pinions H and gearing *f'*.

At the same time the cutters are rotating, they can be simultaneously advanced relatively to the bed by means of the parts at L, L'. L is a cylinder, and L' is a piston rod, with its piston *l* at one end in the said cylinder. At the other end, the piston rod L' bears against the upright or bar M secured to the bed. Preferably there are two feeding cylinders L on each side of the machine, and there are pipe or hose connections of such sort that water, compressed air or other suitable agent can be delivered to the interior of the cylinders behind the pistons *l*. When the feeding agent is so delivered, the cutter carriage or frame and the cutters will be advanced relatively to the bed, as the cylinders L will be forced forward away from the bars M, said cylinders at their front ends being connected to uprights or other suitable bars N secured to the cutter carriage.

For the purpose of drawing the cutter head and the cutters back upon the bed, I use one or more cylinders O and piston rods O' with pistons at *o* in the cylinders, there being preferably two such cylinders and pistons on each side of the machine. The piston O' is secured to bars carried by the bed, and the cylinder O is at the rear end secured to bars attached to the carriage. When the cutter has advanced to the end of its movement, the pistons *o* are in the rear ends of cylinders O, and if water, air, steam or equivalent be let into said rear ends behind the pistons, the cylinders will be forced backward, bringing with them the cutter-frame and cutters. This last described mechanism can also be used for drawing the parts I have referred to as the bed-frame, forward relatively to the cutter.

By placing the hydraulic cylinders and pistons as shown in the drawings, near the sheating, or the tunnel walls, and above and below the central longitudinal planes of the machine I attain many advantages, among the chief being that the power is thus uniformly distributed to a series of points in line with the points at which the cutters attack the coal.

With most of the earlier machines for driving tunnels with which I am acquainted, it has been customary to use a central shaft which not only forms part of the mechanism for rotating the cutters, and serves as a carriage for supporting them, but also is threaded and utilized to feed positively the cutters forward, there being a stationary nut engaging therewith for this purpose; but I have found a positive feed is disadvantageous and sometimes useless in many cases, where the material varies in density, and that in order to obtain the best results, a yielding feed must be employed, and that the power, as said, must be distributed to points where there is the greatest resistance—namely, in line with the points of engagement of the cutters with the material to be cut. In order to support the cutters in their proper relations to the bed, I employ as aforesaid, a carriage which slides on said bed, and is supplemental to and entirely independent of the feeding mechanism, so as far as concerns the feeding mechanism acting as a support and which is preferably utilized to support the engines and the shafting and gearing for rotating the cutters.

I am aware that it is not new to utilize hydraulic feeding devices, and do not wish to be understood as claiming such broadly as of my invention; but as heretofore used, the cylinders and pistons were either arranged centrally longitudinally of the machine, or were all below the central longitudinal plane of the machine, and not placed above and below it, so as to properly distribute the power, as is done in my machine; and in some of such machines the feed mechanism acted as a support for the carriage, whereas as above said my carriage is supported independent of the feed mechanism.

At the rear end of the cutter frame, hydraulic jacks are placed, as shown at P and P', the former being a cylinder and the latter piston rods with pistons *p* adapted to force points or arms *p'* outward with such power as to cause them to engage firmly with or enter the wall of the tunnel. The two pistons *p* can be in a single cylinder, and by applying the water, steam or other agent between them they can be forced out simultaneously.

One or both of the ring-like supports of the bed are provided with a cylinder Q, piston rod Q' and piston q. The cylinder Q is pivoted to the section *a'*, and the piston rod Q' is pivoted to the section *a*, so as to provide sufficient flexibility of attachment. Through suitable connections, water or the like can be admitted to the cylinder Q, and by its pressure upon the piston *q* a powerful expansive action will be exerted upon the two hinged sections *a a'* under which they will engage with the tunnel walls with great firmness.

The central part of the machine is so open longitudinally and free from obstructions, particularly in the lower part, that the operatives can have free access to the material inclosed within the circle of cut; and within this space I frequently mount a conveyer, as shown at S, which may be of any suitable sort. By it the cut material can be carried backward beyond the rear of the machine and either dropped upon the bottom of the tunnel or loaded into a vehicle intended to remove it.

The manner of operation of the machine above described will be readily understood.

Supposing that the parts of the machine are in the relative positions shown in Fig. 1, and that the cutters are ready to enter the coal or rock, water or the other selected agent is admitted to the cylinders Q for the purpose of binding the bed-frame firmly to the tunnel wall in the way above described. The steam,

compressed air or other driving material is admitted to the engines at K K, whereupon the rotating of the cutters will be effected, as has been set forth; and at the same time the water or the like is admitted to the cylinders L L, and as a result the cutters and their supporting and actuating devices will be advanced. As soon as the cutters have formed their annular slot to the desired depth (which will be governed by the distance from the cutter points to the gearing f',) the engines and the movements of the cutters are stopped. The water is cut off from the cylinders L and admitted to the cylinders O, as a result of which the cutter frame and the cutters will be drawn back again to the relative positions shown in Fig. 1. Thereupon, the core surrounded by the newly formed kerf is loosened, and after being loosened is passed backward through the central part of the machine by means of the conveyer or otherwise. Then the water is again admitted to the cylinders L L which again advance the cutters. Thereupon the pressure is admitted to the cylinder P which forces out the jack points or arms p' into powerful engagement with the coal, and the cutter frame or support is firmly bound to the tunnel wall. Then the pressure is cut off from the cylinders Q, so as to release the rings A and the main frame from engagement with the tunnel wall, and it is admitted again to the cylinders O, the result of which is to force the rings A A with their sheet iron jacket B B forward relatively to the cutter frame until the parts are again in the position shown in Fig. 1. Then the pressure is again admitted to the cylinders Q and released from the cylinder P; after which the machine is ready for a second operation.

I am aware that a machine for boring tunnels in soft chalky material has been made or proposed, it having two casing shells or sheathings, one to serve as a carriage, and the other as an abutment, the carriage shell as well as the bed shell being divided along the top.

The present machine is in many respects radically different from the one to which I have just referred. I have indeed, two tubular shells or casing sheaths, one connected with the carriage, and the other being part of the bed; but my carriage shell or casing has a continuous unbroken extension wall, not being split or divided as in the earlier construction. Again, for the bed I have a strong frame consisting of hinged curved bars connected to the shield or casing, by means of which I am not only able to support and move said casing, but am also able to give a firm support to the carriage which projects back through the bed part, and is provided with fastening devices in the rear thereof. The length of the machine as a whole can be thus reduced to one half of that of the earlier one.

It is obvious that as the curved bars are forced outward against the tunnel walls, they take the pressure which without them must be taken by the sheet metal tubular shell, causing the latter to bend and collapse when working in heavy material.

In my construction, the carriage shell supports the tubular cutter head, and is rigidly secured to the front end of the carriage, which consists of a rectangular frame having side bars, the latter sliding in the guides in the said curved bars. Both the carriage shell, and the bed shell are of a diameter much less than that of the circle of rotation of the cutters. With such an arrangement, there is no frictional engagement of the carriage with the tunnel walls to be overcome in feeding the cutters to their work, such as is experienced in the earlier machine. Then too, in order to have the power uniformly distributed on the proper lines when feeding the carriage and bed frame alternately, and in order to get as much central space as possible in the machine, as well as to obtain the requisite amount of piston area in the cylinders, I use two sets of hydraulic cylinders and pistons. In the said earlier machine, four pistons and cylinders and pistons were uniformly disposed on the shell, each being used for the forward and the rear portions of the tubular shell alternately; but I have found that piston rods of relatively large diameter must be employed to prevent their bending, and that when the cylinder is of a size to get sufficient pressure on the free side of the piston, that there is not enough piston area on the opposite side of the piston to provide sufficient power for drawing the bed up for a new cut. Therefore, either a cylinder of great diameter must be employed, or, as I have found it more practicable, a separate set of cylinders.

It will be seen that the cylinders in my machine are very long and of comparatively small diameter, the piston rods being relatively large in cross section to be sufficiently strong, and also that the feeding cylinders for driving the cutters forward are placed as near as possible in the line of the cut, and that the bed advancing cylinders are placed relatively near the carriage side bars in order to get a direct pull along the lines of the guides.

I am also aware that tunneling machines have been proposed with centrally supported cutter heads, but I do not claim these, they being materially different from the centrally open tubular cutter head which I employ, and which is supported in the closed unbroken concentric carriage shell, whereby the cuttings may be withdrawn through the said cutter head.

What I claim is—

1. In a tunneling machine, the combination of the tunnel forming cutter consisting of a tubular cutter head, a main frame having guides therein, and of a diameter adequate to enter the tunnel formed by the cutter, a carriage sliding in said guides and lying in the transverse plains of the bed, the tubular non-rotary support around the cutter head and

connected to the carriage in lines near the walls of the tunnel, a rack arranged on the inside of said cutter head, and a wheel H mounted on the carriage and engaging said rack in said cutter head for rotating said head, substantially as set forth.

2. In a tunneling machine, the combination with the bed adapted to be fastened to the tunnel wall, of the cutters, the cutter carriage projecting beyond the rear of the bed, and the cylinder and two oppositely acting wall engaging pistons mounted on said carriage in rear of said bed, substantially as set forth.

3. In a tunneling machine, the combination with the bed, and the hydraulic piston and cylinder for fastening said bed to the tunnel walls, of the cutters in front of said bed, the sliding carriage for supporting and advancing said cutters and extending from the cutters to points in the rear of the bed, and the hydraulic piston and cylinder having two well engaged spurs, both movable relatively to the carriage mounted on said carriage in rear of said bed, whereby said bed, and said carriage may be alternately fastened to the tunnel walls, substantially as and for the purposes set forth.

4. In a tunneling machine, the combination of the bed having guide supports situated in the central longitudinal diameter of the tunnel, one on each side of the axis, the carriage projecting through the bed and traveling in the said guide supports, the tunnel cutting apparatus mounted upon the said carriage, means for rotating the cutters, means for moving the carriage, the external shell surrounding the bed, and means for forcing said shell against the tunnel walls, substantially as set forth.

5. In a tunneling machine, the combination with the tunnel forming cutter, and the rectangular carriage frame supporting and advancing said cutters to their work, having longitudinal side bars and cross-bars, of the relatively stationary bed frame consisting of two or more pairs of hinged curved bars, means for forcing them apart at their ends into engagement with the tunnel walls, and means for connecting said pairs of bars together, said curved bars having guides for said longitudinal carriage bars, substantially as and for the purposes set forth.

6. In a tunneling machine, the combination of the cutter carriage, the bed which supports said carriage vertically and is formed in two horizontally separable parts whereby it can be spread for fastening against the tunnel walls, a cutting apparatus secured to the carriage, a non-rotary shell or casing secured rigidly to the carriage which advances away from the bed, and having a continuous or unbroken external wall, a rotary hollow cylindrical cutter head supported in the said non-rotary casing, and means for fastening the carriage to the tunnel walls at points in rear of the bed, substantially as set forth.

7. In a tunneling machine, the combination of the bed having an external cylindrical sheathing, interior bars hinged together, and supporting the said sheathing at points in a curved line approximating a circle, means for forcing said hinged bars apart, the carriage supported on the said hinged bars of the bed, and the rotary cutting apparatus at the front of said bed, substantially as set forth.

8. In a tunneling machine, the combination of the cylindrical bed having vertically arranged frame bars and an exterior cylindrical casing shell secured thereto, means for fastening said bed to the tunnel walls, the cutting apparatus at the front, the carriage for said cutting apparatus extending back through the cylindrical bed and consisting of side bars and end bars, a wheel H for rotating the cutters, the two engine cylinders mounted similarly relatively to the axis of the bed, and the shafting connecting the cylinders with the said wheel H, said cylinders and said shafting being mounted on said carriage, substantially as set forth.

9. In a tunneling machine, the combination of the bed having the curved frame bars, means for fastening them to the tunnel walls, guides on said curved bars, a carriage having side bars sliding in said guides, the tubular cutter head mounted on the carriage, and means for advancing the carriage relatively to the said bed frame, substantially as set forth.

10. In a tunneling machine, the combination of the abutment bed, the carriage having guides sliding in supports on said bed, the tubular tunnel forming cutter having an annular groove at its inner end, the tubular support for said cutter mounted on said carriage and having an inwardly turned flange, said flange having an annular groove, and anti-friction balls working in said grooves, substantially as and for the purposes set forth.

11. In a tunneling machine, the combination with the stationary bed having guide supports, the tunnel forming cutters, and means for rotating said cutters, of the carriage having side guides sliding in the aforesaid guide supports on the bed, and one or more pistons and cylinders, supplemental to said carriage and said guides, for feeding the carriage and cutters forward, said pistons and cylinder being located at points adjacent the tunnel walls, above and below the central horizontal plane and on either side of the central vertical longitudinal plane of the machine, whereby there is provided a central open space, substantially as set forth.

In testimony whereof I affix my signature in presence of two witnesses.

JONAS L. MITCHELL.

Witnesses:
CLARENCE E. SMITH,
B. F. KENT.