

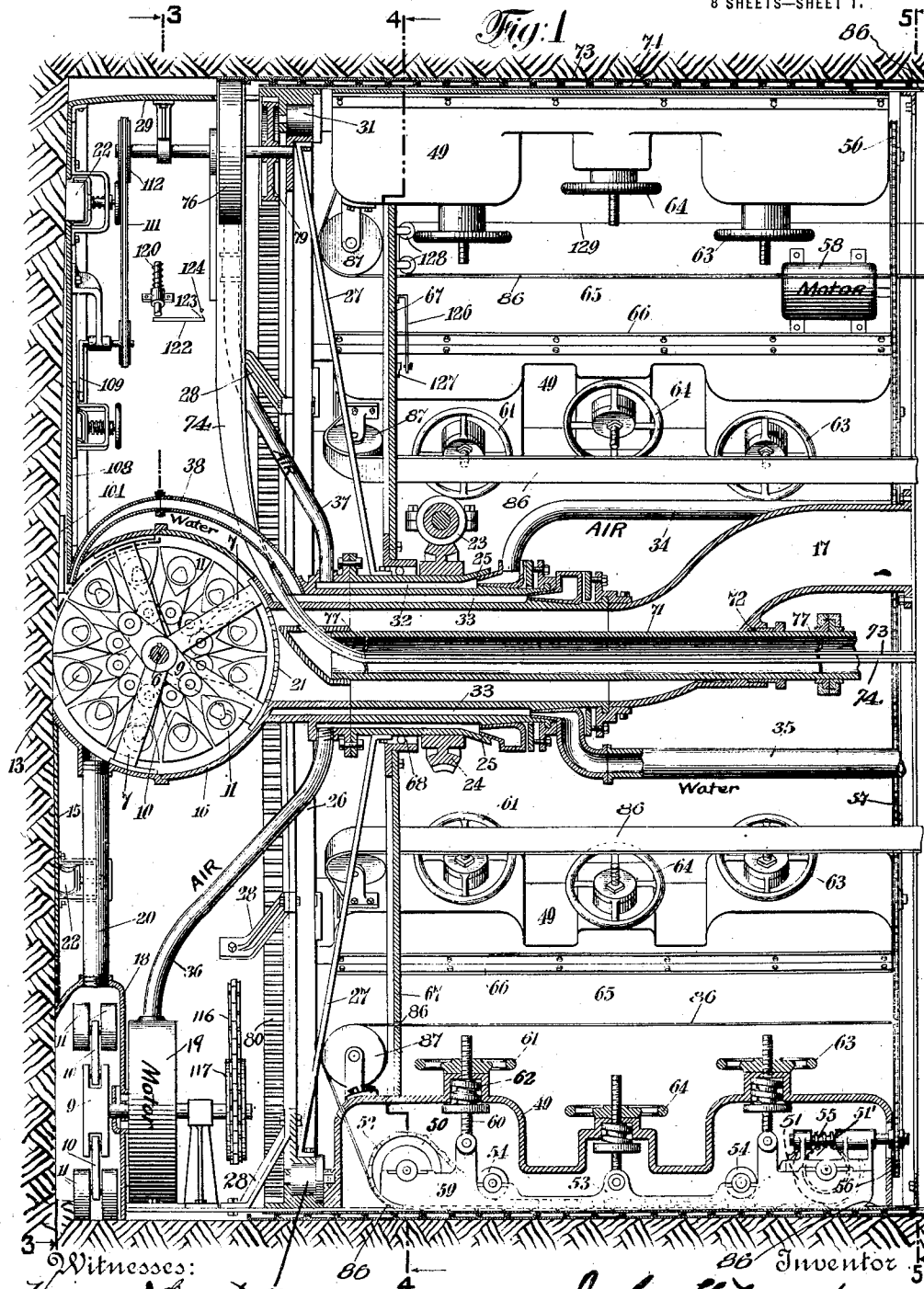
J. K. HENCKEN.
TUNNELING MACHINE.

APPLICATION FILED AUG. 14, 1912. RENEWED JAN. 29, 1919.

1,320,144.

Patented Oct. 28, 1919.

8 SHEETS—SHEET 1.



Witnesses:
Victor D. Bond
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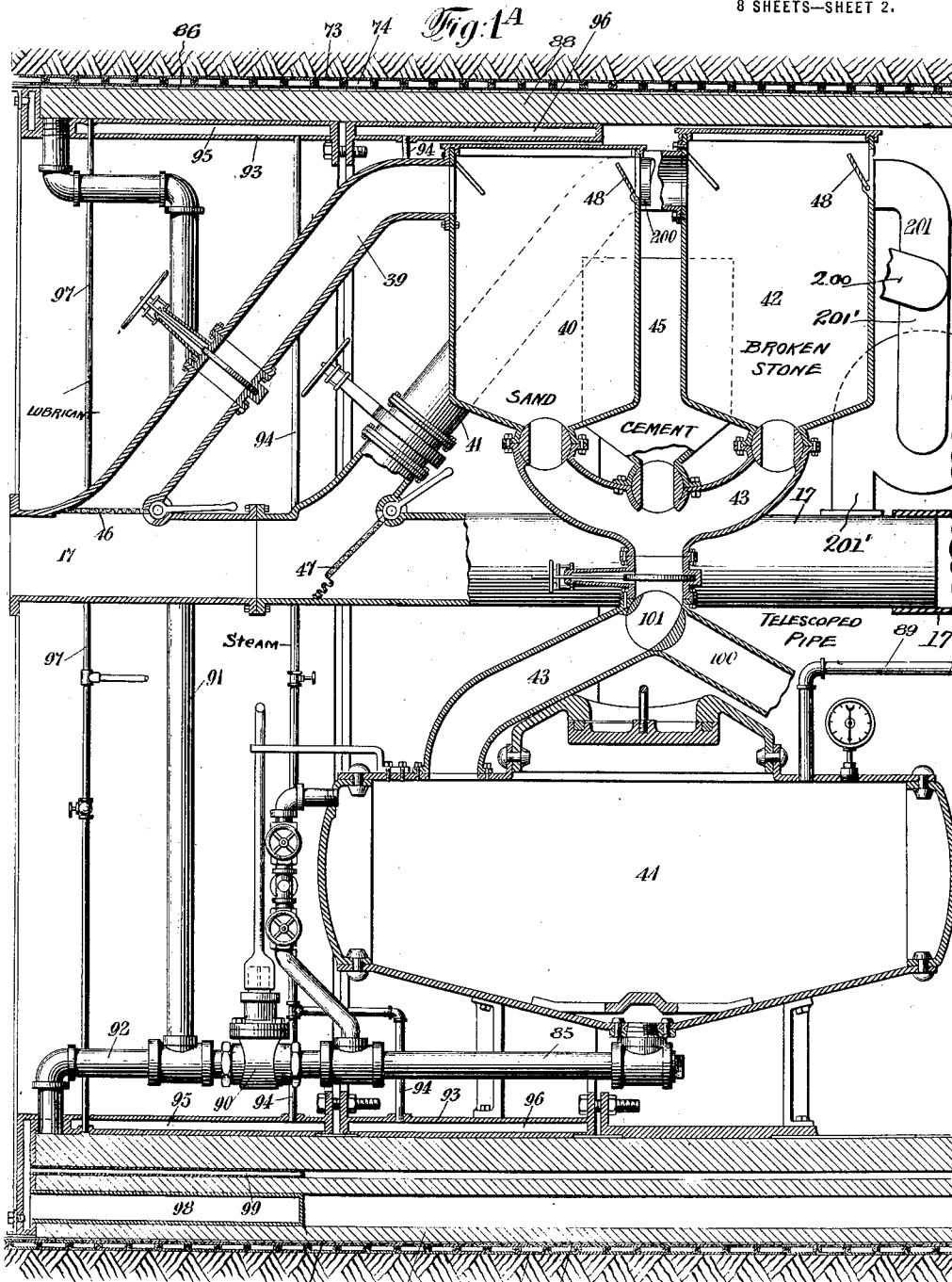
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Witnesses:
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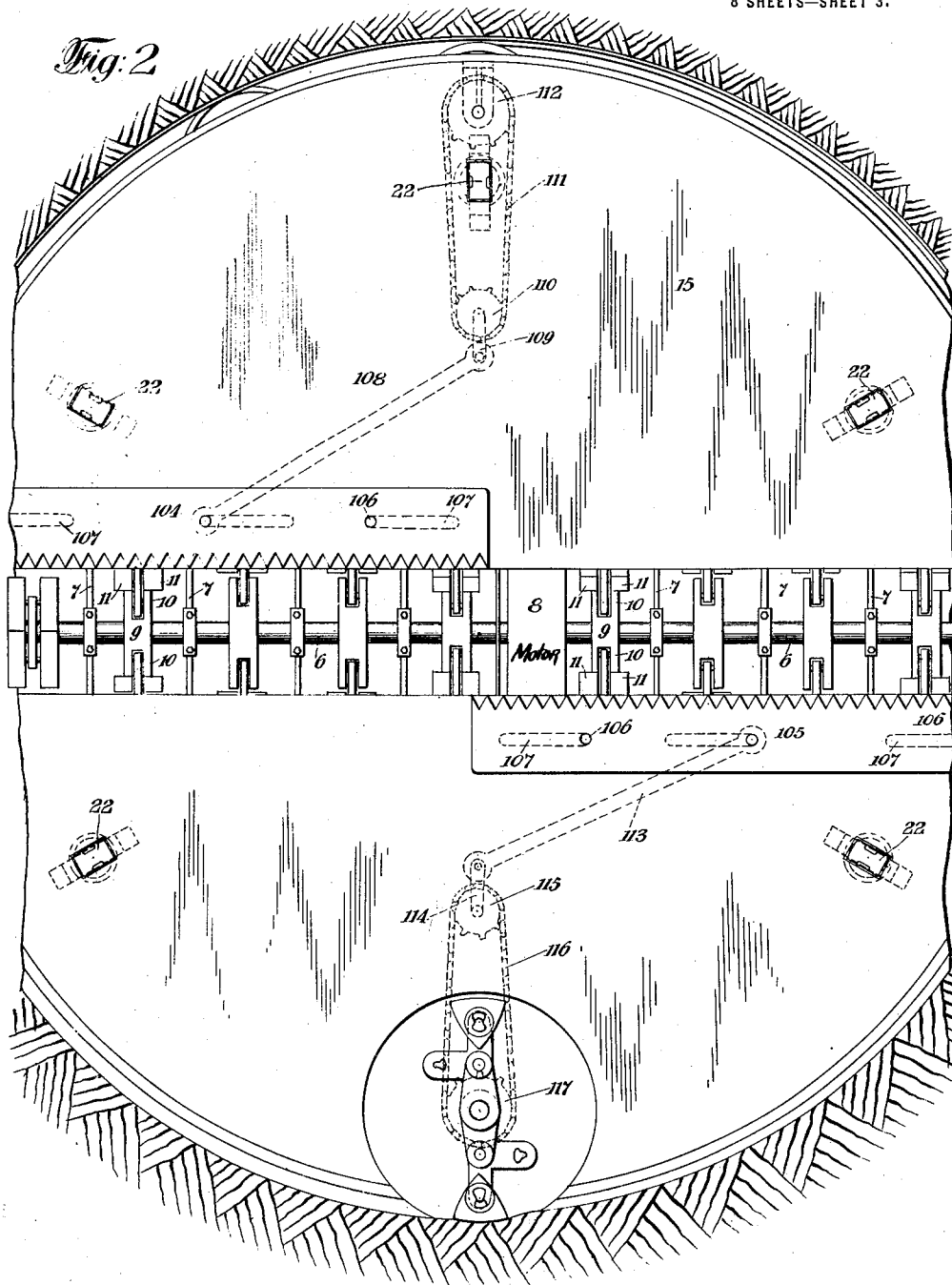
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8 SHEETS—SHEET 3.

Fig. 2



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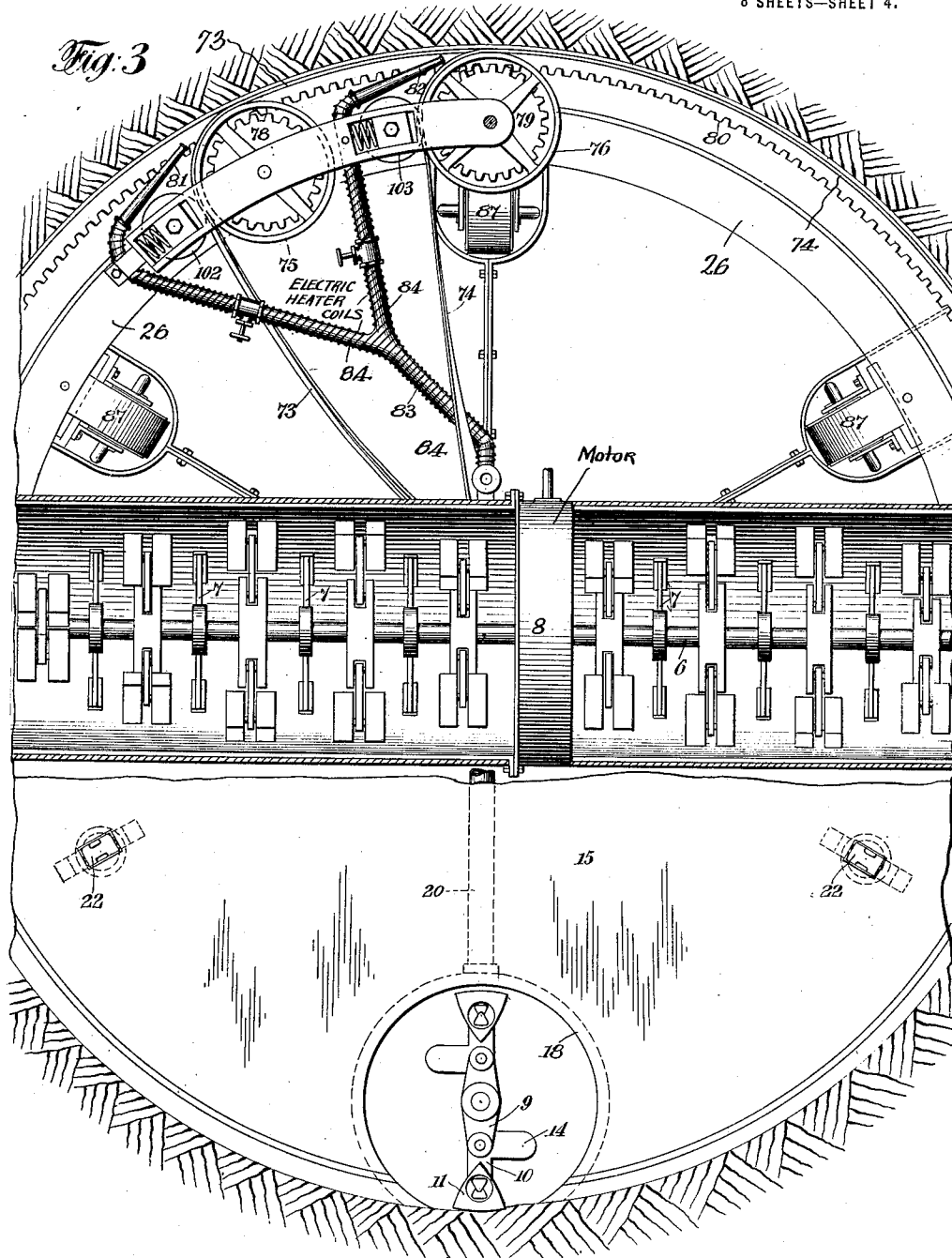
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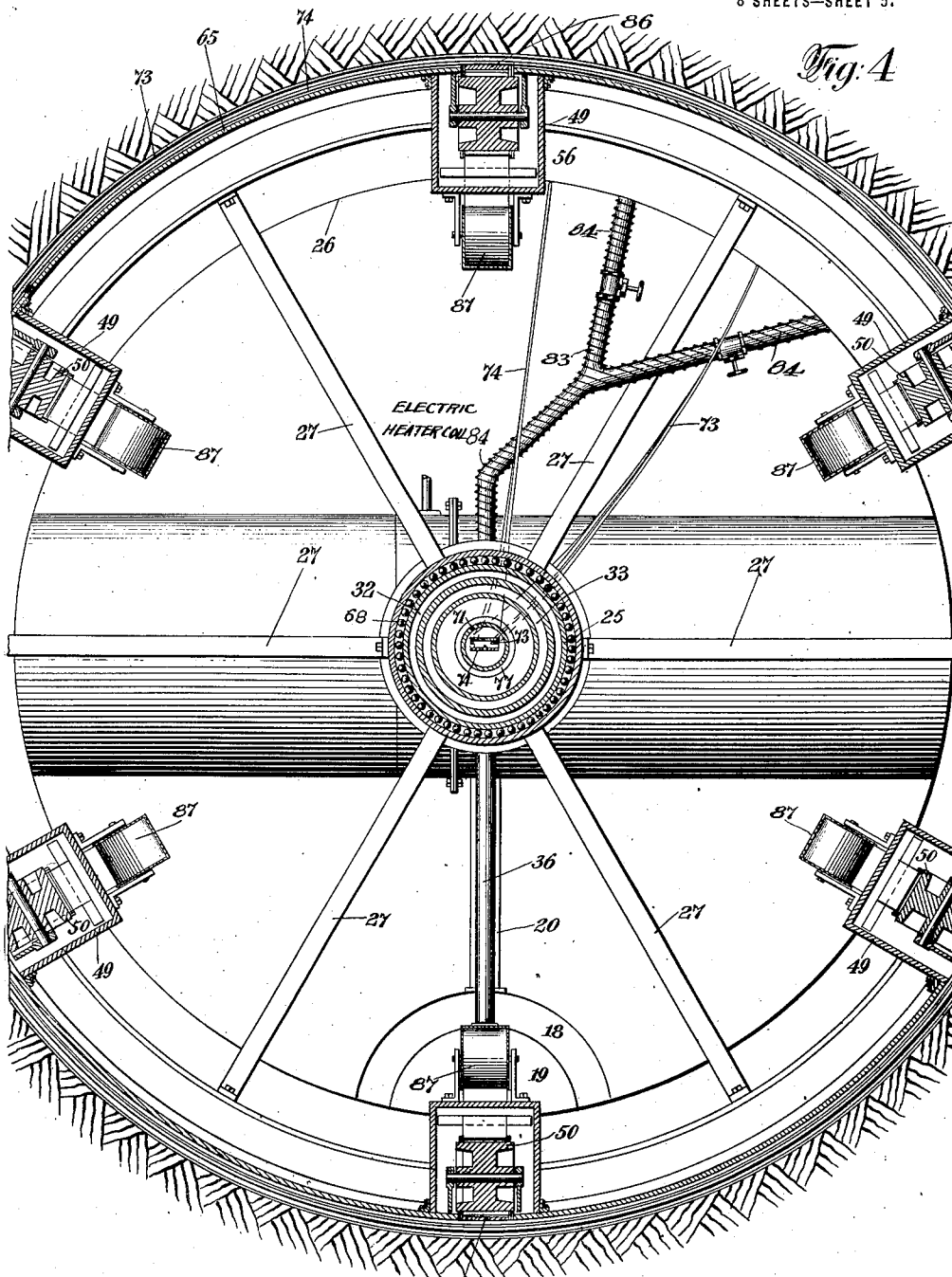
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8 SHEETS—SHEET 5.



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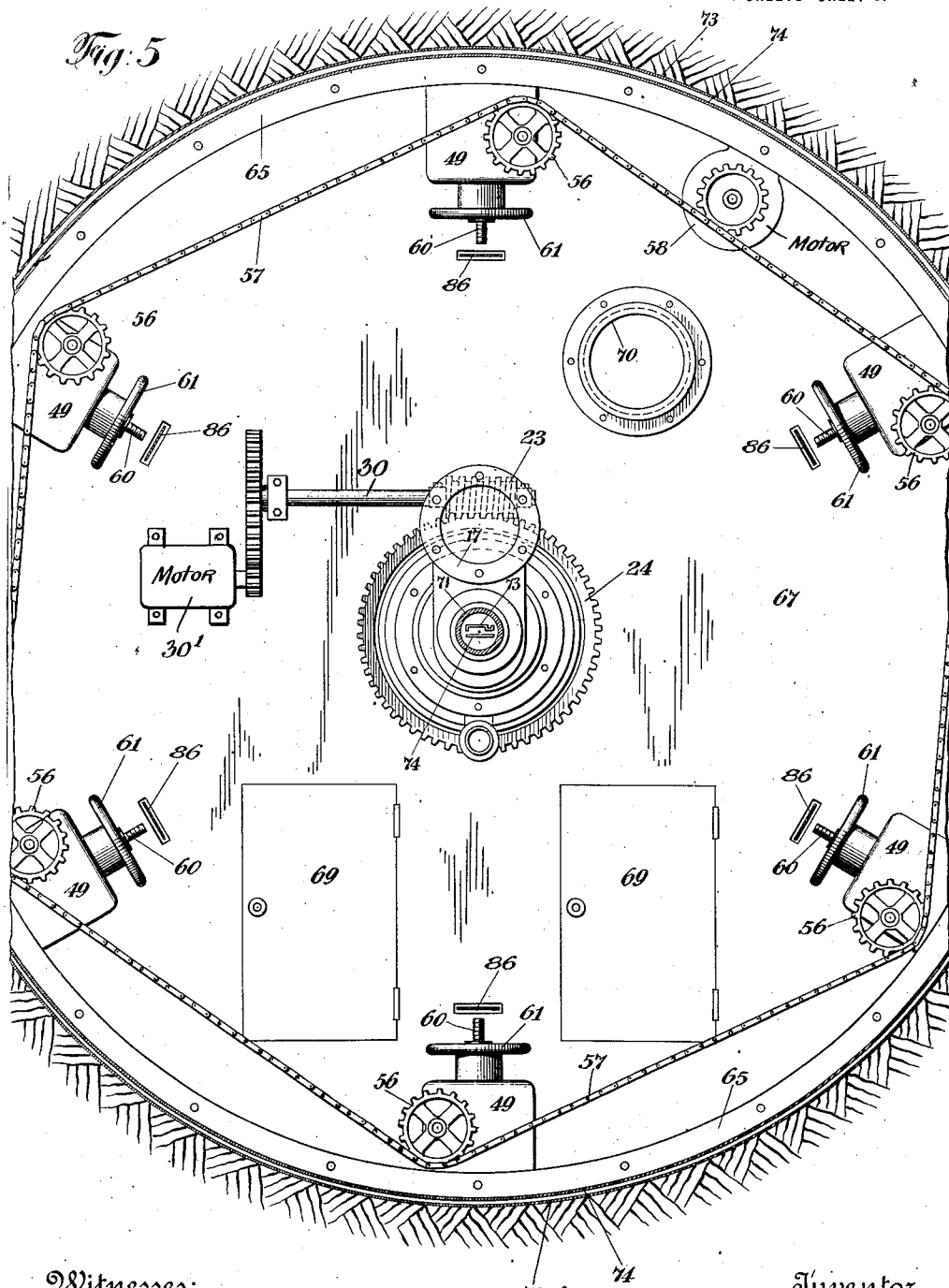
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8 SHEETS—SHEET 6.

Fig. 5



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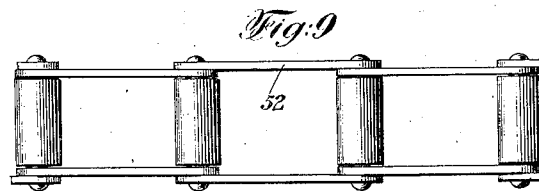
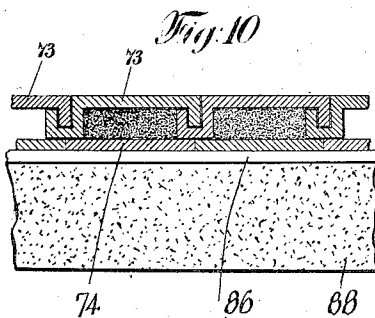
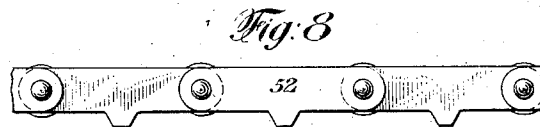
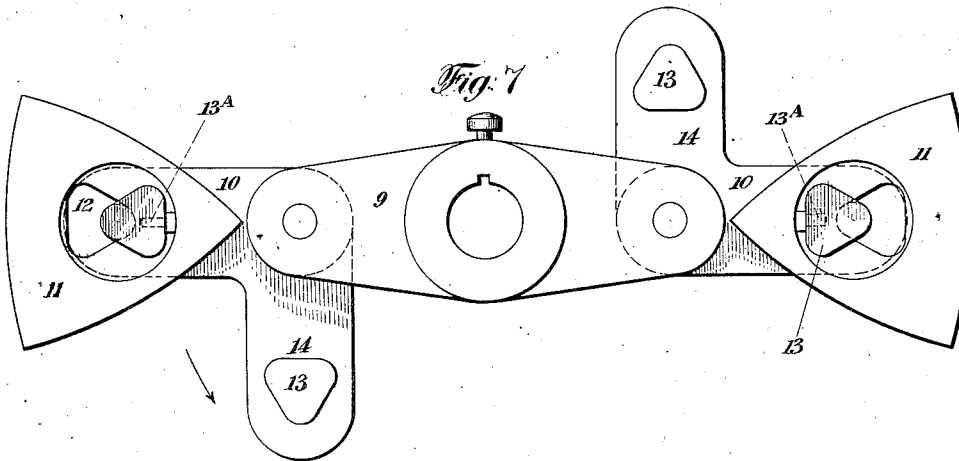
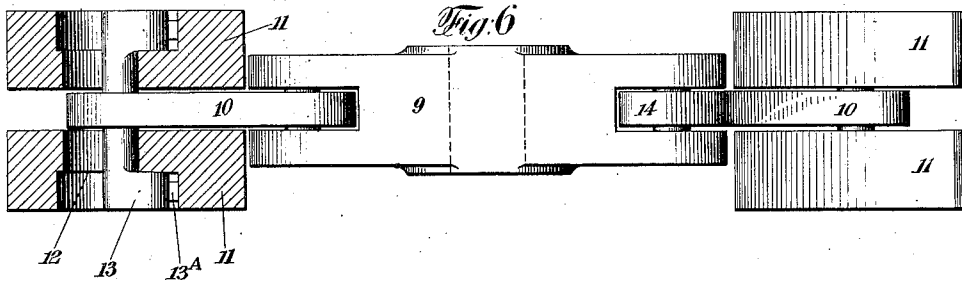
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8 SHEETS—SHEET 7.



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APPLICATION FILED AUG. 14, 1912. RENEWED JAN. 29, 1919.

1,320,144.

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8 SHEETS—SHEET 8.

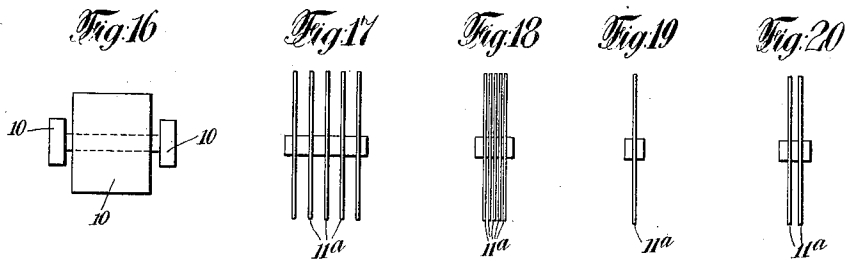
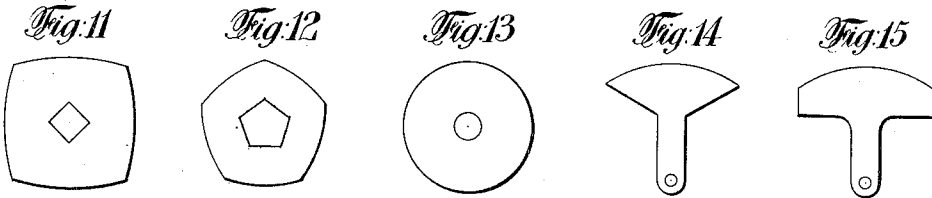


Fig. 21

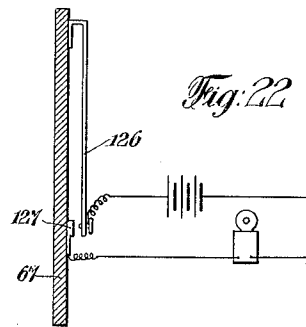
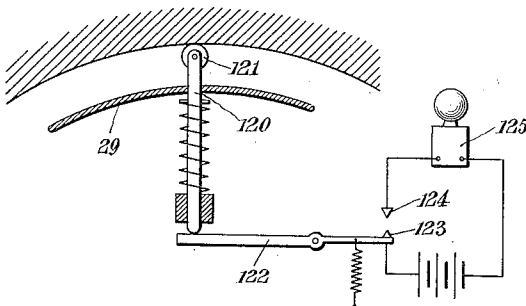
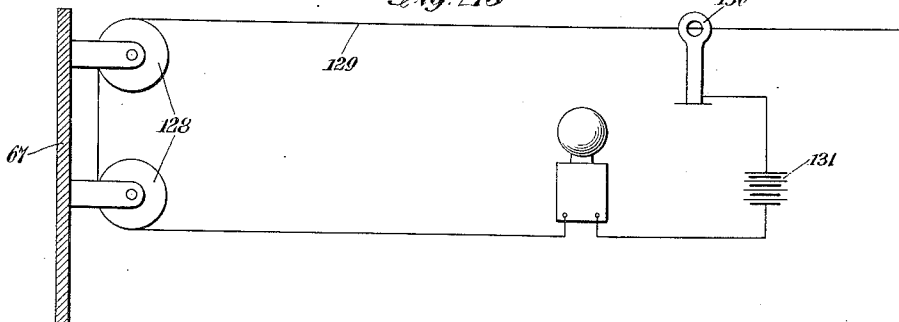


Fig. 23



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UNITED STATES PATENT OFFICE.

JOHN K. HENCKEN, OF NEW YORK, N. Y.

TUNNELING-MACHINE.

1,320,144.

Specification of Letters Patent.

Patented Oct. 28, 1919.

Application filed August 14, 1912, Serial No. 714,976. Renewed January 29, 1919. Serial No. 273,879.

To all whom it may concern:

Be it known that I, JOHN K. HENCKEN, a citizen of the United States, residing at borough of Manhattan, city of New York, in the county of New York and State of New York, 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, forming part thereof.

My invention relates to tunneling machines, and means embodying my invention are adapted for excavating tunnels, shafts, etc., without blasting or drilling.

An object of my invention is to provide effective means for rapidly boring or wearing away of the tunnel heading. Another object is to provide convenient means for disposing of the material which is excavated. Still other objects and advantages of my invention will appear from the following description.

With these objects in view my invention comprises various novel features of construction and arrangements and combinations of parts as will hereinafter more fully appear.

I shall now describe the embodiment of my invention illustrated in the accompanying drawings and shall thereafter point out my invention in claims.

Figure 1 is a central transverse longitudinal section of the front part of a machine embodying my invention, shown in operation.

Fig. 1^A is a view similar to Fig. 1 of the rear end of the machine and is a continuation of Fig. 1 on the right thereof.

Fig. 2 is a front elevation of the machine.

Fig. 3 is partly a front elevation and partly a transverse sectional elevation taken on the line 3—3 of Fig. 1.

Fig. 4 is a transverse sectional elevation taken on the line 4—4 of Fig. 1.

Fig. 5 is a transverse sectional elevation taken on the line 5—5 of Fig. 1.

Fig. 6 is a partial plan and partial longitudinal sectional detail of one of the centrifugal hammers, and

Fig. 7 is a side elevation of the same.

Fig. 8 is a side elevation, and

Fig. 9 is a plan of a portion of one of the driving sprocket chains.

Fig. 10 is a transverse sectional detail of a portion of the completed lining as laid by my machine.

Figs. 11 to 15 inclusive, are face views of different forms of hammers.

Figs. 16 to 20, inclusive, are edge views of hammers, showing different ways of manipulating them.

Fig. 21 is a diagrammatic view of my diameter gage.

Fig. 22 is a diagrammatic view of my vibrator safety device.

Fig. 23 is a diagrammatic view of my alinement device.

To cut or bore the tunnel heading, I employ a series of centrifugal hammers which are arranged longitudinally upon a transverse shaft, which shaft is made to rotate about an axis coincident with the central longitudinal axis of the tunnel. This shaft 6 extends diagrammatically across the tunnel heading, as shown in Figs. 2 and 3, and is supported upon bearings which are connected by spider braces 7 to the rotative head of the machine. The rotation of this head, which will be hereinafter described, causes this hammer-bearing shaft 6 to be rotated bodily about a central axis. This hammer-bearing shaft 6 is also rotated upon its own longitudinal axis by a motor 8 mounted upon the shaft near its middle.

The centrifugal hammers, which are mounted at intervals along the shaft 6, are preferably of the construction shown in detail in Figs. 6 and 7, and each comprises a jointed arm extending radially from the shaft and two hammers pivoted to the outer end of the arm. As shown, the jointed arm consists of the rigid member 9, which is set or fixed upon the shaft 6 in any suitable way, as by a key and set screw, and has two arms extending radially oppositely from the shaft 6 and the outer end of each of these radially extending arms is bifurcated, and pivoted within each bifurcation is an outer freely swinging arm 10 on the outer end of which are pivoted two hammers 11. This jointed arm construction resembles the human arm in construction and operation, and has proven to be extremely effective and durable in operation. The hammers 11 of each pair are arranged side by side, and are provided with a triangular opening 12, through which the rearwardly extending

triangular ends of the pivot pin 13 may pass, but which is so arranged, that the hammer will be held outwardly by centrifugal force so that the triangular opening 12 is reversed to the triangular end of the pivot pin 12 and the hammers are thereby locked on their pivots by centrifugal force, and this lock is made secure by a pin 13^A (Fig. 7). The hammers shown in Figs. 1, 6 and 7 are triangular, and their faces are arcuate corresponding substantially to the arc swept out by them, and the angle of their impact faces is therefore self-sharpening. This sharpening of the cutting angle of the hammers 11 is due to the wiping and consequently grinding action produced upon the arcuate faces, by which the cutting point which follows the one doing the cutting is ground sharp; also this grinding goes on at times when no cutting blow takes place, such as when the rock or other gritty material breaks away slightly in advance. By reason of the occasional rotative shifting of the cutting hammers 11, their cutting points are successively brought into action. Instead of being triangular, the hammers may be of various suitable shapes, and in Figs. 11 to 15, inclusive, I have shown a quadrangular and a pentagonal hammer, each with arcuate faces, a circular, and two irregular shaped hammers. As far as possible their central openings correspond in shape to the periphery of the hammers. That is to say, the hammer is provided centrally with an angular pivot opening having the same number of angles as the working face, and it is to be noted this pivot opening is arranged so that the angles of the pivot opening are located upon diameters which fall midway between the angle of the working face at the other or opposite side of the central axis, as appears in Figs. 1, 7, 11 and 12 of the drawings.

As shown in Figs. 6 and 7, the outer or swinging arm 10 may have an angularly projecting arm 14 extending at substantially right angles to the arm 10 in the direction of rotation of the arm 10, and is in all respects a duplicate thereof, so that either arm may be interchangeably connected to the hammers 11. This arm 14 serves as an inertia member to assist in the quick release of the hammer in case the material encountered is too hard to be penetrated by the impact of the blow. When the hammer strikes, the inertia of the arm 14 carries the arm outward and assists in releasing the hammers from the material and thereby loosens the jar which is transmitted to the rigid arm 9. Two pairs of hammers are thereby arranged radially oppositely to each other and it is apparent that, as the shaft 6 is rotated upon its axis by the motor 8, centrifugal force will hold the hammers 11 outward in a radial line in alignment with the arm 9, and

that centrifugal force will tend to hold them in this position and that this tendency is slightly reduced by the weighted angular extensions 14. For the sake of clarity, these extensions 14 are not shown in the assembly views. The centrifugal hammers are arranged spirally about the shaft 6, as shown in Fig. 1, so that the hammers impart a succession of blows upon the face of the rock.

Instead of a pair of hammers 11, various members and sizes of hammers may be employed, according to the work to be done. For instance the end of the arm 10 may be bifurcated and one hammer mounted therein, as shown in Fig. 16. Also when it is merely desired to cut channels instead of breaking the material into small particles, one or more very thin hammers 11^a may be used, spaced at the desired distance apart, as shown in Figs. 17 to 20, inclusive.

The rotary head of the machine has a front shield or bulkhead 15, which has a transverse central slot or opening through which the centrifugal hammers work upon the face of the rock or other material which is being bored. The rotary hammers are inclosed in a cylindrical casing or shield 16, which has at its front side a longitudinal opening registering with that in the front bulkhead 15, and at its rear side has a substantially central cylindrical opening communicating with the discharge or outlet pipe 17, as will be later described.

Due to the arrangement of the hammers upon the shaft 6, while the outer hammer may cut beyond the casing to any desired extent, they will be rotated in an arc such that they will not cut squarely up to the outer edge of the full diameter of the tunnel at the extreme face of the tunnel, and to assist the outer pairs of hammers, an auxiliary centrifugal hammer device 18 may be employed, as shown in Figs. 1 and 3. This hammer device 18 is arranged at the outer edge of periphery of the rotating head just back of the front bulkhead 15, and is rotated by a motor 19 just back of an opening provided for this purpose in the bulkhead 15. This hammer device 18 discharges the pulverized rock or material through the pipe 20 into the cylindrical casing 16, where the pulverized rock is further comminuted by the action of the hammers until it is reduced to sufficient fineness to pass through the opening in a sieve or screen 21 controlling the opening into the outlet or discharge pipe 17.

To facilitate the rotation of the head, a number of anti-friction rollers 22 are provided about the front head or bulkhead 15, which receive the thrust and rotate over the face of the tunnel heading. The rotative head is rotated by means of the worm 23 (see Figs. 1 and 5), which meshes with a worm wheel 24 which is secured to a rearwardly extending conduit 25 having a plu-

reality of passages, as will appear later, and arranged in alinement with the outlet pipe 17, as shown in Fig. 1. This conduit 25 is connected to an annular supporting frame 5 or plate 26 by spider arms 27, and this annular frame 26 is connected by braces 28 to the head which includes the cylindrical shield 29 and the front shield or bulkhead 15. The worm 23 is continuously rotated 10 by any suitable source of power applied to the shaft 30, such as the motor 30' shown as geared thereto (Fig. 5), and it is apparent that through these means the head of the machine is continuously rotated. The annular frame 26 is flanged at its periphery as shown in Fig. 1, and rides upon anti-friction rollers 31.

By the means above described, the boring is made. Turning now to the disposition of 20 the material which is cut out and broken up by my centrifugal hammers, the walls of the conduit 25 are cored out to provide a plurality of annular conduits to conduct air, water, cement, etc., to the head of the machine, and I have shown an air conduit 32 and a water conduit 33. Compressed air enters from an outside source through the pipe 34, which communicates with the air conduit 32 and water is forced in under pressure 30 through the pipe 35 which communicates with the water conduit 33. The compressed air passes through the pipe 36, which communicates with the front end of the air conduit 32 and which leads to the motor 19 35 which operates the peripheral hammer device 18, and through one or more pipes 37 which open into the interior of the revolving head, and escapes from these pipes 37 and from the motor 19 into the chamber of the revolving head and passes into the cylindrical hammer shield 16 and out through the conduit 25 and exhaust pipe 17. The water 40 which enters the conduit 33 passes through a pipe 38 which communicates with the water conduit 33 and leads to the opening in the front of the shield 16 and serves to direct the water upon the tunnel heading which is being operated upon. The water then passes 50 through the shield 16 and rearwardly through the conduit 25 and the exhaust pipe 17 as does the compressed air. These outwardly moving fluids carry with them the broken rock and this is disposed of by the mechanism illustrated in Fig. 1A.

55 Leading off from the exhaust pipe 17 is the conduit 39, which communicates with a sand measuring receptacle 40, and leading off from the exhaust pipe 17 in rear of the pipe 39 is a pipe 41 which leads to a broken stone measuring receptacle 42, deflectors being provided at the entrance to the receptacle to direct the material to the bottom of the receptacle, and self closing gates or valves 48 being provided at the top of each 65 receptacle opposite the inlet to shut off the

draft when the receptacles are full. Both of these receptacles communicate through manually controlled valves with a conduit 43, which leads downwardly into a grouting machine 44. A cement receptacle 45 70 arranged at the rear of and between the receptacles 40 and 42 also communicates through a manually controlled valve with the conduit 43 and through these means the sand and cement are admitted to the grouting machines for mixing to form concrete 75 in the usual way. A manually controlled screen 46 is arranged across the entrance to the sand pipe 39, in the position shown in Fig. 1A and a manually controlled inclined 80 screen 47 is arranged at the entrance to the broken stone pipe 41 and extends partially across the pipe 17, and the mesh of the screen is such that only sand can pass 85 through the screen 46 into the sand receptacle 40, and part of the coarser material will be deflected by the screen 47 into the broken stone receptacle 42 through the pipe 41. The outlet pipes 200 and 201 for the receptacles 40 and 42 lead into a return pipe 90 201' (Fig. 1A) which leads back to the exhaust pipe 17, and in this return pipe an auxiliary exhausting device 201^a is preferably provided. The draft in the pipes is so regulated that it is stronger through the 95 pipe 39 than it is through the pipe 17 with the result that sand will be drawn up through the screen 46 as long as the gate or valve 48 is open: while the draft through the pipe 41 is less strong than through the pipe 17, 100 with the result that the sand will be drawn on out of the pipe 17 through the screen 47, while the broken stone will be deflected into the pipe 41 by the inclined screen 47. The surplus material at all times passes out of 105 the exhaust pipe 17 and is disposed of at the rear in any suitable way, and when the valves 48 are closed and no material is being diverted to the receptacles 40 and 42, it is apparent that all of the exhaust material 110 passes out of the pipe 17.

To advance the machine as the boring is made, continuous power-driven means are provided, which will now be described. Disposed about the periphery of the shield back 115 of the head of the machine are six carriages consisting of suitable frames 49 (Figs. 1 and 5) in which are journaled two sprocket wheels 50 and 51 in front and rear respectively, and a sprocket drive chain 52 passes 120 around these two sprocket wheels as appears at the bottom in Fig. 1. This chain is composed of a succession of pivoted links separated by sleeves about the pivots, which serve as anti-friction rollers, as shown in 125 detail in Figs. 8 and 9, and the lower side of each link is provided with a central downward projection, as illustrated in Fig. 8, so that each of these chains 52 may straddle the longitudinal ribbon which is auto- 130

matically laid as part of the lining of the tunnel, as will hereinafter appear. The sprocket chain 52 passes underneath the central guide frame 53 provided with guide rollers 54 at its ends (Fig. 1) and the chain rides upon the lining to the tunnel which has been laid, as will hereinafter be described. To actuate these sprocket chains, means are provided for rotating the rear sprocket wheel 51 of each carriage consisting of the worm wheel 51' rotative with the sprocket wheel 51 and engaged by a worm 55 on the end of which is a sprocket wheel 56, and these six sprocket wheels are connected and driven by a sprocket chain 57, which is continuously rotated by a motor 58 (see Fig. 5) of any suitable kind. By these means the sprocket wheels 50 and 51 of each of the six carriages are continuously rotated and the combined tractive effort of the chains 52 is ample to force the machine ahead at a continuous rate of speed, dependent upon the rapidity with which the chain 57 is driven by the motor 58.

In order to change the direction in which the machine is driven ahead, as is necessary in turning corners, for example, means are provided for changing the relative radial disposition of the sprocket wheels 50 and 51. As shown in Fig. 1, the sprocket wheel 50 is journaled in bearings 59, which are radially adjustable relative to the tunnel opening, and the radial disposition of the bearings 59 is determined by a screw 60, which is controlled by a hand wheel 61, and the bearing is yieldingly forced radially outward against the wall of the tunnel, by a stiff coiled spring 62, so that the sprocket wheels will yield in case they encounter any unevenness due to wearing or breaking of any of the hammers, or other reason. A hand wheel 63 controls the adjustment of the bearing in which the rear sprocket wheel 51 is journaled through similar means, while the radial disposition of the guide frame 53 is controlled through a similar means by a central hand wheel 64. It is now apparent that, by adjusting the relative radial positions of the front and rear sprocket wheels 50 and 51, through the means just described, the direction of the movement of the machine may be altered at will. The carriage frames 49 are secured to the cylindrical shield 65 of the machine by angle irons 66, as shown in Fig. 1. A rear bulkhead 67 is also secured to the shield 65 and is provided with a central opening which serves as a bearing for the rotative conduit 25, antifriction rollers 68 being provided for this purpose. This rear bulkhead 67 is provided with two doors 69, as shown particularly in Fig. 5, to provide access to the forward part of the machine, and also with a sight opening 70 to enable the operators to inspect the forward part of the machine without entering it.

The exhaust pipe 17 is made telescopic, as appears in Fig. 1^A to provide a continuous conduit communicating with the rear as the machine advances, all of the telescopic portions not being shown. It is apparent that the pressure exerted by the grouting behind the shield will assist in moving the machine forward, and in certain instances this pressure may be relied upon as the sole means of advancing the machine.

Turning now to the automatic means for lining the walls of the tunnels as the machine progresses, I provide for this purpose means for first coating the rough walls with a layer of thin concrete and for then winding overlapping and interlocking steel ribbons spirally about the tunnel walls, and for then coating this lining with a second layer of thin concrete, and for then winding a second lining of steel ribbon spirally over this second concrete coating, and for then laying a plurality of longitudinal steel ribbons, and for then lining the entire walls with coarse cement which may be made in the apparatus shown in Fig. 1^A. Entering the exhaust pipe 17 at the point where it makes a turn, as shown in Fig. 1, is a ribbon conduit 71, which extends centrally into the rotative conduit 25. A packing gland 72 is provided to make the joint between the pipes 71 and 17 air tight, and two steel bands or ribbons 73 and 74 enter through this conduit 71 and pass out over the wheels or pulleys 75 and 76, respectively, at the periphery of the tunnel opening, the former in advance of the latter. Gaskets 77 are provided in the conduit 71 to prevent the escape of any air or water through the conduit 71. These reels 75 and 76 are rotated by pinions 78 and 79, respectively, on the axes of which they are mounted to rotate therewith (Figs. 1 and 3), and which mesh with a stationary circular rack 80 extending about the shield of the machine just ahead of the supporting plate 26. The ribbon 73 is flanged, as shown in detail in Fig. 10, and the ribbon is spun about the periphery of the tunnel as the head revolves, so that the successive windings of the ribbon interlock, as shown in Fig. 10, to form the outer layer of the lining of the tunnel. The ribbon 74 is flat and the successive windings are merely wound side by side by the reel 76. To straighten out any folds in the ribbons as they pass over their spools, smoothing wheels 102 and 103 (Fig. 3) are mounted in slidable bearings and are pressed by springs against the peripheries of the reels 75 and 76, respectively, and each ribbon passes between the peripheries of its respective smoothing wheel and reel and is smoothed thereby. These wheels also serve to hold the ribbon tightly over their reels and to produce a tractive effort which will cause the ribbons to be laid under tension. This is important

where the boring is being made through sandy or soft material which is not self supporting.

Before the ribbon 73 is spun in place, the walls are coated with a thin coating of fine concrete and another coating of fine concrete is immediately laid upon this lining of ribbon 73. As shown in Figs. 3 and 4, these respective coatings are spread by two nozzles 81 and 82, the former of which precedes the reel 75 and the latter of which follows the reel 75, and these nozzles 81 and 82 communicate with the common concrete pipe 83 into which the fine concrete is forced from any suitable source into the pipe 83. If it be desirable to use asphalt for these linings instead of concrete, it will be necessary to keep the asphalt hot so that it will flow sufficiently freely, and for this purpose electrical conducting wires 84 may be wound around the pipe 83 and its two branches, as shown, and an electrical current passed through these conducting wires in order to maintain a high temperature.

In the illustrated machine, there are in all six longitudinal ribbons 86 laid, as shown in Figs. 1, 4 and 5, one ribbon being laid by each carriage. This ribbon is laid longitudinally of the tunnel between the downward projections of the side links of the sprocket chains 52 as the chain moves along, and is fed over a pulley 87 from a reel or other suitable source of supply from the rear.

The final layer of the lining is a thick layer of coarse concrete 88, which is laid upon the longitudinal ribbons 86 and upon the outer lining formed by the ribbons 73 and 74, and the interposed thin concrete. This layer of coarse concrete is forced out of the grouting machine by air, which is admitted through the pipe 89, for the purpose of agitating the mixture, and enters the pipe 85 and, under the control of a manually operated valve 90, passes on to the two branch pipes 91 and 92 which open underneath the cylindrical shield 93 of this portion of the machine at diametrically opposite points. This layer of concrete 88 is thus forced underneath the shield by the air pressure and fills up the entire space under the shield, and steam is admitted through the pipe 94 into the steam chambers 95 and 96 in the shield 93, and this steam serves to quickly set the concrete 88. To permit the shield 93 to slide freely over the layer 88 of concrete as the machine advances, this layer of concrete may be coated with paraffin or other lubricant, which enters from any suitable source through a plurality of pipes 97 at various points about the periphery of the tunnel. This inner layer 88 of coarse concrete is formed of the broken stone and sand which enters from the respective receptacles 40 and 42 into

the grouting machine while the inner layer of fine grout, which is laid by the nozzles 81 and 82, is composed only of sand and cement. Thus the tunnel is lined, as the machines moves along, first with a thin layer of fine concrete, then with a spiral steel lining, then with another thin layer of fine concrete, then with another spiral steel lining, then with longitudinal reinforcing ribbons, and then with a thick layer of coarse grout. The cores 98 and 99 are carried by the shield 93 and form the sewer and wire conduits, respectively, in the concrete lining at the bottom of the tunnel. The conduit 43 (Fig. 1^A) has a branch leading off therefrom to enter a grouting machine (not shown), admission to which is controlled by two-way valve 101, which may be used alternately while the other is being charged.

It will be apparent, that, with the hammers arranged close together upon the shaft 6 and with these hammers revolved bodily over the face of the tunnel, as above described, the rock will be reduced to very fine fragments, and that the face of the rock will be completely cut away as the boring progresses. With the hammers farther apart upon the shaft 6, however, and particularly if the shaft 6 be reciprocated over the face of the rock instead of revolved bodily about its center as an axis, grooves will be cut by the rotating hammers and the rock between the planes of rotation of the hammers will not be cut away. The hammers would be so set when it is not desired to break up the material being bored into small fragments, as, for example, in coal mining. The construction of hammers illustrated in Figs. 11 to 20 is especially suitable for this purpose. In order to cut away the ridges left by the machine when so operated, one or more reciprocative saws may be employed which follow up the hammers and cut away material which is left by them. Such saws may be operated as shown in Fig. 2, in which two reciprocative saws 104 and 105 are employed at opposite sides and opposite ends of the operating slot in the front bulkhead 15. These saws are arranged just back of the bulkhead 15 and slide upon guide pins 106 which are secured to and carried by the saws and project through guide slots 107 in the bulkhead 16. These saws are reciprocated by cranks. The saw 104 is reciprocated by a pitman 108, which is operated by a crank 109 on a sprocket wheel 110 mounted on the back of the bulkhead 15 and rotated by a sprocket chain 111, which is driven by the sprocket wheel 112 on the shaft of the pulley 76. The saw 105 is operated by a pitman 113, which is operated by a crank 114 on the sprocket wheel 115, which is rotated by a sprocket chain 116, this sprocket

chain being driven by the sprocket wheel 117, which is mounted on the shaft of the motor 19, as appears in Figs. 1 and 2, the parts omitted in Fig. 1 to avoid confusion being of substantially the same construction as the corresponding parts there shown for operating the other saw 104 and as clearly appears in Fig. 2.

In order to be always informed whether or not the machine is working properly, I provide certain safeguards. To determine the diameter of the tunnel which is being cut, I provide on the rotary head the diameter gage illustrated by a diagram in Fig. 21. A spring pressed rod 120 slides through an opening in the shield 29 and carries at its outer end an antifriction wheel 121 which rotates about the periphery of the tunnel. The device is so set that the inner end of its rod 120 is in position to operate on a pivoted contact lever 122, and if a hammer breaks or for any reason the cut is smaller than that for which the machine is set, the rod 120 is pressed in thereby and operates the contact lever 122 to close the electric contacts 123 and 124 and sound an alarm as an electric bell 125, or, by means of suitable arrangements, as is well understood in the engineering art, this device may perform other functions.

Another automatic safety device is a vibrator cut out diagrammatically illustrated in Fig. 22. In the bulk head 67 I provide a vibratory electric contact member 126 normally out of contact with a stationary electric contact 127. When for any reason the cut made by the machine is uneven, as would be caused, for instance, by the breaking or undue wearing of the hammer, unusual vibration results as the machine is advanced and the vibrating member 126 is thereby caused to close the switch stationary contact 127, and an alarm may be sounded or other operations performed as in the case of the diameter gage.

To determine whether or not the machine is advancing in a perfectly direct line, an alinement guide may be used, such as is illustrated diagrammatically in Fig. 23. On the bulkhead 67 two pulleys 128 may be provided over which runs an electric conducting wire 129, which is connected at one end to a contact guide 130 suitably located at the rear of the machine, and which passes rearwardly through an eye in the contact guide 130 and is fed out from a reel (not shown) at the rear of the machine. The contact guide 130 is so positioned that when the head of the machine is headed in the right direction, the conductor 129 passes through the eye in the guide 130 without making contact therewith, but if the head of the machine turns from direct alinement with the rear of the machine, the conductor 129 contacts with the the side of the eye in

the guide 130, and closes an electric circuit through the battery 131. This electric circuit may, as in the case of the other safety devices, be employed to sound an alarm to cut off the power from the machine.

It will be noted that the rollers 22 are adjustable toward and away from the tunnel heading to vary the depth of the cut.

It is obvious that various modifications may be made in the construction shown and above particularly described within the principle and scope of my invention.

I claim:

1. In a tunneling machine, a centrifugal hammer device comprising a rotative hammer having a peripheral working face provided with a plurality of salient angles forming cutting edges and provided centrally with an angular pivot opening having the same number of angles as the working face and arranged so that the angles of the pivot opening are located upon diameters which fall between the angles of the working face at the opposite side of the central axis, a pivotally jointed arm having an outer member and an inner member, a pivot pin carried by the outer member of the arm and fitting with sufficient looseness in the angular pivot opening of the hammer to occupy one of the angles of this opening, and means engaging the inner member of the arm for operating the arm and the hammer carried thereby.

2. In a tunneling machine, a centrifugal hammer device comprising a rotative shaft, a jointed arm having an inner member rotatively carried by the shaft and having an outer member pivoted to the inner member, a hammer pivoted to the outer member of the arm and having an arcuate face terminating in salient angles forming cutting edges, and means for rotating the shaft to operate the hammer.

3. A cutting head for tunneling machines comprising a transverse shaft, a plurality of hammer devices carried by the shaft and arranged along the length thereof, each hammer device comprising a rigid arm extending radially from the shaft, a freely swinging arm pivoted to the outer end of the rigid arm, and a hammer pivoted to the outer end of the pivoted arm, means for rotating the shaft upon its longitudinal axis, and means for rotating the shaft about its transverse central axis substantially coincident with the longitudinal axis of the tunnel.

4. A cutting head for tunneling machines comprising a transverse shaft, a plurality of centrifugal hammer devices carried by the shaft and arranged along the length thereof, each hammer device comprising a jointed arm extending radially from the shaft, and a hammer provided with arcuate faces pivoted to the outer end of the arm, means for rotating the shaft upon its longitudinal axis,

and means for rotating the shaft about its transverse central axis substantially coincident with the longitudinal axis of the tunnel.

5 5. A tunneling machine comprising a rotative head forming an inclosing shell having a front end closure provided with an opening, a transverse shaft carried by the head, a plurality of centrifugal hammers carried by the shaft and arranged along the length thereof, means for rotating the shaft upon its longitudinal axis and adapted to operate through the opening in the front end closure of the head, and means for rotating the head.

15 6. A tunneling machine comprising a rotative cutting head forming an inclosing shell having a front end closure provided with a transversely slotted opening, means to rotate the cutting head, cutting means adapted to operate through said slotted opening, and feeding means to advance the cutting head along its axis of rotation as the cutting is made.

25 7. A tunneling machine comprising a rotative head having a front end closure provided with a transversely slotted opening, a transverse shaft carried by the rotative shaft in proximity to and parallel with said transversely slotted end opening in the head, a plurality of centrifugal hammers carried by the shaft and arranged along the length thereof to operate through said slotted opening in the end of the head, means to rotate the shaft upon its longitudinal axis, means to rotate the rotative head, and an auxiliary cutting device disposed at the periphery of the rotative head and operative to cut about the periphery of the tunnel in proximity to the tunnel heading to provide clearance for the rotative head.

40 8. A tunneling machine comprising a rotative head, a transverse shaft carried by the rotative shaft, a plurality of centrifugal hammers carried by the shaft and arranged along the length thereof, means to rotate the shaft upon its longitudinal axis, means to rotate the rotative head, and an auxiliary cutting device disposed at the periphery of the rotative head and operative to cut about the periphery of the tunnel in proximity to the tunnel heading, comprising a centrifugal hammer device rotative upon an axis substantially parallel to that of the rotative head.

55 9. A tunneling machine comprising a rotative head, a transverse shaft carried by the rotative shaft, a plurality of centrifugal hammers carried by the shaft and arranged along the length thereof, means to rotate

the shaft upon its longitudinal axis, means to rotate the rotative head, and an auxiliary cutting device disposed at the periphery of the rotative head and operative to cut about the periphery of the tunnel in proximity to the tunnel heading, comprising a rotative shaft extending substantially parallel to the axis of the rotative head, a radially extending arm rigidly secured to the shaft, a freely swinging arm pivoted to the outer end of the rigid arm, a hammer pivoted to the outer end of the pivoted arm, and means to rotate the shaft.

10. A cutting head for tunneling machines comprising a transverse shaft, a plurality of hammer devices carried by the shaft and arranged along the length thereof, each hammer device comprising a rigid arm extending radially from the shaft, a freely swinging arm pivoted to the outer end of the rigid arm, and a hammer pivoted to the outer end of the pivoted arm.

11. In a tunneling machine, a centrifugal hammer device comprising a rotative cutting hammer having a peripheral working face provided with a plurality of salient angles forming cutting edges and provided centrally with an angular pivot opening having the same number of angles as the working face and arranged so that the angles of the pivot opening are located upon diameters which fall substantially midway between the angles of the working face at the opposite side of the central axis, and means for carrying and operating such hammer including a pivot pin fitting with sufficient looseness in the angular pivot opening of the hammer to enter one of the angles of this opening.

12. In a tunneling machine, a centrifugal hammer device comprising a rotative cutting hammer, of substantially triangular shape having sharp cutting edges formed by the angles of the triangle and provided centrally with a substantially triangular pivot opening the triangular sides of which extend substantially in the same direction as the triangular sides of the working face of the hammer, and means for carrying and operating such hammer including a pivot pin fitting with sufficient looseness in the triangular pivot opening of the hammer to enter one of the angles of this opening.

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

JOHN K. HENCKEN.

Witnesses:

VICTOR D. BORST,
BERNARD COWEN.