G. A. FOWLER.

TUNNELING MACHINE.

APPLICATION FILED MAY 22, 1909.

996,842.

Patented July 4, 1911.

6 SHEETS—SHEET 1.

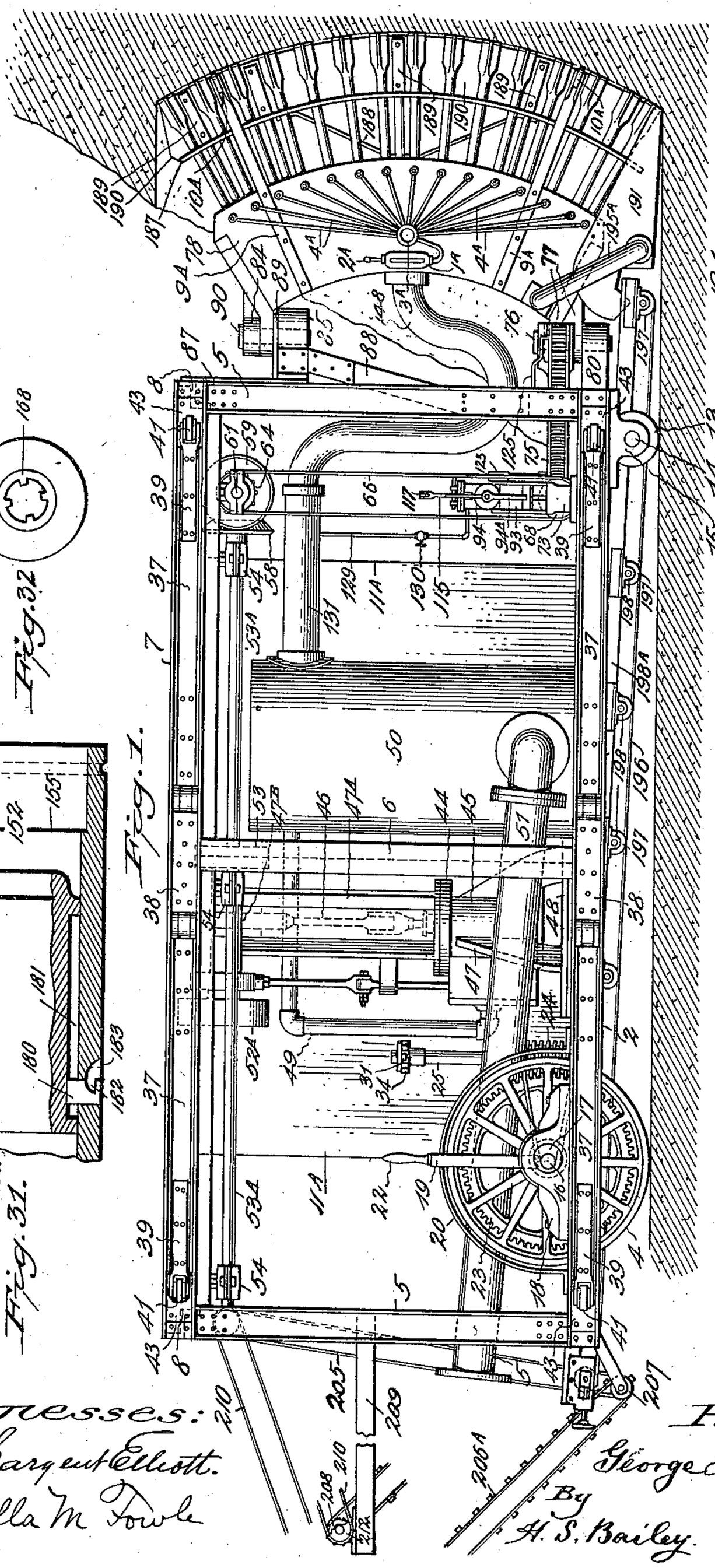

Fig. 1.

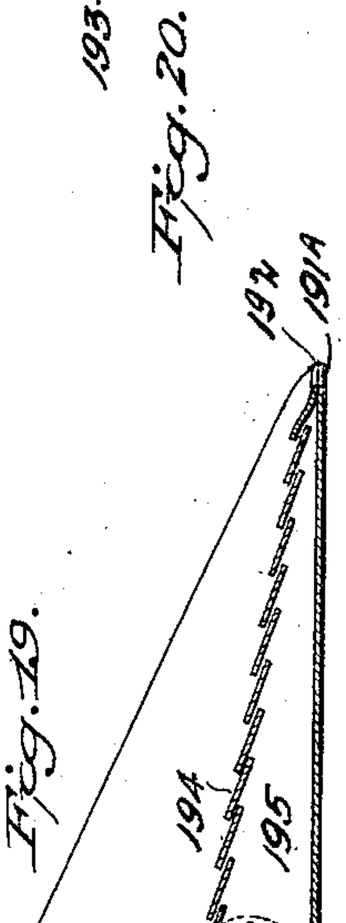

Fig. 20.

Fig. 32.

Fig. 31.

Fig. 19.

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6 SHEETS—SHEET 2.

Fig. 4

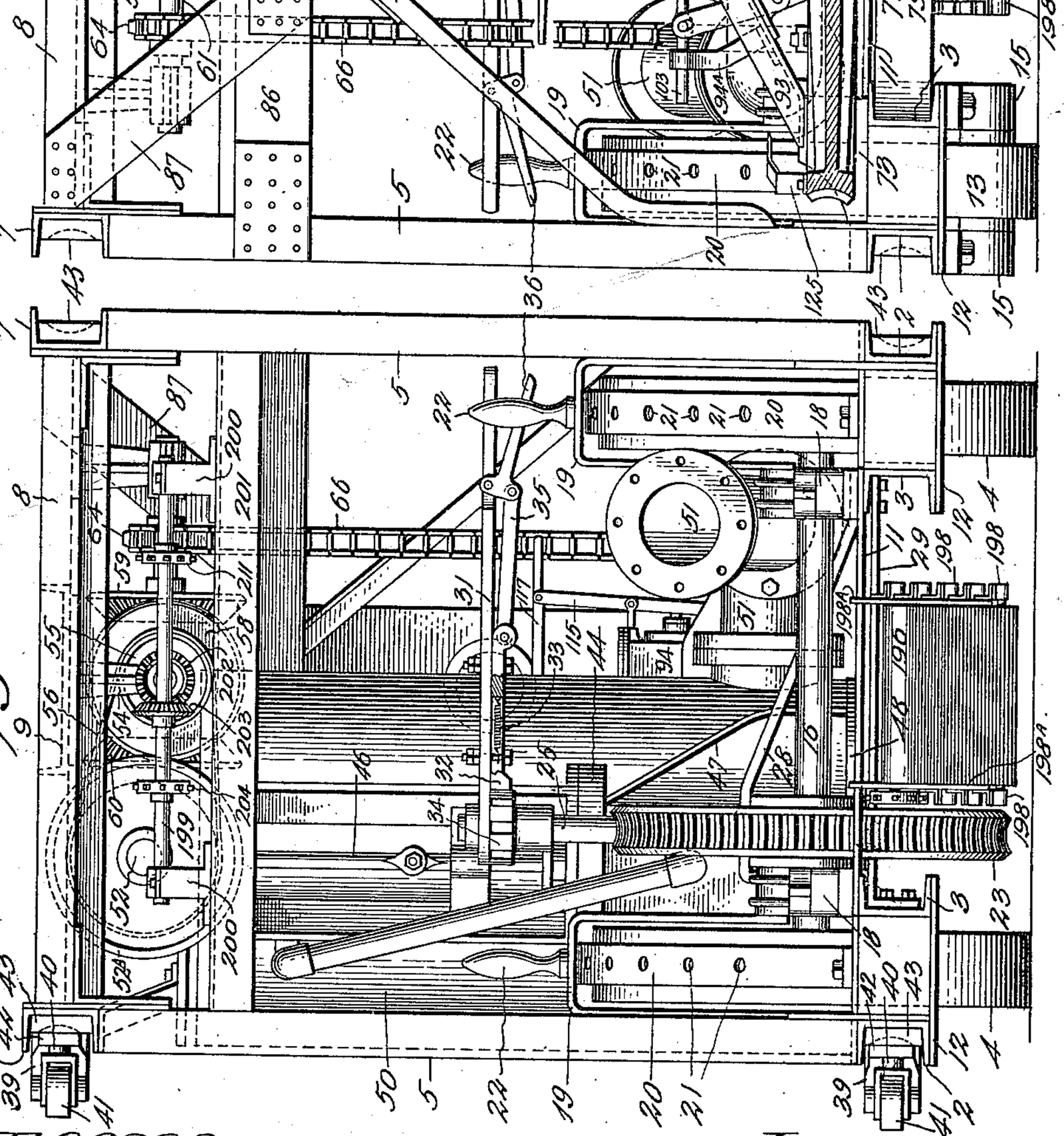

Fig. 3.

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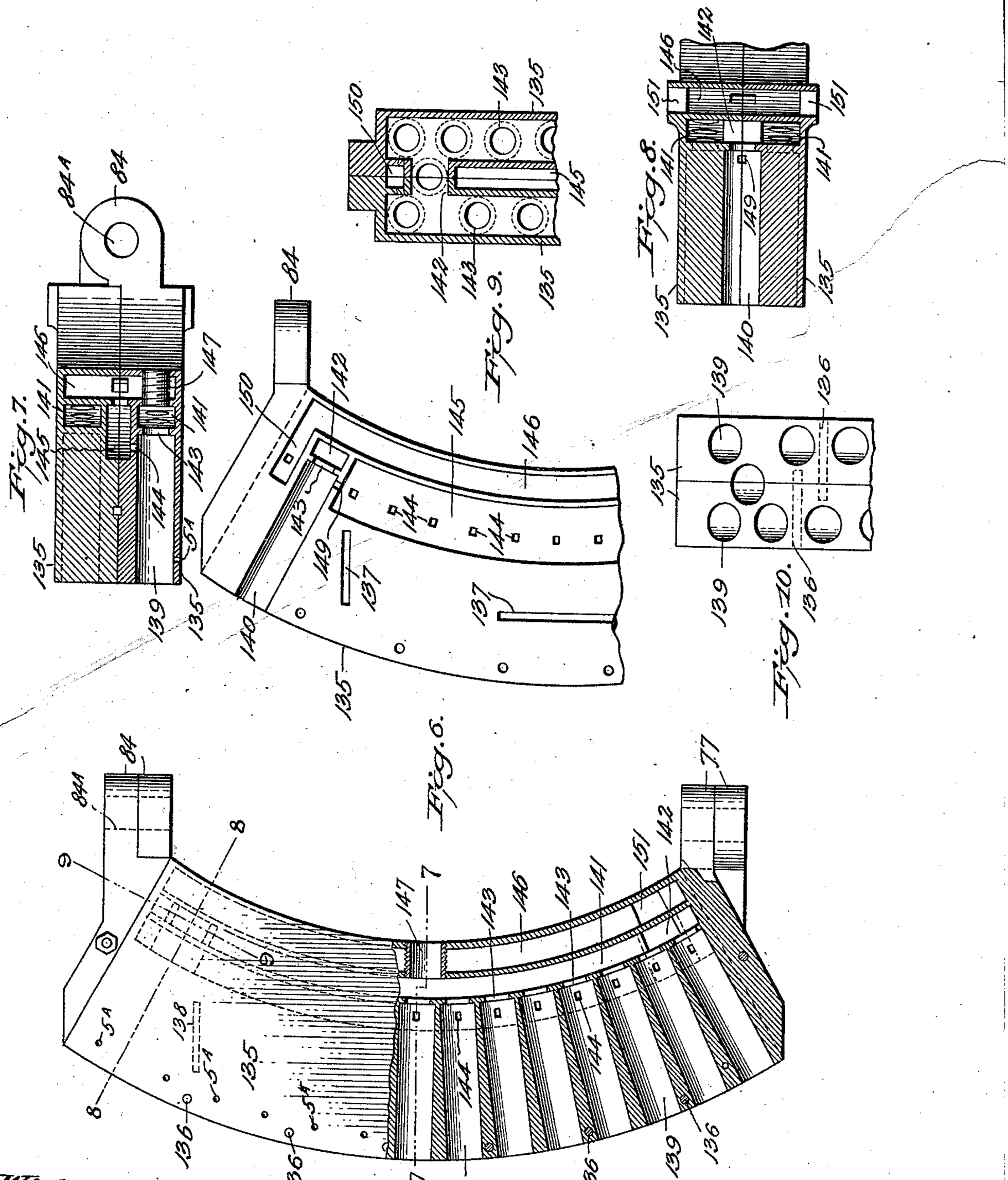

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6 SHEETS—SHEET 4.

Fig. 11.

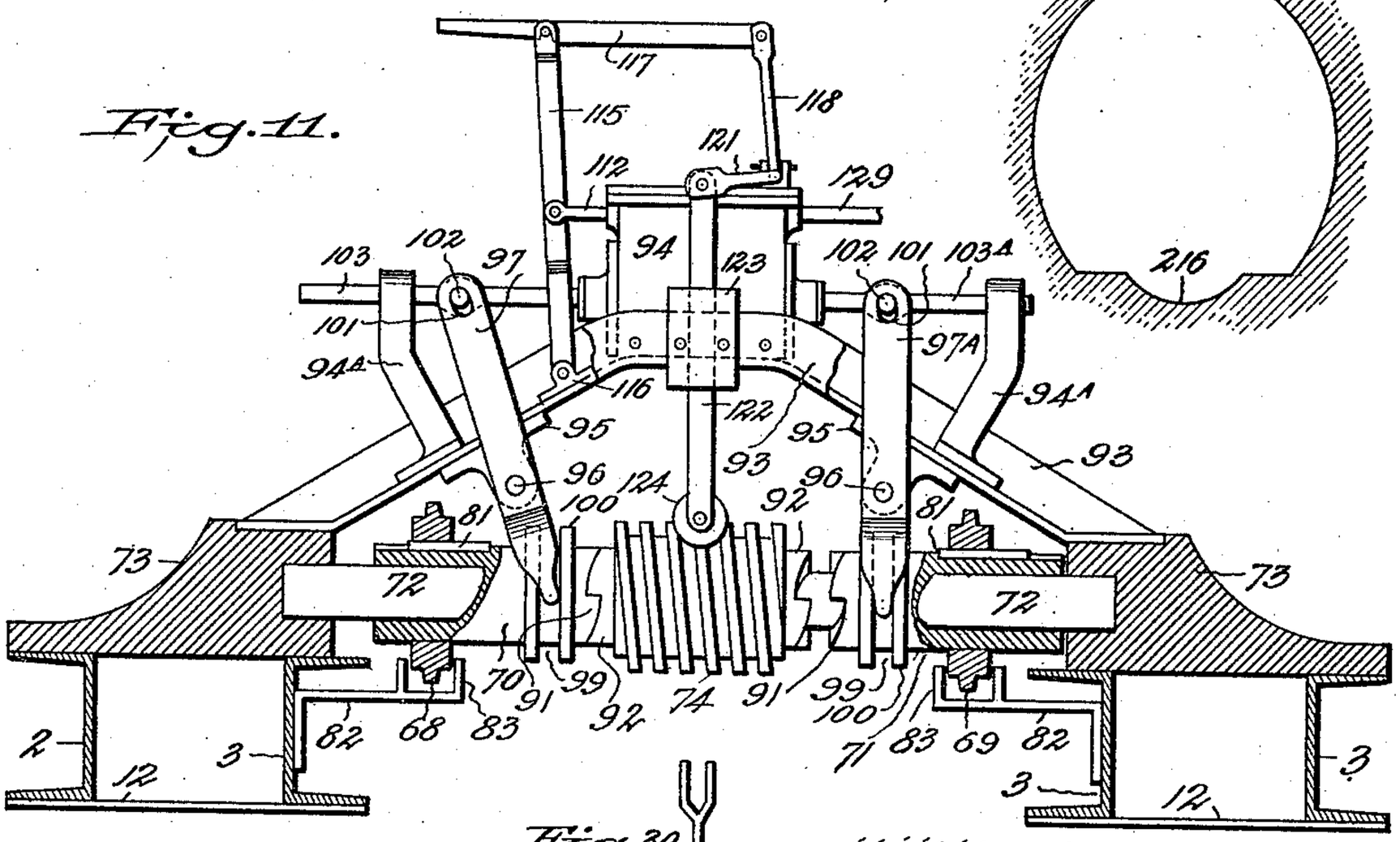


Fig. 29.

Fig. 30.

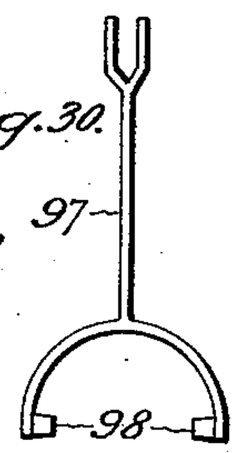


Fig. 12.

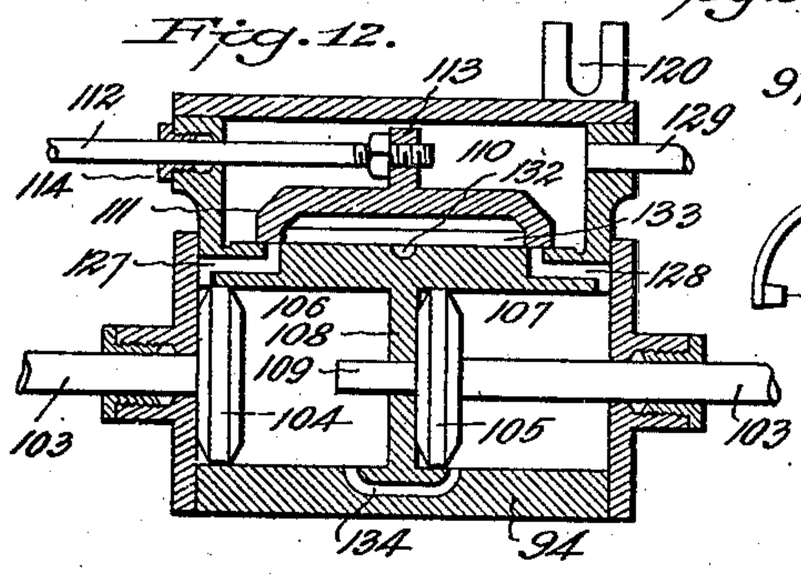


Fig. 13.

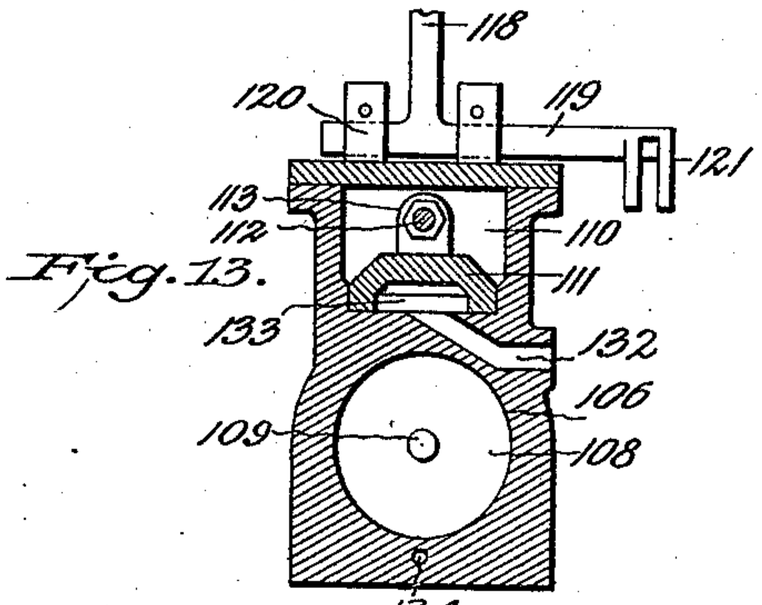
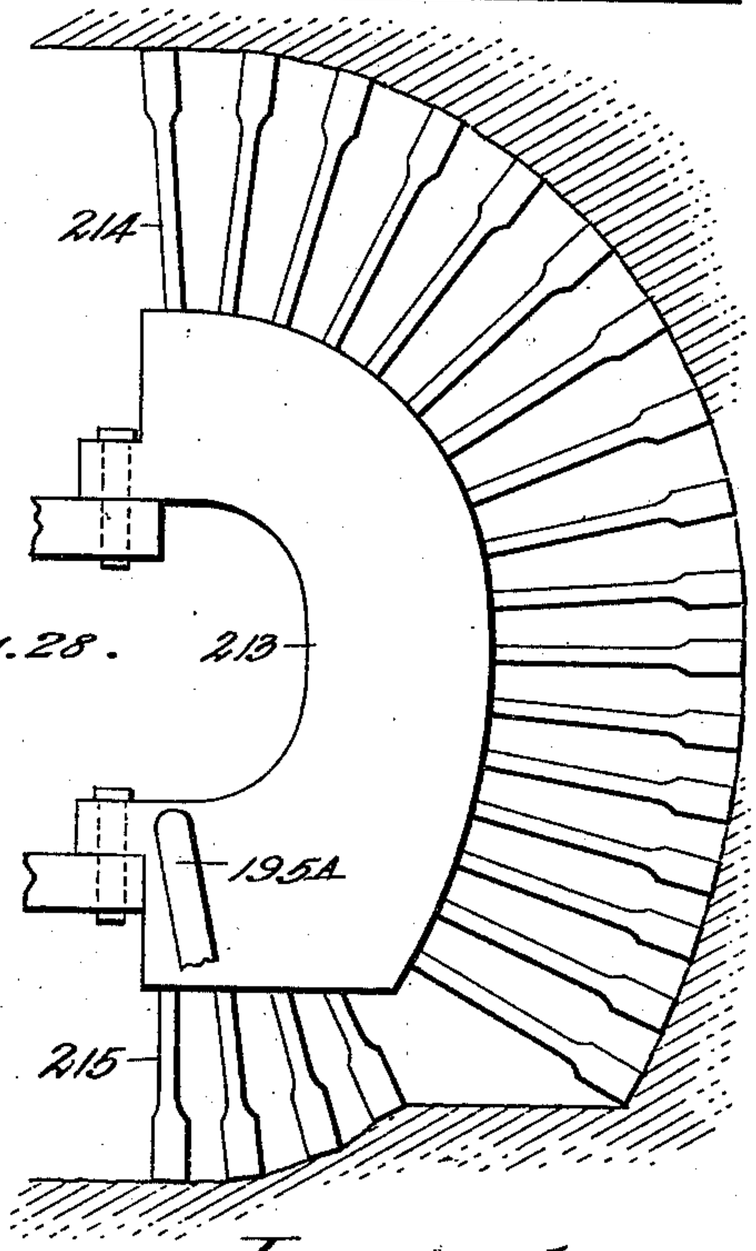


Fig. 28.



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6 SHEETS—SHEET 6.

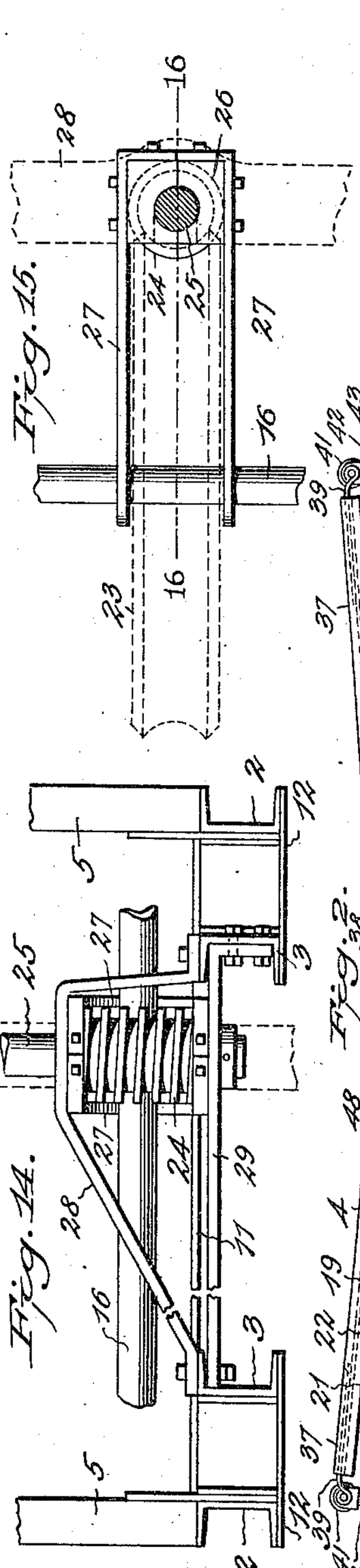

Fig. 15.

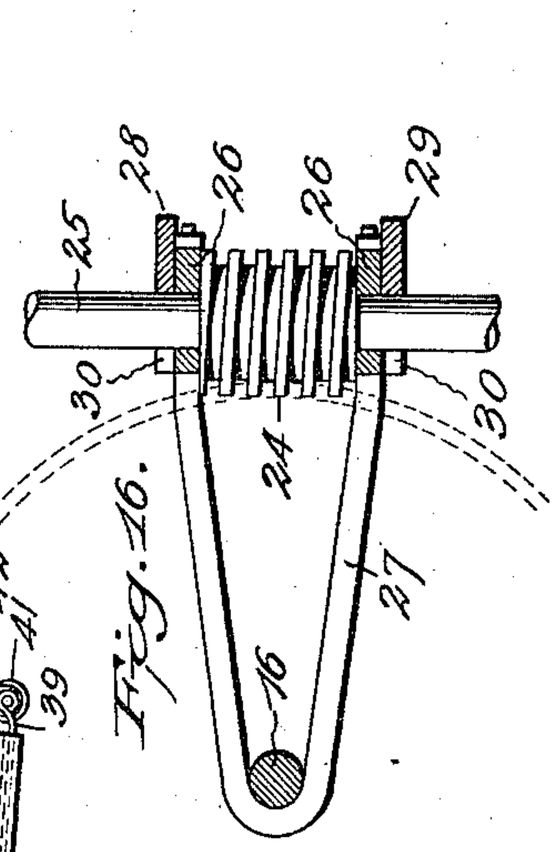

Fig. 16.

Fig. 14.

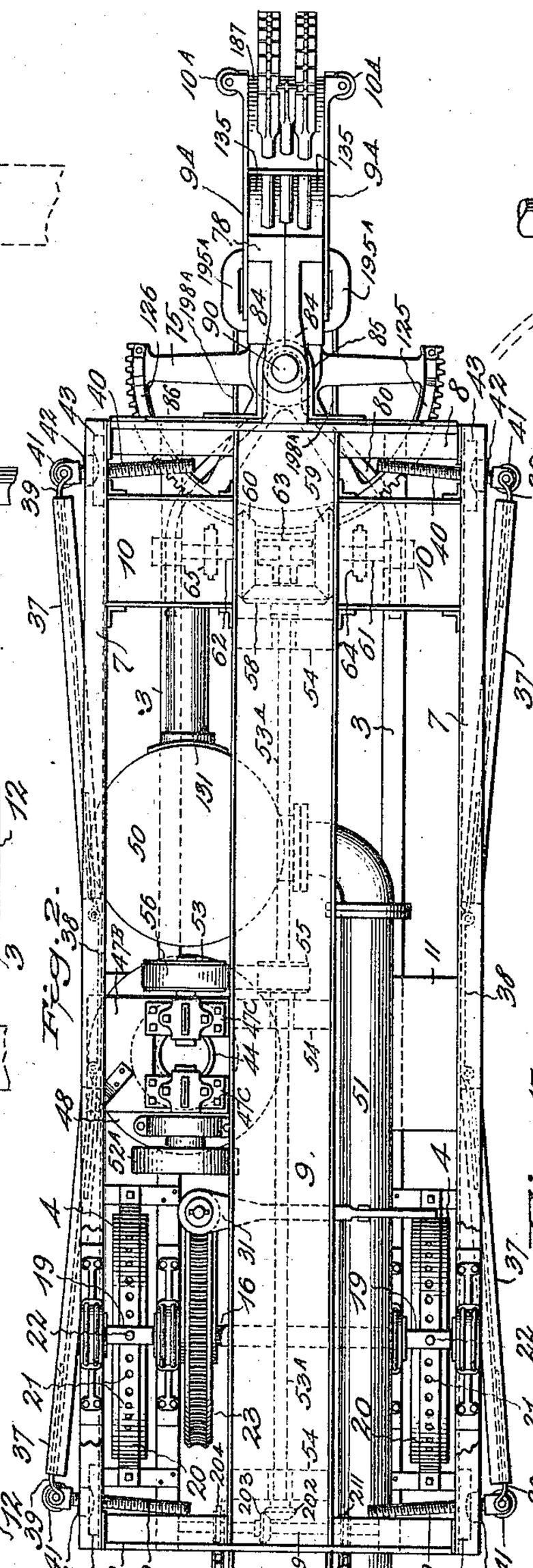

Fig. 12.

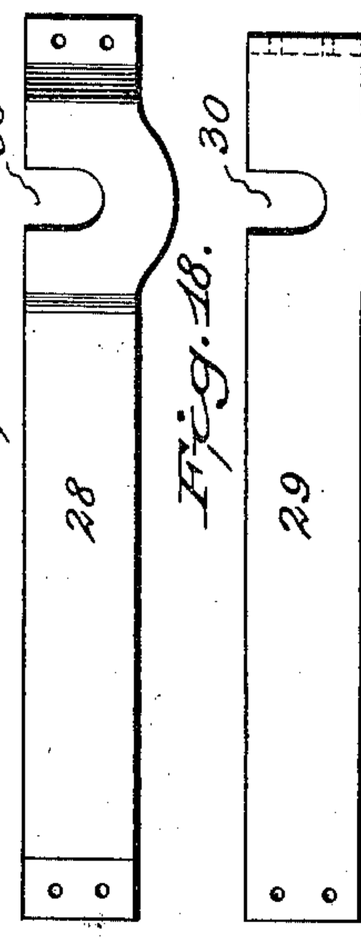

Fig. 17.

Fig. 18.

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6 SHEETS—SHEET 6.

Fig. 21.

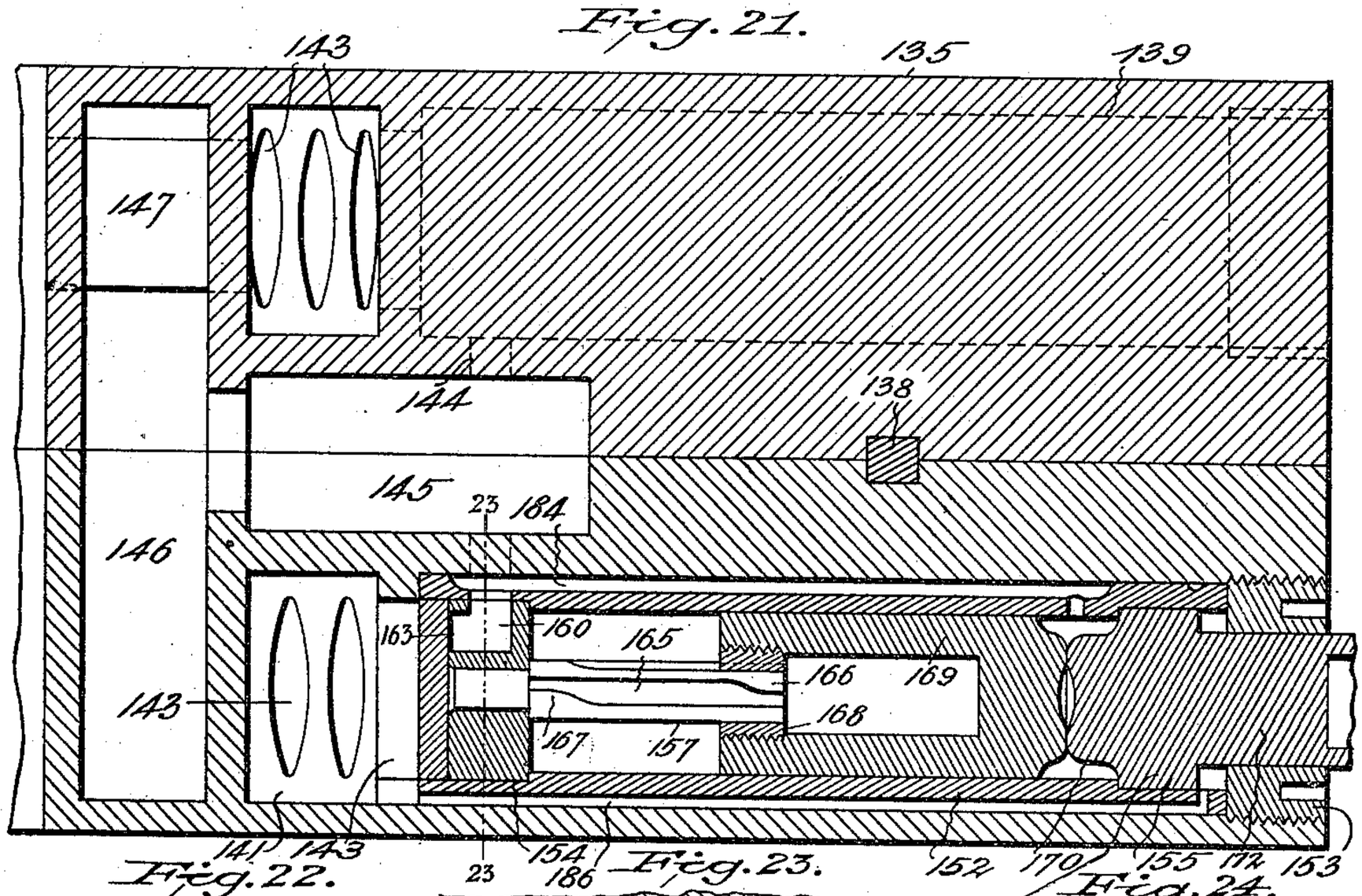


Fig. 22.

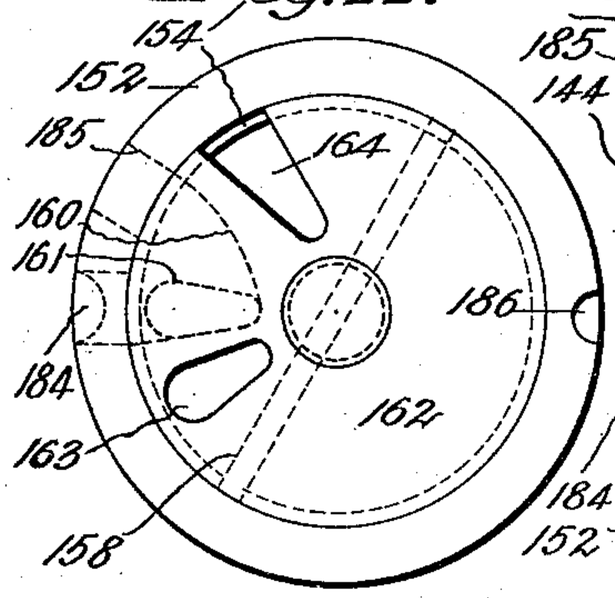


Fig. 23.

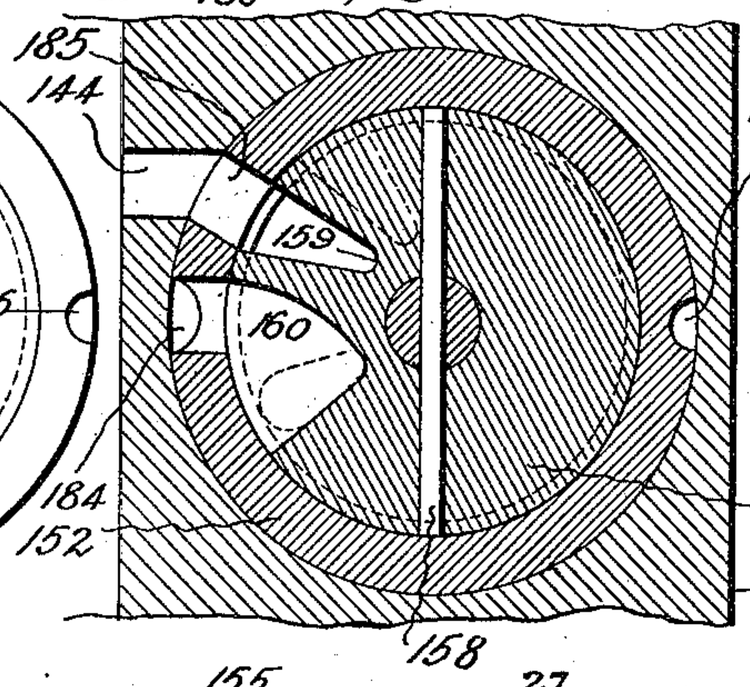


Fig. 24.

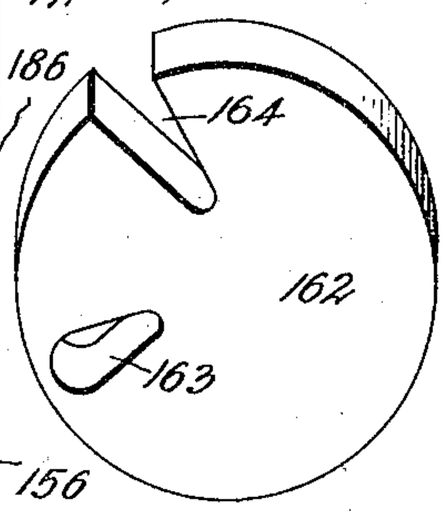


Fig. 25.

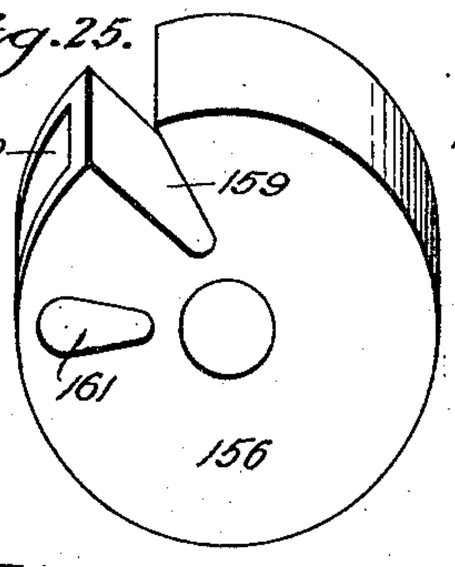


Fig. 26.

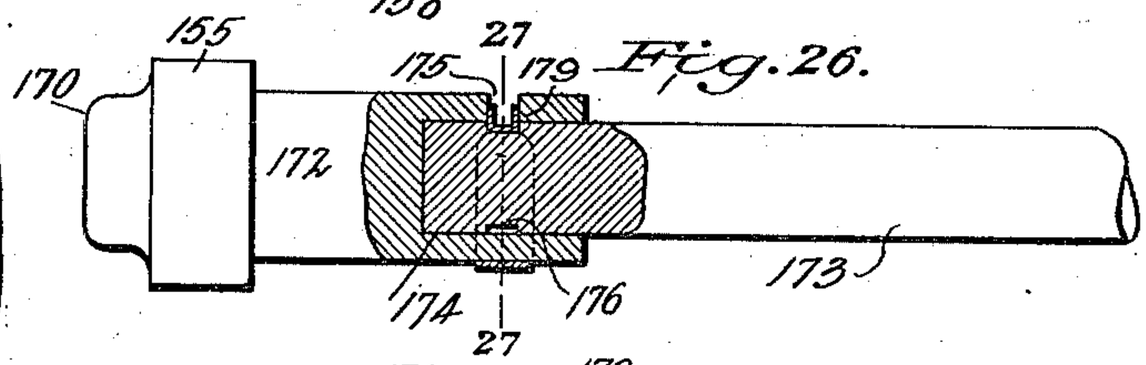
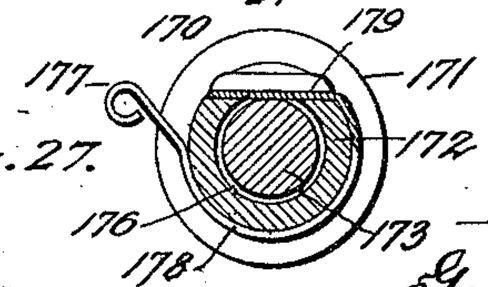


Fig. 27.



Witnesses

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UNITED STATES PATENT OFFICE.

GEORGE A. FOWLER, OF DENVER, COLORADO.

TUNNELING-MACHINE.

996,842. Specification of Letters Patent. Patented July 4, 1911.

Application filed May 22, 1909. Serial No. 497,775.

To all whom it may concern:

Be it known that I, GEORGE A. FOWLER, a citizen of the United States of America, residing at the city and county of Denver and State of Colorado, have invented a new and useful Tunneling-Machine, of which the following is a specification.

My invention relates to improvements in tunneling machines.

The object of the invention is to provide a suitable frame mounted upon wheels, said frame being provided at its forward end with a drill head provided with a plurality of fluid operated drills, said head being pivotally mounted on the frame and adapted to swing from side to side in the arc of a circle, upon a vertical axis, means being provided for admitting fluid under pressure to said drills, and for automatically swinging said head from side to side and for manually moving said machine forward against the breast of a tunnel.

A further object of the invention is to provide in connection with a machine of this character, a mucker, which is in position to receive the rock cuttings and which is adapted to receive air under pressure whereby the rock cuttings are blown rearward and are deposited upon an endless conveyer supported upon the frame, means being provided for operating said conveyer and for automatically swinging said head from right to left, said automatically operating means being adapted to reverse the movement of the head at a predetermined point in its travel.

A further object of the invention is to provide a wheeled frame having a cutter head pivoted upon one end, means for swinging said head from side to side and for automatically reversing its movement at a predetermined point in its travel, said head being provided with a plurality of fluid operated drills which are adapted to form either a square or an arched tunnel, means being provided for raising or lowering the rear end of said frame.

A still further object of the invention is to provide in connection with a suitable supporting frame, a cutter head which is pivotally mounted on said frame to swing from side to side, said head being provided with a plurality of rows of fluid operated drills which radiate from a common point, the drills in one row being arranged to alternate with those in the adjoining row or rows, means being provided for moving the machine forward as the breast of the tunnel is cut away.

These objects are accomplished by the mechanism illustrated in the accompanying drawings, in which:

Figure 1, is a side elevation of the improved tunneling machine, the inclosing plates on the near side of the machine being removed. Fig. 2, is a plan view of the same. Fig. 3, is a rear end elevation of the machine, one pair only of the side bearing rollers being illustrated. Fig. 4, is a front end elevation of the same, the cutter head being removed, and the worm gear by which said head is operated and also its bearing block being shown in section. Fig. 5, is a side elevation partly in section of the cutter head, the drill cylinders and drills being removed. Fig. 6, is a side elevation of a portion of one of the half sections constituting the cutter head, looking at its inner face. Fig. 7, is a horizontal sectional view on the line 7—7 of Fig. 5. Fig. 8, is a similar view on the line 8—8 of Fig. 5. Fig. 9, is a sectional view through a portion of the cutter head on the line 9—9 of Fig. 5. Fig. 10, is a front elevation of a portion of the cutter head, showing the arrangement of the sockets which receive the drill cylinders. Fig. 11, is a front elevation partly in section of the cutter head reversing mechanism. Fig. 12, is a horizontal sectional view of the engine used in connection with said reversing mechanism. Fig. 13, is a transverse vertical section of said engine. Fig. 14, is a front elevation of the supporting means for the worm pinion, by which it meshes with a worm gear on the rear axle of the machine for propelling the machine forward. Fig. 15, is a detail plan view illustrating the means of holding said pinion in engagement with said gear. Fig. 16, is a sectional view on the line 16—16 of Fig. 15. Figs. 17 and 18 are plan views respectively of the upper and lower supporting plates for the worm pinion shown in Fig. 14. Fig. 19 is a vertical longitudinal sectional view through the muck receiver. Fig. 20, is a plan view thereof. Fig. 21, is an enlarged sectional view of the drill head showing a drilling engine arranged in operative position. Fig. 22, is an end view of the sleeve, showing the stationary valve in position to admit air to the rear of the hammer piston. Fig. 23, is a sectional view on the line 23—23 of Fig. 21, showing the valve in position to admit air

at the forward end of the piston. Fig. 24, is a perspective view of the valve plate or stationary valve. Fig. 25, is a perspective view of the rotatable valve. Fig. 26, is a side view partly in section, of the striking pin, the rear end of the drill being shown in locked position therewith. Fig. 27, is a sectional view on the line 27—27 of Fig. 26. Fig. 28, is a side elevation of a form of drill head which is adapted to cut an arched tunnel, and also a muck channel in the floor of the tunnel. Fig. 29, is a sectional view showing the form of tunnel cut by the drill head shown in Fig. 28. Fig. 30, is a view of one of the clutch reversing levers. Fig. 31, is a sectional view through the piston hammer sleeve, the piston hammer being partly broken away, to show the feather key by which it is prevented from axial rotation within said sleeve. And Fig. 32, is a front elevation of the hammer piston.

Similar letters of reference refer to similar parts throughout the several views.

Referring to the drawings, the numeral 1, designates the supporting frame of my machine. This frame is preferably constructed of channel bars or beams, but may be made of other material if desired, and comprises four longitudinal base beams 2 and 3, which are preferably arranged in pairs side by side on opposite sides of the machine, the two beams of each pair being arranged at sufficient distance apart to receive the rear supporting wheels 4, between them, upon which the rear end of the frame of the machine is mounted. To the base beams are secured corner standards 5, and central standards 6, to which are secured longitudinal roof beams 7, which are connected at their opposite ends by Z bars 8. A central longitudinal channel beam 9 is supported upon and secured at each end to the Z bars, and transversely arranged channel plates 10 are secured at their ends to the beams 7 and 9, near the front end of the frame. Each pair of beams 2 and 3 are connected by plates 11, and the beams 2 and 3 of each pair are connected by plates 12. The front end of the frame is mounted on a pair of small rollers 13, and these rollers are placed between the beams 2 and 3, and are each mounted on an axle 14, which axles are journaled in boxes 15, secured to the under sides of the beams.

The rear wheels 4, are preferably larger than the rollers 13 that carry the front end of the frame, and are mounted on an axle 16, which extends across the frame and is journaled in eccentric sleeves 17 which are rotatably mounted in boxes 18, which are bolted to the upper edge of the beams 2 and 3, on each side of the frame. These eccentric sleeves are each secured to the terminal ends of yoke-shaped hand levers 19, the yoke portion of which straddles the wheels. Segment plates 20 are secured to the frame, and partially surround each wheel, and the plates are provided with a plurality of holes 21, which are adapted to receive removable pins 22, which are each passed through apertures in the levers 19, and in any one of the holes 21 of the adjacent segment plate 20. By this arrangement, the yoke levers can be moved to turn the eccentrics in their boxes to raise or lower the axle and wheels, either in unison or independently, and by inserting the pins 22, in the holes in the tops of the yoke levers, and in registering holes in the segment plates, the eccentric sleeves may be secured at the desired adjustment. The eccentrics are positioned in the boxes to stand with their throw portions in horizontal planes, and with their operating lever 19 locked to the segments in a vertical position, in which position the frame stands in a horizontal plane, but when the eccentrics are turned, the rear end of the frame is either raised or lowered according to the direction of movement of the levers 19.

The object of raising or lowering the rear end of the frame above or below a horizontal plane, is to enable the machine to form a tunnel of any practical upward or downward grade or pitch of inclination to a horizontal grade, and also for the purpose of guiding the machine back to the specified grade of the tunnel when the machine accidentally works away from it, as it is apt to do when streaks of soft shattered rock or talcky ground are encountered.

The frame is moved forward or backward on the floor portion of a tunnel, by a worm gear 23, which is mounted on and secured to the axle 16, and is operated by a worm pinion 24. The worm pinion 24 is positioned in a vertical plane in mesh with the worm gear, and it is provided with a shaft 25, which extends beyond its opposite ends and is journaled at opposite ends of the pinion in bearing plates 26, which are bolted to a pair of parallel yokes 27, which extend around the axle 16, and hold the pinion in mesh with the gear, as shown in Fig. 16. The pinion and its shaft are further supported by upper and lower bracket plates 28 and 29, respectively, which are bolted to the inner base beams 3, as shown in Fig. 14. These brackets are provided with open ended bearing recesses 30, through which the shaft 25 passes, and in which it is permitted a slight rocking movement to allow the worm pinion to remain in mesh with the worm gear when the said frame is raised or lowered by the turning of the eccentric sleeves 17. The shaft 25 of the worm pinion extends above the hanger, and at its upper end an operating arm or lever 31 is pivotally secured to turn freely on the end of the shaft. This arm is provided with a pawl 32, which is arranged to be held by a

spring 33, in engagement with notches in a disk 34, which is keyed to the top end portion of the shaft. This pawl is connected by a rod 35, to a hand lever 36, which is pivotally attached to the handle end of the arm 31. This auxiliary handle is arranged relative to the main handle to be grasped by the hand of the operator, with the main handle, to withdraw the pawl from the notches in the disk 34. The pinion is manually rotated to turn the worm gear by oscillating the arm 31 back and forth, and in doing this the two handles are grasped to disengage the pawl from the disk 34, and the lever is moved in one direction and the auxiliary handle released to allow the spring to throw the pawl into a notch, after which the arm is moved in the opposite direction, and the shaft and pinion are thereby rotated.

To the sides of the base and roof beams of the frame are pivotally secured lateral bracing arms 37. These four arms are hinged at their inner ends to plates 38, which are secured by bolts or rivets to the central portions of said beams. The arms 37 are in the form of channel bars, and to their outer ends are riveted hinge straps 39, which are bifurcated at their free ends to receive the bifurcated ends of bolts 40, and in the bifurcated ends of the bolts are supported rollers 41, which are pivotally mounted upon pins which pass through them, and through the bifurcated ends of the bolts 40, and hinge straps 39. The bolts pass through nuts 42, having convex faces, which rest in corresponding concave faces of plates 43, which are bolted to the beams, and which are provided with holes through which the said bolts pass. By adjusting the nuts upon the bolts, the outer ends of the arms 37 are moved out from the frame against the opposite sides of the tunnel, and the rollers 41 are adapted to bear and roll against the side walls of the tunnel, as the frame is advanced against the breast thereof by the worm pinion and its gear. Upon the central portion of the frame 1, I place a suitable motor 44, preferably an air operated single cylinder slide valve engine, which is placed in a vertical position, with its cylinder 45 close to the base beams of the frame, and with its connecting rod 46 extending vertically upward toward the roof of the frame. The engine is supported in this position by suitable braces 47, which are secured to the engine at one end and to a base plate 48, which is secured to the base beams of the frame. To the upper cylinder head is integrally connected a distance piece 47^A, having a platform 47^B, at its upper end, to which are bolted bearings 47^C, in which the driving shaft of the engine is mounted.

A pipe 49 is connected to the valve chest of the engine, and extends to and is connected to an air receiving tank 50, which is placed on the floor of the frame adjacent to the engine, and the engine is provided with the usual exhaust port. A supply pipe 51 extends from this tank to the rear end of the frame, and is adapted to be connected with a supply of compressed air.

The engine's driving shaft 52, is provided with a fly wheel 52^A on one side, and with a belt pulley 53 on its opposite side. A shaft 53^A extends longitudinally through the frame, and centrally of its width, and is journaled in hangers 54, which are bolted to the under side of the channel beam 9. This shaft carries a pulley 55, which is secured to it, and is driven by a belt 56 from the driving pulley 53 of the engine. This shaft extends to the front end portion of the frame, and a bevel gear 58 is secured to its end. This bevel gear meshes with two bevel gears 59 and 60, which are secured on the ends of two shafts 61 and 62 respectively, which are journaled at right angles to the main shaft 53^A, in a three-bearing hanger 63, which is also secured to the channel beam 9. The bearings for the shafts 61 and 62 are in line, and the third bearing is at right angles to these bearings and supports the forward end of the shaft 53^A. These shafts 61 and 62 extend in opposite directions from the horizontal center of the main shaft and from each other, and are rotated in opposite directions by the gear 58 and the gears 59 and 60. On each of the shafts 61 and 62, sprocket wheels 64 and 65 respectively are secured, on which sprocket chains 66 and 67 respectively are mounted. The sprocket chains extend to and are mounted on sprocket wheels 68 and 69 Fig. 11, which are slidably mounted on sleeves 70 and 71, which are slidably and rotatably mounted on a shaft 72, that is journaled in bearing blocks 73, that are secured to the beams 2 and 3 of the frame.

The two gears 59 and 60, and their shafts, are driven by the gear 58 on the end of the shaft 53^A, in opposite directions, and this opposite direction of rotation is imparted to the sprocket wheels 68 and 69 on the sleeves 70 and 71, by the sprocket wheels and the sprocket chains. A worm pinion 74 is formed or secured on the central portion of the shaft 72, which pinion meshes with and drives a semi-circular worm gear 75, the hub of which is pivotally mounted on a pin 76, that extends through overlapping lugs 77, formed on a two-part drilling head 78, and which also extends through a block 79 that is supported in a yoke-shaped channel beam 80, the ends of which are bolted to the inner base beams 3.

The sprocket wheels 68 and 69 are secured to the sleeves 70 and 71, by feather keys 81, which permit a sliding movement of the sleeves within the said sprocket wheels, but lock the said wheels to the

sleeves, so that the sleeves are rotated by the wheels. The wheels 68 and 69 are held against lateral sliding movement by brackets 82, having upward projections 83, between which the said wheels lie, and the projections prevent the wheels from sliding with the sleeves, when the said sleeves are moved, as will be presently more fully explained.

The drilling head 78 is provided at its upper end with apertured lugs 84, a lug being formed on each half section of the head, and arranged to overlap, so that their apertures will register. A yoke-shaped bracket 85 is secured to a bar 86, which is secured to the upper portion of the forward uprights 5, of the frame, and the bar 86 is further supported by braces 87, which are secured to the forward Z bar 8. The bracket 85 is supported from beneath by braces 88, which are secured to the bracket, and to the uprights 5. Within the bracket 85, is secured a block 89, having an aperture in axial line with the aperture in the block 79, and a pin 90 is passed through the apertured lugs 84 and the block 89. Thus the pins 76 and 90 support the drill head, and permit it to be swung from right to left in the arc of a circle.

The worm pinion 74 and the worm gear 75 are adapted to swing or oscillate the drill head in a horizontal plane, and in a semi-circular path from one side of the tunnel to its opposite side, through the medium of the engine and shafting, and the bevel gears 58, 59 and 60, the sprocket wheels 64 and 65, the sprocket chains 66 and 67, and the sprocket wheels 68 and 69. The sleeves 70 and 71 are formed with clutch teeth 91 on their inner ends, which are adapted to engage similar teeth 92 on the opposite ends of the pinion 74, and these clutch teeth may be of any suitable form. The sleeves, which are rotated in opposite directions, are operated to alternately engage the clutch faces of the pinion 74, thereby to reverse the direction of the rotary movement of the said worm pinion at the ends of the reciprocal swinging movements of the drilling head from one side of the tunnel to the other, and they also are adapted to permit the operator to stop the head at any desired point and reverse its movement as often as desired in either direction. It is essential, however, that some reliable and powerful method of moving these oppositely rotating clutch sleeves be employed in order that they may be moved in successive and regular order without interfering with each other. I preferably carry out this feature of my invention in the following manner: To the bearing block 73, are secured a pair of parallel angle bars 93, which are bent in the form shown in Fig. 11, and which together form a bridge or support, upon the upper central portion of which a suitable engine 94 is secured. A space is left between these bars and to their under sides are bolted brackets 95, the brackets on one bar being in line with those on the other bar. These brackets are apertured and a pin 96 is passed through the apertures of each pair of alined brackets, and upon the pins are mounted levers 97 and 97A, which are yoke-shaped at each end. The lower yoke ends of each lever are provided at their extremities with inwardly extending lugs 98, which are adapted to extend into annular grooves 99, of the sleeves 70 and 71, which grooves may be formed directly in the sleeves, or they may be formed by securing collars 100 upon the sleeves, as shown in Fig. 11, a space being left between each pair of collars, which constitutes the groove.

The levers 97 and 97A are provided with elongated apertures 101, at their upper ends, through which pass pins 102, which also pass through enlargements on a pair of piston rods 103, and 103A respectively, which extend out through the heads of the engine 94, and are supported in standards 94A secured to the bars 93.

The piston rods are attached to and extend from piston heads 104 and 105, which are reciprocally mounted in the engine cylinder. The engine cylinder is provided with two cylindrical bores 106 and 107, in which the piston heads 104 and 105 are reciprocally mounted, and these cylinder bores are arranged in direct horizontal alinement, and are separated from each other by a partition 108. The axial center of this partition is provided with an aperture, in which a pin 109 is slidably mounted. This pin is made enough longer than the thickness of the partition to permit it to be moved by the piston heads in alternate order far enough to move the opposite piston a sufficient distance to uncover its actuating fluid inlet port, as will be hereinafter described.

The cylinder is provided with a valve chest 110, which is provided with a valve seat, and a flat slide valve 111 is seated on the valve seat within the valve chest. This valve is operated by a rod 112, which is secured at one end to an apertured lug 113, on the valve, and which extends out through a stuffing box 114, on the end of the chest, and is pivotally secured at its opposite end to a lever 115, which is pivotally connected at its lower end to a bracket 116, secured to the bars 93. The lower end of this lever is yoke-shaped, to straddle the adjacent piston rod 103, and its upper end is pivotally attached to a lever 117, having a handle portion at one end, while its opposite end is pivotally secured to a lever, comprising an upright arm 118, which is connected to the lever 117, a horizontal member 119, which is mounted in bearings 120 on the top of the valve chest, and an arm 121, which

projects at right angles from the forward end of the member 119. The arm 121 is pivotally connected at its extremity to a vertical bar 122, which is slidably supported in a guide block 123, which is secured upon the outer bar 93. The lower end of the bar 122, carries a roller 124, which is adapted to be engaged alternately by cam plates 125 and 126, which are secured at opposite extremities of the worm gear 75. The cam 126 is adapted to pass under the said roller and lift the bar 122, when the gear 75 reaches the limit of its movement in one direction, while the cam 125 passes over the roller and thereby draws the bar down again, when the gear reaches the limit of its movement in the opposite direction, the object of which is to reverse the slide valve 111, as will presently be more fully described.

The valve 111 is enough shorter than the length of the inside of the valve chest to control by its alternate strokes two ports 127 and 128, which are formed at opposite ends of the valve chest, through the valve seat of the cylinder, to admit the actuating fluid from the valve chest into the outer ends of the two piston bores of the cylinder. An actuating fluid inlet pipe 129, in which a valve 130 is placed, is threaded to the valve chest and extends to a pipe 131, which connects the air receiving tank 50 with the drill head, and an exhaust port 132 in the wall of the engine cylinder connects with an exhaust chamber 133 formed in the bottom of the valve, and with the atmosphere. This exhaust chamber of the valve communicates alternately with the ports 127 and 128 of the valve chest, at the ends of its opposite reciprocal movements. The two piston bores of the cylinder are connected on opposite sides of their dividing partition 108, by a port 134, which extends from each bore through the wall of the cylinder and below the said partition.

The entrances of this port 134 in each cylinder, are positioned at a sufficient distance from the opposite sides of the partition to enable the piston heads 104 and 105 to stand wholly between the entrances to the port and the partition when the piston heads are against or almost against the partition, and the object of this port is to allow the actuating fluid to pass from one cylinder to the other, and move the pistons on their outward strokes, as will be presently explained, and in order to accomplish this, the peripheral edge portion of each piston is beveled on both sides to allow the actuating fluid to flow readily behind them when at the opposite ends of their strokes, or when one piston is moved away from the partition beyond the adjacent port entrance, by the impact of the other piston on the pin 109. This rotary motion reversing mechanism operates to reverse the direction of the rotary movement of the pinion and gear and of the drilling head in the following manner: The valve 130 being opened, compressed air is conveyed through the air inlet pipe 129 to the valve chest. The operator then grasps the hand operating end of the valve lever 117, and moves the valve to one end of the valve chest, and assuming that the valve has been moved to uncover the port 127, the compressed air enters the cylinder 106 and moves the piston 104 against the partition, and as it moves to the rear end of its cylinder, its rod 103 moves the clutch operating lever 97 with it, and this lever moves the clutch sleeve 70 on the driving shaft 72, away from the clutch of the adjacent end of the worm 74, and consequently uncouples it from the worm, and when the piston 104 reaches the limit of its stroke, it strikes the pin 109 and moves it through the partition 108, and the pin moves the piston 105 away from the partition far enough to open the farther end of the port 134 and allow the compressed air to flow through this port from the cylinder 106 and into the cylinder 107, and behind the piston 105, which has been moved away from the partition by the pin far enough to uncover this port to admit air behind it. The air then moves the piston 105 to the front of its cylinder 107, and in doing so its piston rod 103[A] moves the clutch sleeve 71, into engagement with the adjacent end of the worm pinion 74, and as the sprocket wheel 69 carried by this sleeve is rotating in an opposite direction from the sprocket wheel 68 carried by the sleeve 70, the direction of rotation that was imparted to the worm pinion 75 before the clutch sleeve 70 was uncoupled from it, is reversed, and the drill head is swung in the opposite direction.

The operator can allow the motion of the worm to continue until the drilling head has swung around at or close to right angles to the longitudinal axis of the frame and tunnel, when he can at any time reverse it, by grasping the valve operating lever 117 and moving it to close the port 127 and open the port 128. When the lever 117 is pushed to uncover the port 127, the bar 122 carrying the roller 124, is raised by the upward movement of the arm 121, and as the worm gear 75—which is turning from left to right, as one looks toward the front end of the machine—approaches the limit of its movement in this direction, the cam plate 125 passes over the roller 124, and draws the bar 122 down, which movement is imparted to arms 118, 117 and 115, thereby reversing the position of the valve 111, and uncovering the port 128. The air then flows behind the piston 105, and moves it to the rear of its cylinder, where it engages the pin 109, and moves it to move the piston 104 beyond the

entrance of the port 134, and when the piston 105 reaches the partition, and uncovers the adjacent end of the port 134, the air flows through the said port behind the piston 104 and moves it to the front end of its cylinder, and in doing so its piston rod moves the clutch lever 97 to throw the clutch sleeve 70 again in mesh with the adjacent clutch of the worm pinion 74, again reversing the direction of movement of the pinion and of the driven gear.

The drill head comprises two segmental sections 135, which are bolted together by a plurality of bolts 136, and the sections are each formed with registering key seats 137, in which keys 138 Fig. 21 are placed, when the parts are assembled, and these keys prevent twisting of the sections one upon the other, and the constant strain upon the connecting bolts. Each section is provided with the rearwardly projecting apertured hinge lugs 84, previously referred to, and these lugs are formed to overlap so that their apertures 84[A] will register, and the pins 76 and 90 are passed through these lugs and through the blocks 79 and 89, thus hinging the drill head to the front end of the frame, so that it may be swung from side to side in the arc of a circle, as previously described.

Each section is provided with a row of cylindrical sockets 139, which radiate from the point from which the arc of the cutter head is described, and the sockets in one section alternate with those in the other section. The top and bottom sockets of each section are on the same plane, and as this would make the intervening space between the two upper sockets in one section and the two lower sockets in the other section greater than the space between the other sockets, a half socket 140 is formed in each section at the upper and lower end thereof, and between the last two sockets, which register when the sections are assembled, and the drill placed in these two sockets will cut away the rock which would be left by the two drills at each end, which are farthest apart, as will be apparent. Back of each row of sockets a live-air chamber 141 is formed, and these chambers extend from one end of the section to the other, and communicate at each end of the head through passages 142, which are immediately behind the central sockets 140. Each socket has a supply aperture 143 in its bottom, which communicates with the adjacent chamber 141, and in the wall of each socket next to the inner face of the section is formed an exhaust port 144, which opens into an exhaust chamber 145, which is located between the two live-air chambers 141, and which forms part of a larger exhaust chamber 146, which extends the whole length and width of the head, and which is behind and parallel with the chambers 141. A threaded nipple 147 extends through the rear wall of the exhaust chamber 146, and into and through the dividing wall between this chamber, and one of the live-air chambers 141, and this nipple is adapted to receive one end of a hose 148, extending from the supply pipe 131 of the tank 50, whereby air under pressure is admitted to the chambers 141, as will be understood by reference to Figs. 5 and 7.

The chamber 145 terminates at each end, where it is intercepted by the walls of the two central sockets, and these sockets have their exhaust ports 149 in these walls, and as the chamber 145 terminates short of the two uppermost and two lowermost sockets, a small chamber 150 is formed in the half sections, between each two of said sockets, which communicates with the chamber 146, and the exhaust ports from the uppermost and lowermost sockets communicate with this chamber 150, as will appear by reference to Figs. 6 and 9.

At the lower end of the exhaust chamber 146, an exhaust port 151 is formed in the outer wall of each section, and these ports are connected by pipes 195[A] with a pneumatic mucker, which will be fully described hereinafter.

Any suitable character of rock drilling engine may be employed in connection with the drill head, but I preferably employ a hammer piston drilling engine, in which the blows of the drill bit striking mechanism are cushioned, so that the bits cannot be driven into soft or seamy rock or into talcky ground beyond a stroke of predetermined limit, and the front ends of the engines cannot be broken or knocked out by the action of the hammer piston. It is also preferable to employ removable sleeves or cylinders which fit into the sockets 139, and in which the hammer pistons and other movable parts of the engine are mounted, and which receive the wear of these parts. These sleeves 152 are pressed into the sockets 139, and rest against the bottoms thereof. They are shorter than the depth of sockets, the outer ends of which are threaded for a suitable distance, and apertured nuts 153 are screwed into the sockets, against the outer ends of the sleeve, to secure them in place.

The sleeves are counterbored for a short distance at each end, as shown at 154 and 155, and before they are secured within the sockets, they are each supplied with the parts which make up the drilling engine, and which are as follows:

A rotatable disk valve 156 is placed in the counter-bore 154, so as to rest against its shoulder. This valve has a central aperture through which is inserted the reduced end of a rifled bar 157, which is secured to the valve by a pin 158, which passes through the valve and the said reduced portion of the

rifled bar. The valve is provided with a radial port 159, which extends entirely through it, and with a port 160, which is in the form of a chamber extending into the valve from its peripheral edge, and a port 161 extends from the port 160 through the rear side of the valve. A port plate or disk 162 is suitably secured in the end of the sleeve against the valve 156, and this plate is provided with a port 163, with which the port 161 of the valve 156 registers, in one position of the said valve, and it is also provided with a port 164 which extends out through its peripheral edge. The port plates are of the same diameter as the apertures 143 in the bottoms of the sockets 139.

The rifled bar 157 is provided with longitudinally disposed grooves 165, preferably four in number, which extend from the valve to the end of the bar, and one side of each groove at its forward end terminates in an inwardly projecting cam surface 166, which reduces the groove to one half of its width at this point, while the opposite sides of the rear ends of the grooves are formed with similar cam surfaces 167. The rifled bar extends through a rifled nut 168, which is threaded in the end of a hollow hammer piston 169, which delivers its blows against a striking pin 170, which is positioned in the counterbore 155. This striking pin consists of a head portion 171 and a drill holding hub portion 172. The head portion reciprocates between the shoulder of the counterbore of the cylindrical sleeve, in which it is reciprocally confined, and the nut 153 which is provided with an axial aperture through which the hub of the striking pin projects reciprocally and extends far enough beyond the nut to receive and be locked to the shank end of a drill bit 173.

The drill bit may be removably secured to the projecting end of the striking pin in any suitable manner, but I preferably carry out this feature of my invention in the following manner: I form a recess or socket 174 in the end of the striking pin to receive and fit the end portion of the drill bit with a free but close fit, and across the projecting end of the outside surface of the striking pin into this aperture I form a keyway 175. A circumferential keyway 176 is also formed around the end of the drill shank in a position to register with the keyway in the hub of the striking pin, when the drill bit is inserted therein. The drill bit is then locked to the shank of the striking pin by a spring key 177, which fits in the keyways of both the striking pin and of the drill bit. This spring key comprises a spring band 178, one end of which is bent to form a U-shaped cross section, and this bent end 179 constitutes the key. The ends of the spring are arranged at a distance apart that will enable them to spring over the end of the striking pin. The hammer piston is feathered to the cylindrical sleeve by a key 180, which extends through the sleeve and projects into a keyway 181, formed between the opposite ends of the hammer piston. The key has a notch 182, which registers with a recess 183 in the sleeve, in which recess a suitable implement may be inserted to withdraw the key, in order to remove the piston hammer from the sleeve. The cam surfaces of the rifle flutes of the rifle bar occupy but a short portion of the stroke of the hammer piston, and its rifled nut on the rifle bar. The cam surfaces at the front and rear ends of the rifle bar have a short straight portion beyond them, and the position of these cam surfaces may be changed either nearer the ends of the rifle bar or farther away from them than I have illustrated, if it is desired to secure a quicker or slower action of the valve.

The sleeve 152 has a longitudinal groove or port 184 in its peripheral surface, which opens at its rear end into the port 160 of the valve 156, and at its opposite end it extends through the sleeve forward of the hammer piston, and when the valve is in the position shown in Fig. 23, live air entering through the port 163 is admitted through ports 161, 160, and 184, to the front of the hammer piston, and the air back of said piston exhausts through the port 159, and through a port 185 in the sleeve, which registers with one of the exhaust ports 144, and when the valve is in the position shown in Fig. 22, live air enters the rear end of the sleeve through ports 164 and 159, and the air in front of the hammer piston exhausts through ports 184, 160, 185, and 144. When the rifled nut 168 contacts with the cams 166 of the rifled bar on the forward stroke of the hammer piston, the valve 156 is turned to the position shown in Fig. 23, and when the said nut engages the cams 167 at the rear end of the rifled bar, the valve is thrown to the position shown in Fig. 22.

The actuating fluid is also used to cushion the striking pins and hold them at the end of their forward position, to receive the full blows of the hammer pistons, and it passes to the rear of the heads of the striking pins, through a port 186, which is grooved in the peripheral surface of the sleeve at a point opposite the port 184. The ports 186 communicate at their rear ends with the live air chambers 141. The ports 186 are arranged to enter the counterbores 155, behind the striking pin at the rear of their head portions, in order to allow the striking pin when driven back by a blow of the hammer piston to cross this port and to compress for an instant the air filling the space between this port and the head nut 153, thus cushioning the striking pin so that it cannot hammer against the said nut, and also pre-

venting the striking pin from hammering the drill bit when it is not held up against and in operative drilling relation to the breast of the tunnel.

While the drill bits are firmly supported by the striking pins of the drilling engines, I preferably provide an additional support for them at about the center of their lengths, in which they are slidably mounted. This support consists of a sheet iron plate 187, which is supported at a distance of about one-half of the length of the drills by a brace 188, which is secured to the face edge of the head. This plate is provided with apertures of the shape of the drill steel used, through which the drill bit extends and fits loosely but close enough to support the drill bits against springing to either side of their central positions. In order to discharge the muck or rock drillings as fast as it is made, it is necessary that it be guided to drop directly to the floor as fast as it is drilled off of the breast of the tunnel by the drill bits, and confined to the area of the drill bits instead of permitting it to fly in all directions from the drill bits, and form a bed all over the area of the floor at the foot of and adjacent to the breast of the tunnel.

I preferably carry out this feature of my invention in the following manner: To the front of the guide plate 187, I secure at intervals arms 189, on which I secure in any convenient manner curtains 190, of canvas or rubber or other suitable material. These curtains extend close to the rock drilling ends of the drill bits, and consequently they extend close to the breast of the tunnel when the drill bits are drilling against it, and the pieces of rock and fine cuttings instead of flying in all directions from the drill bits, strike these curtains and are confined to a space of the width of the gang of drill bits, and fall to the floor of the tunnel, where they are shoveled or otherwise moved to the rear of the tunneling machine.

I preferably convey the muck to the rear end of the drilling head by means of a pneumatically operating muck conveyer, which is secured to the lower edge portion of the drilling head and moves with it as it swings across the breast of the tunnel, and is provided with a shoveling lip portion that moves along the floor of the tunnel against or very close to its surface, as the drilling head swings from one side wall to the other, under any muck that falls outside of the side curtains, and that is arranged to extend close to the rock drilling points of the lower drill bits of the drilling head under drill bits and close enough to the breast of the tunnel and under all of the drill bits in such a manner that the muck falls directly onto the shoveling lip end of the conveyer. This muck conveyer consists of a pan 191, which is provided with a muck shoveling lip 192, at its forward end, and with a discharge spout 193 at its rear end, and an inclined floor 194 composed of overlapping slats or strips, spaces being left between the strips to admit of air under pressure being forced therethrough, and the strips being overlapped so that the air will be directed toward the discharge spout. This floor extends from the shoveling lip to within a slight distance of the spout, and the space between it and the bottom of the pan 191 forms an air receiving chamber 195, which is supplied with air from the exhaust chamber 146 of the drill head, by pipes 195A, which connect with the opening 151 of the exhaust chamber. The shoveling lip is formed by curving up and over and back upon itself the terminal end of the bottom plate, and the top edge of this lip extends backward from the end substantially parallel with the bottom of the pan a short distance, and forms the end of an air passage space along the inside of the bottom of the pan, as will be more fully described hereinafter. The edge of the lip is formed with semi-circular notches or recesses 191A, which accommodate the ends of the drills, as will be apparent.

The rear end of the pan terminates in a vertical wall, which is bent over at its upper end as shown in Fig. 19, to form the bottom of the discharge spout, the top of which is curved as shown. This spout is designed to discharge the muck upon an endless conveyer, and I preferably use an endless belt conveyer 196, which is mounted on rollers 197, which are journaled in bearings 198, secured to parallel bars 198A, which are suitably supported from the bottom beams of the frame, and these bars extend above the upper rim of the belt, and prevent the material discharged thereon from rolling over the sides of the belt.

When the drilling engines are in operation against the breast of a tunnel, the exhaust air flows from them to the chamber 195 in the bottom of the pan, and this air being under high pressure rushes to the lip portion of the bottom of the pan and then flows through the air passages between the strips of the floor 194, at a backward angle that will move and force the muck that falls on the lip portion of the conveyer backward over the said floor, and out of the discharge spout 193 at the rear end of the conveyer onto the belt conveyer, by which it is conveyed to the rear end of the tunneling machine. As the drilling head moves from one side of the tunnel to the other, the shoveling lip moves under any muck that accumulates on the floor outside of the curtains, and gathers it up. This endless belt conveyer is operated from a counter-shaft 199, journaled in bearings 200, secured upon a beam 201, which is supported between the rear stand-

ards 5. This counter-shaft is driven by a bevel gear 202, mounted on the rear end portion of the shaft 53A. The bevel gear 202 meshes with a bevel gear 203, that is secured to the end of the counter-shaft 199. A sprocket wheel 204 is secured on the shaft, from which a sprocket chain 205 extends to a sprocket wheel 206, mounted on the axle of the rear end roller of the conveyer belt. This belt discharges upon a belt 206A, which is mounted on rollers 207 and 208. The roller 207 is supported in brackets attached to the rear end of the frame, and the roller 208 is supported in bearings mounted on a beam 209, extending from the rear end of the frame. The belt is operated by a sprocket chain 210, which is driven by a sprocket wheel 211 on the counter shaft 199, and which passes around a sprocket wheel 212 on the shaft of the roller 208.

In Fig. 28, is illustrated a form of drill head 213, in which the drills are arranged in radial order, and are extended from the floor line around the head until the uppermost drill 214 is in line with or substantially in line with the axis of the head. With the drills arranged thus, an arched tunnel is formed, as the head swings from side to side, and by supplying the lower end of the head with drills 215, arranged in the order shown, a muck channel 216 may be formed in the bottom of the channel, as shown in Fig. 29, which figure also shows the whole contour of the tunnel formed by the head 213.

An oil receiving reservoir 1A is secured upon one side of the drill head, and is connected at one end by a pipe 2A with the exhaust air chamber of the drill head. This reservoir is connected with a hollow ring 3A, from which a plurality of oil tubes 4A extend to apertures 5A (Figs. 5 and 7) in the side of the drill head, and these apertures register with annular grooves 6A Fig. 31 in the piston hammer sleeve, and this groove is intersected by a longitudinal groove 7A, which is intersected by a vertical aperture 8A, that opens against the hammer piston, and by this arrangement of grooves and pipes oil from the reservoir 1A is forced by the exhaust air within the piston hammer cylinder to lubricate the same.

Arms 9A are secured to the side of the drill head which carry rollers 10A at their outer ends, which are adapted to bear against the breast of the tunnel, and prevent the machine from being fed against the breast of the tunnel faster than the drills can cut.

The sides of the main frame are provided with housing plates 11A, which protect the operating mechanism and the operator as well.

The operation of my improved tunneling machine is as follows: The receiver is provided with a supply of compressed air through the pipe 51, from an air compressing plant, which is located outside of the tunnel but which I do not illustrate. This air from the receiver operates the engine 44, which runs the driving shaft 53A, and the drilling head swinging and reversing mechanism. The compressed air direct from the receiver operates the drilling engines, and the exhaust air from the drilling engines is used in the muck shoveling conveyer of the drilling head, while the endless belt conveyer is driven from the main driving shaft.

The frame is guided to cause the drilling head to drill a tunnel at any desired grade, either straight or curved, by raising or lowering the rear end of the frame, and by manipulating the side arms 37 to move the machine to either one side or the other of the center of the tunnel. The drilling head is manipulated to swing in the arc of a circle, from one side of the tunnel to the other, and its movements can be reversed by hand, or it will reverse itself automatically. The drilling engines and drill bit are preferably arranged to drill a slightly curved breast vertically as shown in Fig. 1, but can be arranged to drill a straight breast tunnel if desired, and one having either a flat or an arched roof.

The swinging head allows the drill bits to strike the rock breast at the sides and at the angle of the floor and roof, with the breast, at substantially right angles to the line of greatest resistance the face of the rock presents to the drilling ends of the drill bits, and as the rock muck is drilled it falls on the air operated muck conveyer and is conveyed by the exhaust air to the belt conveyer 196 by which it is conveyed and discharged to the rear of the frame, and as the drilling head reciprocates across the breast of the tunnel, the drill bits strike it with powerful blows, which are struck with great rapidity, and as the drilling points of these drill bits are arranged to overlap the drilling area of each other, they drill off the entire surface area of the breast of the tunnel, and as the head swings slowly around from one side to the opposite sides, the breast of the tunnel is rapidly drilled away, and the operator feeds the frame forward by swinging the lever 31 to turn the worm pinion 24 and its gear 23 to rotate the rear wheels to move the frame forward as fast as the drill cuts away the rock.

The drilling head, when standing at substantially or fully at right angles to the side walls of the tunnel, strikes square right angle blows against the surface of the rock, thus insuring that the tunnel will be maintained at the full width of the sides as well as at the angles of the roof and floor, with the breast, and should any part of the breast be much harder than the rest, the operator can stop the drilling head in its regular

swinging stroke and feed the drilling head back and forth over it by reversing the valve of the reversing mechanism with the hand operating lever 117 as long as desired.

My invention contemplates a centrally pivoted swinging oscillating and reciprocating multiple drilling engine and drill bit holding drilling head, operatively arranged and supported on a suitable portable carriage adapted to be guided to permit said drilling head to drill tunnels of any desired degree of inclination, vertical or horizontal curvature; and while I have illustrated and described the preferred construction and arrangement of my improved tunneling machine, I do not wish to be limited to the construction and arrangement shown, as many changes might be made without departing from the spirit of my invention.

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

1. In a tunneling machine, the combination of a frame provided with wheels at its front end, and with bearing boxes at its rear end, with eccentrics rotatably mounted in said boxes, an axle having the rear wheels mounted therein, said axle being rotatably journaled in said eccentrics, semi-circular bands surrounding the wheels and provided with apertures; yoke levers which straddle said bands and are secured at their ends to the eccentrics; removable pins for adjustably locking the levers to the bands; and means including gearing for rotating said rear wheels to move said frame along a tunnel.

2. In a tunneling machine, the combination with a supporting frame, bearings on said frame, sleeves mounted in said bearings, a shaft eccentrically mounted in said sleeves and supporting wheels on said shafts; of semi-circular plates having apertures and secured to said frame above said wheels, having a plurality of apertures; yoke levers having apertures, said levers straddling said plates and wheels, and secured at their ends to the adjacent sleeves, and removable pins which are adapted to extend through apertures in the upper ends of the yoke levers, and through any one of the apertures in the said semi-circular plates, whereby the said sleeves may be turned and locked at any point of adjustment.

3. In a tunneling machine, a supporting frame, a drilling head pivotally attached to one end of said frame, means including gearing for oscillating said drilling head, in a semi-circular path from side to side of said frame, rock drilling engines and drill bits removably mounted in said drilling head, a supporting guideway for each drill bit projecting from said head, muck confining curtains on opposite sides of said drill bits, means connected with said guideway and with said head for supporting said curtains, and a muck conveyer secured to and carried by said head and arranged to extend under said drill bits and between said curtains.

4. In a tunneling machine, the combination of a wheeled frame, a drilling head mounted on said frame to oscillate in a horizontal semi-circular path, a plurality of percussion drills and drill bits mounted in said head, muck confining curtains supported by said head at the side of said drill bits, a muck shoveling pan secured to and carried by said drilling head below said drill bits and curtains, means for delivering a supply of compressed air into said muck pan for conveying the muck of said muck pan to the rear of said drilling head, and a suitable conveyer on said frame arranged to receive the muck from said air operated muck shoveling pan and convey it to and discharge it from the rear of said wheeled frame.

5. In a tunneling machine, the combination with a drill head, having a compressed air receiving chamber, an exhaust chamber, and parallel rows of sockets which radiate from a common point, the sockets in each row alternating with those in the other row, sleeves in said sockets and ports connecting the receiving and exhaust chambers with said sleeves; drilling engines in said sleeves comprising piston hammers, valves for admitting the actuating fluid to operate said hammers, and striking pins operated by said hammers, carrying drill bits, of means for lubricating said engines; comprising an oil receiving reservoir connected at one end with the exhaust air chamber of the head, and at its opposite end with a hollow ring; and tubes connecting said ring with holes in the drill head, which register with oil passages in said sleeve, connected with its interior.

6. In a tunneling machine, a supporting frame, a horizontally arranged worm gear segment pivotally mounted on one end of said frame, a worm pinion in mesh with said worm gear, a drilling head pivoted to one end of said frame and secured to said worm gear to swing in a semi-circular path across the end of said frame, a shaft extending through said worm pinion, oppositely arranged clutch faces on the opposite ends of said worm pinion, intermeshing clutches slidably mounted on said pinion shaft arranged to intermesh with the clutch faces of said pinion, means including countershafts rotating in opposite directions for rotating said slidable clutches in opposite directions, and means including a valve controlled cylinder and expansive fluid operating pistons for moving said sliding clutches in alternate order to engage the clutches of said pinion to reverse the direction of movement of said pinion and gear and drilling head.

7. In a tunneling machine, the combination of the wheeled frame, a motor and a pair of oppositely rotating counter-shafts, driving connections between the motor and countershafts, a reversing mechanism comprising a driving shaft provided with reversely driven clutch mechanisms, connections to said countershafts for rotating said clutch mechanisms in opposite directions, a cylinder and fluid actuated valve-controlled pistons operatively mounted in said cylinder and operatively connected to said reversely driven clutch mechanisms, and means for admitting fluid to the cylinder to operate said pistons.

8. In a tunneling machine, the combination of the frame, provided with oppositely rotating counter shafts, arranged to drive a shaft carrying a worm gear, said worm gear being also provided with oppositely arranged clutch faces, sleeves oppositely rotatably and slidably mounted on said shaft, having clutch toothed faces adapted to engage the clutch faces of said worm gear, power transmission wheels slidably mounted on said sleeves and arranged to be rotated in opposite directions by said counter-shafts, means for preventing axial rotation of said wheels upon said sleeves, and means including valve controlled fluid operating pistons operatively connected to said oppositely rotating sleeves for moving them into clutch engaging contact with the clutch faces of said pinion in alternate order.

9. In a tunneling machine, the combination of a frame, provided with a rotatable shaft, a worm pinion secured on said shaft and provided with oppositely arranged clutch faces, rotatable clutch members slidably mounted on said shaft to register with said clutch faces; means including a compressed air operating motor mounted on said frame for rotating said clutches in opposite directions, a rock arm pivotally supported intermediate of its ends, and adjacent to each slidable clutch, a pivotal connection between one end of each rock arm and the adjacent sliding clutch, a valve controlled cylinder adjacent to said rock arm provided with a central partition, pistons, mounted in said bore on each side of said partition, and provided with piston rods extending from said cylinder in opposite directions, a pivotal connection between the opposite ends of said rock arms and their adjacent piston rods, a port connecting said cylinders at the adjacent opposite sides of said partition, a sliding pin in said partition adapted to be engaged by said pistons in alternate order to move the inoperative piston into operative relation to said port, a valve chest on said cylinder provided with actuating fluid inlet and exhaust ports leading into the opposite ends of said cylinder, and into and from said valve chest, a slide valve in said valve chest arranged to control said ports, means for moving said valve to reciprocate said pistons to alternately move said power driven sliding clutch members into and out of coupling contact with the clutches of said worm-pinion shaft, a gear in mesh with and adapted to be rotated in reverse rotary direction by said worm pinion and said clutches, and a drilling head provided with a plurality of vertical rows of operative drilling engines pivotally mounted on said frame and secured to said worm gear and arranged to be oscillated in a semi-circular path by said reversing mechanism.

10. In a tunneling machine, the combination with a wheeled frame provided with a driving shaft provided with a power transmitting pinion, having reverse clutch faces, opposing clutch members slidably mounted on said shaft to register with the oppositely arranged clutch faces of said pinion, means for rotating said slidable clutch members in opposite rotative directions, a cylinder in operative relation to said shaft, a pair of fluid controlled pistons in said cylinder, means including rock arms for connecting said pistons with said slidable clutches, a valve for controlling said pistons to move said slidable clutch members into and out of said pinion clutch faces, and means for moving said valve, a power wheel arranged to be driven by the power wheel of said driving shaft, and an operative rock drilling head pivotally mounted on said frame and secured to said power wheel and arranged to be oscillated in a semi-circular path by said power driven pinion and wheel.

11. In a tunneling machine, a wheeled frame provided with an oscillating drilling head and with a reversing mechanism, for driving and reversing said head, comprising a driving shaft mounted on said wheeled frame and provided with a power transmitting wheel, having oppositely arranged clutch faces, and having sliding and rotary clutch members mounted on said driving shaft in engaging relation to said wheel clutch faces, and means mounted on said wheeled frame for rotating said clutch members in opposite rotative directions, with a fluid actuating cylinder provided with a pair of pistons, means including rock arms for connecting said pistons and sliding clutch members together, and means including a manually operated valve for reversing the direction of engaging and disengaging movements of said sliding clutch members, relative to the clutch faces on said driving shaft, and a power receiving wheel in operative driven relation to said driving shaft.

12. In a tunneling machine, the combination of a wheeled frame, a driving shaft rotatably journaled on said wheeled frame, and provided with a worm pinion having

reverse direction rotating clutch faces on its ends, oppositely rotating power operated sliding clutch members arranged to register with said gear and shaft driving clutch faces, and means including a cylinder and a pair of pistons and piston rods arranged to move in the same direction in successive order in said cylinder, a valve for controlling the operating fluid and means for operating it, and operative connections between said pistons and said sliding clutch members to move one out of engagement with its adjacent pinion clutch face, and to successively move the opposite clutch member into engagement with its adjacent pinion clutch face whereby the direction of rotation of said worm pinion is reversed in alternate order, a worm gear in mesh with said pinion, a drilling head provided with an operative group of drilling engines secured to said gear and pivotally mounted to said wheeled frame, and arranged to be oscillated ahead of said frame in operative rock drilling relation to the breast of a tunnel.

13. In a tunneling machine, a wheeled frame provided with a rock drilling head, arranged to be oscillated ahead of said frame, across the breast of a tunnel, and provided with a reversing mechanism, consisting of a driving shaft provided with a worm pinion having reverse clutch faces, reversely rotating power-driven sliding sprocket wheels and clutch members mounted on said driving shaft, means including a motor mounted on said frame for driving said sliding sprocket wheels and clutch members in opposite directions, a cylinder, a pair of pistons and piston rods in said cylinder, a valve and means for operating it to control the movements of the pistons, and operative connections between said piston rods and clutch-members.

14. In a tunneling machine, the combination of a wheel frame provided with a driven shaft, oppositely rotating sprocket wheels and clutch members on said driven shaft, and means mounted on said frame for driving said sprocket wheels and clutches in opposite directions on said shaft, with a cylinder provided with two piston bores in axial alinement separated by a partition positioned centrally between them, an air port extending from one cylinder past said partition, and entering each cylinder at a short distance from said partition, a piston head in each cylinder narrower than the space between said partition and the entrance to said port, a sliding pin in said partition arranged to be engaged by each piston in alternate order and to move the other piston far enough away from said partition to receive air from said port between said port and said partition, piston rods projecting from said pistons through and beyond said cylinder, grooved collars on said sliding clutch members, rock arms connected with said piston rods and with said grooved collars, a valve chest on said cylinder, air inlet and exhaust outlet apertures leading into and out of said valve chest and from said valve chest into the outer and opposite end portions of said cylinders, a slide valve in said valve chest, and means for reversing said slide valve, whereby the pistons are reversed to rock the said arms in alternate order.

15. In a tunneling machine, a wheeled frame, a driving shaft journaled on said frame, provided with a worm pinion having oppositely arranged clutch faces formed on its opposite ends; sleeves having clutch faces mounted on the shafts and adapted to engage the clutch faces of the pinion; sprocket wheels mounted on said clutch sleeves and feather keys connecting said sleeves and sprocket wheels; means including a motor and shafting and sprocket wheels and chains for rotating the sprocket wheels and clutches of said driving shaft in opposite directions, grooved collars on said sleeves, rock arms pivotally supported intermediate of their ends and provided with yoke ends which straddle said collar, having lugs which project into said grooved collars, means including a valve controlled fluid actuating cylinder and a pair of pistons reciprocally mounted therein, having piston rods pivotally connected to the opposite ends of said rock arms, for reciprocally moving said sliding clutch members in alternate order into and out of operative engagement with the clutch faces of said worm, and a worm wheel in mesh with said worm pinion and arranged to be operated thereby, and a drilling head secured to said worm gear and pivotally mounted on one end of said wheeled frame and provided with a tunnel driving group of drilling engines and arranged to be oscillated across the breast of a tunnel by said driving shaft and its worm pinion.

16. In a tunneling machine, the combination of a wheeled frame, a driving shaft journaled on said frame and provided with a worm gear pinion, oppositely pitched clutch faces at the ends of said pinion, sleeves each having a clutch face slidably mounted on said shaft, each clutch face being arranged to face one of the clutch faces of said pinion and adapted to engage it, a sprocket on each slidable clutch sleeve, means mounted on said frame for rotating said sprockets and clutch members in opposite directions, a fluid receiving cylinder adjacent to said driving shaft, provided with two independent piston bores, operative actuating fluid ports in said cylinder for operating said pistons in unison, a valve arranged to control said ports, a pair of piston heads and piston rods reciprocally mounted in said cylinder bores, means in-

cluding rock arms for connecting said piston rods to said sleeve, a driven gear in mesh with the worm pinion of said driving shaft, a manually operating lever connected to said valve, and means including engaging projections connected with said worm gear and valve lever for automatically moving said lever and valve, a drilling head pivotally mounted on said wheeled frame, and secured to and carried by said driven gear, a plurality of vertical rows of rock drilling engines operatively mounted in said drilling head to drill away the breast of a tunnel, and means including an air receiver on said wheeled frame for operating said drilling engines.

17. In a tunneling machine, the combination of the wheel frame, a counter-shaft journaled at the center of the top of said frame, a beveled gear on the end of said shaft, means including an engine on said frame for rotating said shaft, a pair of countershafts journaled on opposite sides of the axial center of said shaft, provided with bevel gears arranged in mesh with the bevel gear of said shaft whereby said countershafts are rotated in opposite directions, sprocket wheels mounted on each of said counter-shafts, a worm pinion provided with shaft ends journaled on said frame parallel with and adjacent to said countershafts, sleeves having clutch faces on said shaft, sprocket wheels slidably mounted on said clutch sleeves, sprocket chains mounted on the sprocket wheels of said counter-shaft and extending to the adjacent sprocket wheel of said pinion shaft, oppositely arranged clutch faces on the opposite ends of said pinion, with which said clutch sleeves are adapted to engage in alternate order, means including an actuating fluid operating valve controlled cylinder and a pair of pistons for alternately operating the clutch sleeves to engage the clutch faces of said pinion and reverse the direction of rotary movement of said pinion, a segmental worm gear in mesh with said pinion, a drilling head pivotally attached to the adjacent end of said frame and secured to and arranged to be carried by said worm gear segment and swung in a reciprocal semi-circular path in front of said frame, a gang of operative rock drilling engines mounted in said head, and a conveyer arranged on said head and frame.

18. In a tunneling machine, a supporting frame, a drilling head pivotally mounted on said frame; a worm gear connected to said head; a worm pinion in mesh with said worm gear, having clutch faces on its opposite ends; slidable sleeves having clutch faces adapted to engage alternately with said clutch faces of the pinion; means for rotating said sleeves in opposite directions; a fluid operated engine having axially alined twin cylinders, pistons, and piston rods; a lever connecting each piston rod with a sleeve; a valve chest upon said engine; a slide valve in said chest adapted to admit actuating fluid to said engine cylinders alternately; a rod extending from said valve; a hand lever pivotally connected with said rod and with a rock lever mounted on said engine; a vertical bar extending down from said rock lever, and having a roller mounted on its lower end; a cam on said gear adapted to raise said roller and bar at the limit of movement of said gear in one direction to move the slide valve, and a second cam on said worm gear adapted to engage said roller to draw said bar down, and reverse the position of the slide valve, when the said worm gear reaches the limit of its movement in the opposite direction.

19. A tunneling machine having an oscillating drill-head and means for operating it, drilling engines and bits mounted in said head, a muck confining housing secured to said head, and a conveyer secured to the under side of said drill-head and to said housing.

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

GEORGE A. FOWLER.

Witnesses:

G. SARGENT ELLIOTT,

ADELLA M. FOWLE.