

[54] **RAISE BORING MACHINE**

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[58] Field of Search299/31, 10; 175/94

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[57] **ABSTRACT**

A raise boring machine for producing a raise of circular cross section has a main frame with a rotating drum which has two rotating tangentially cutting heads. Three wall engaging shoes are suspended in rods in toggle arrangements and they are biased outwardly against the wall of the raise by means of spring devices braced between the shoes. By this arrangement these shoes guide the machine by sliding on the wall during a cutting advance of the main frame effected by means of six advance jacks connected between the main frame and a rear anchoring frame. During the time that the anchoring frame is released from the raise and pulled forward by the advance jacks, however, the same shoes hold the main frame firmly in the raise as a result of the action of the toggle joints. Steering is effected by moving the rear portion of the main frame sidewise in the anchoring frame in any desired direction.

17 Claims, 8 Drawing Figures

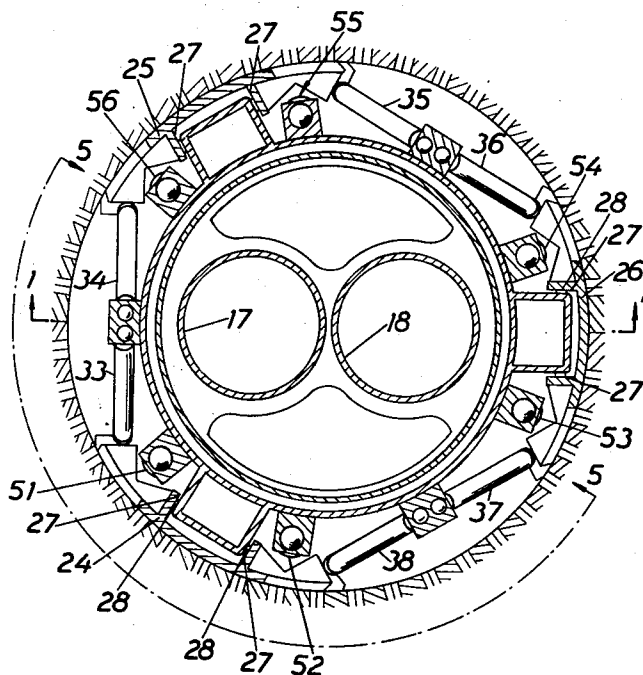
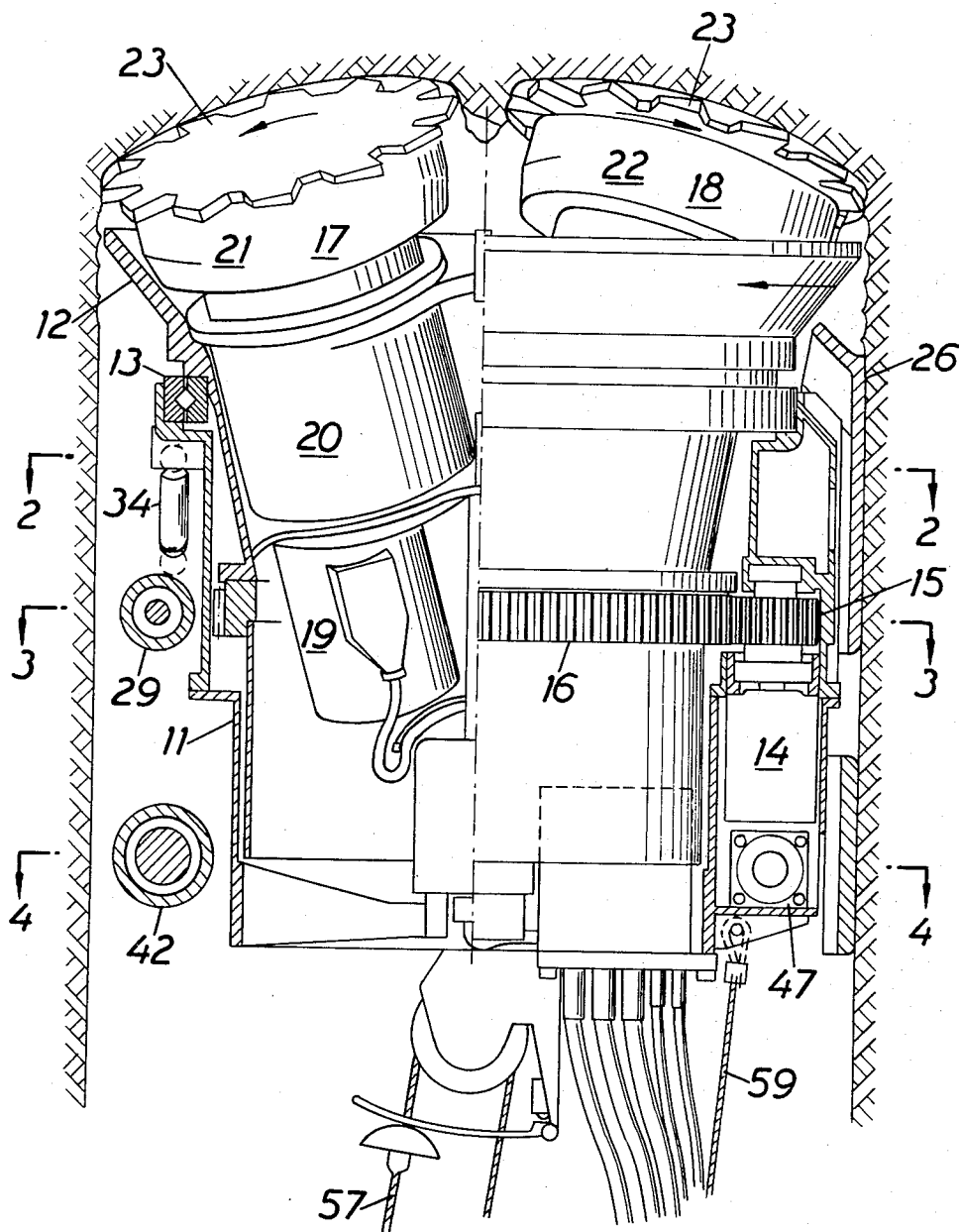


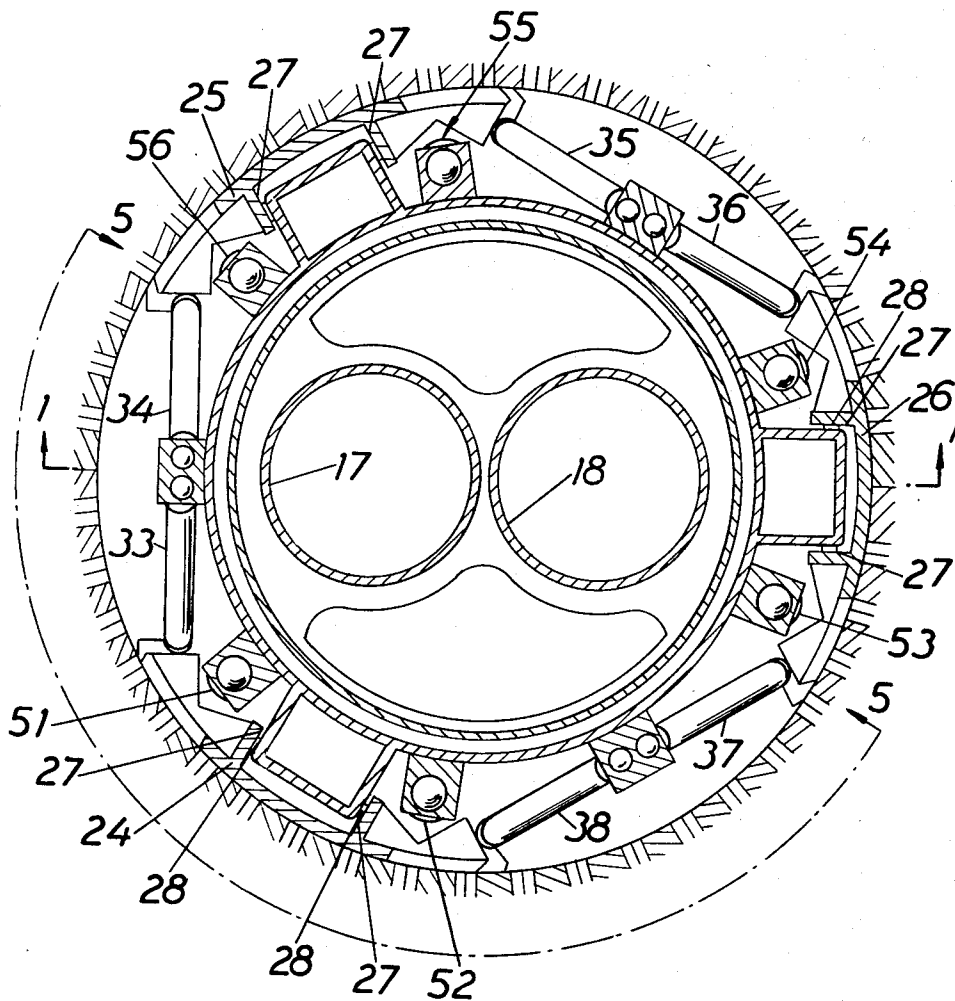
Fig. 1



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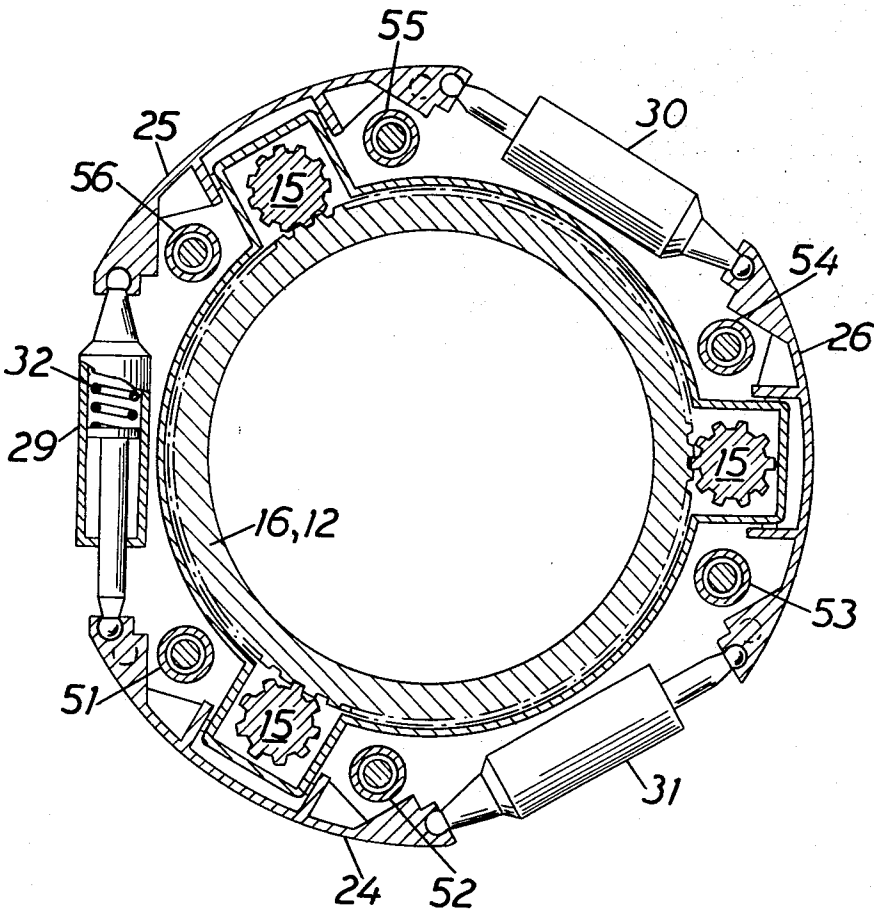
Fig. 2



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Fig. 3

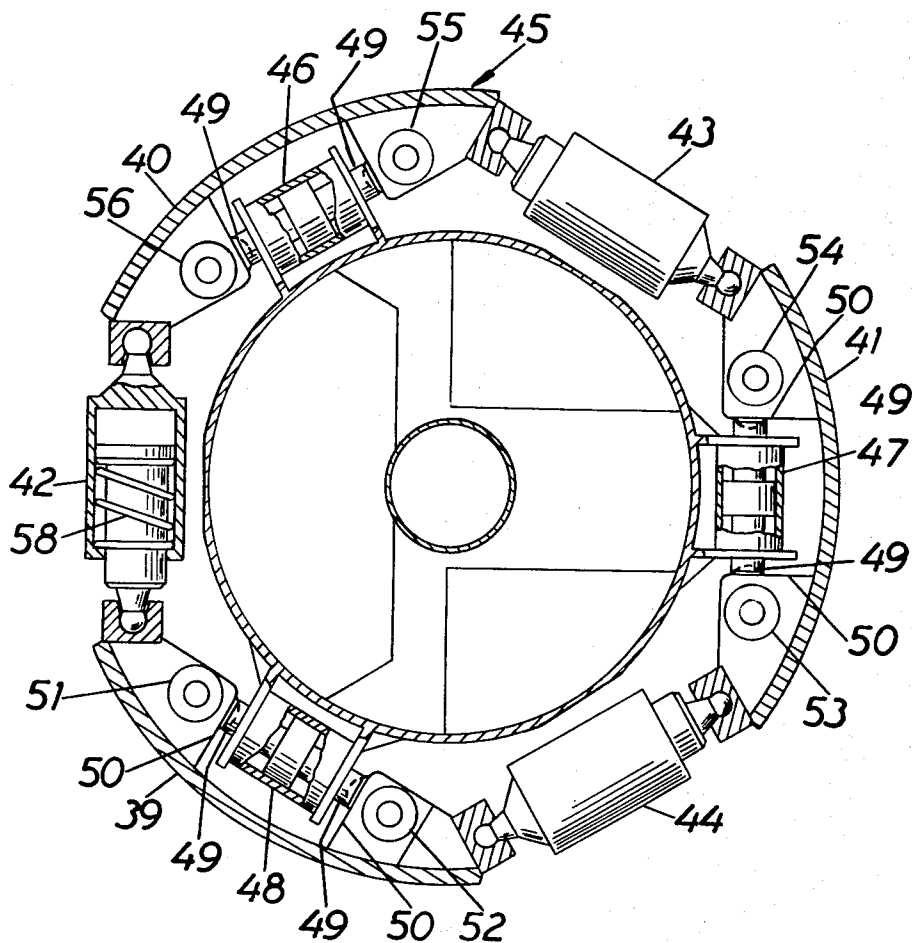


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Fig. 4



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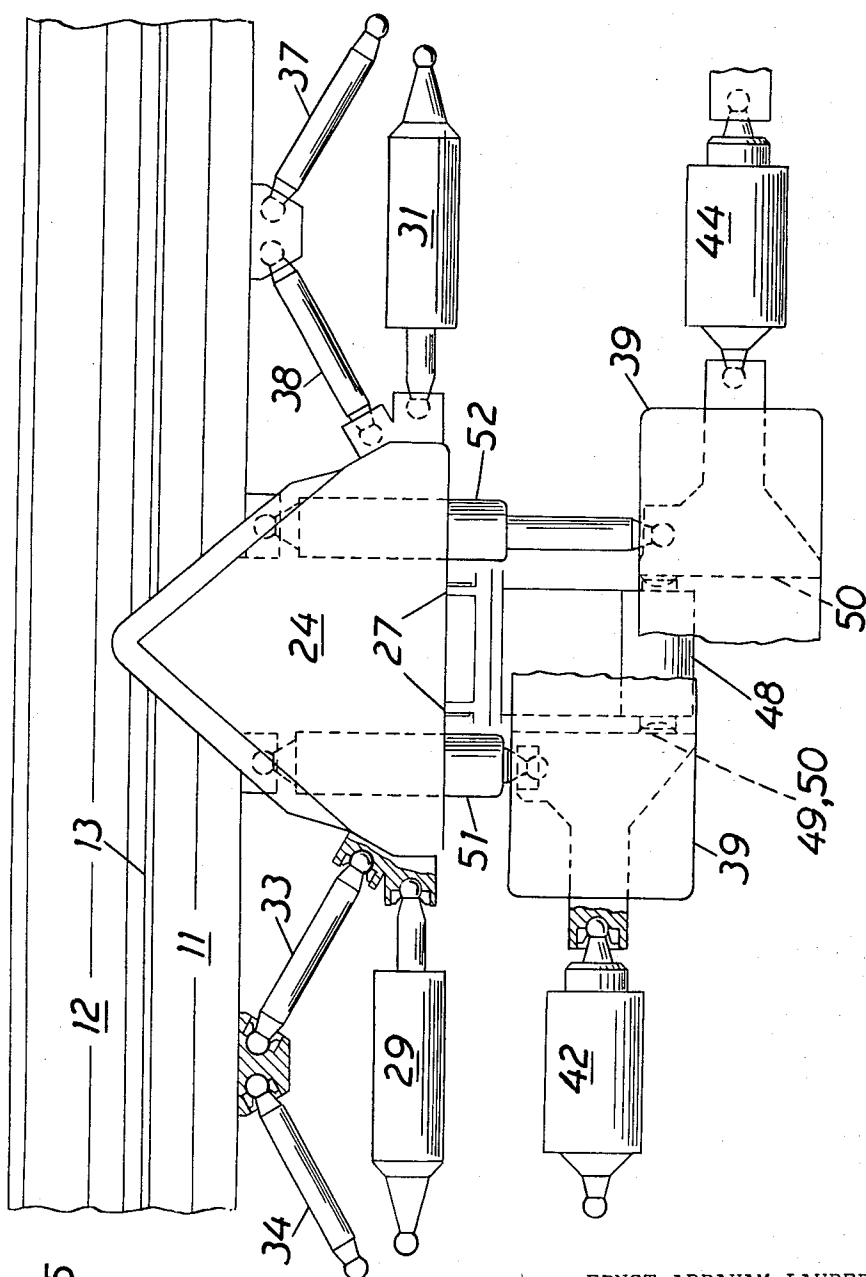


Fig. 5

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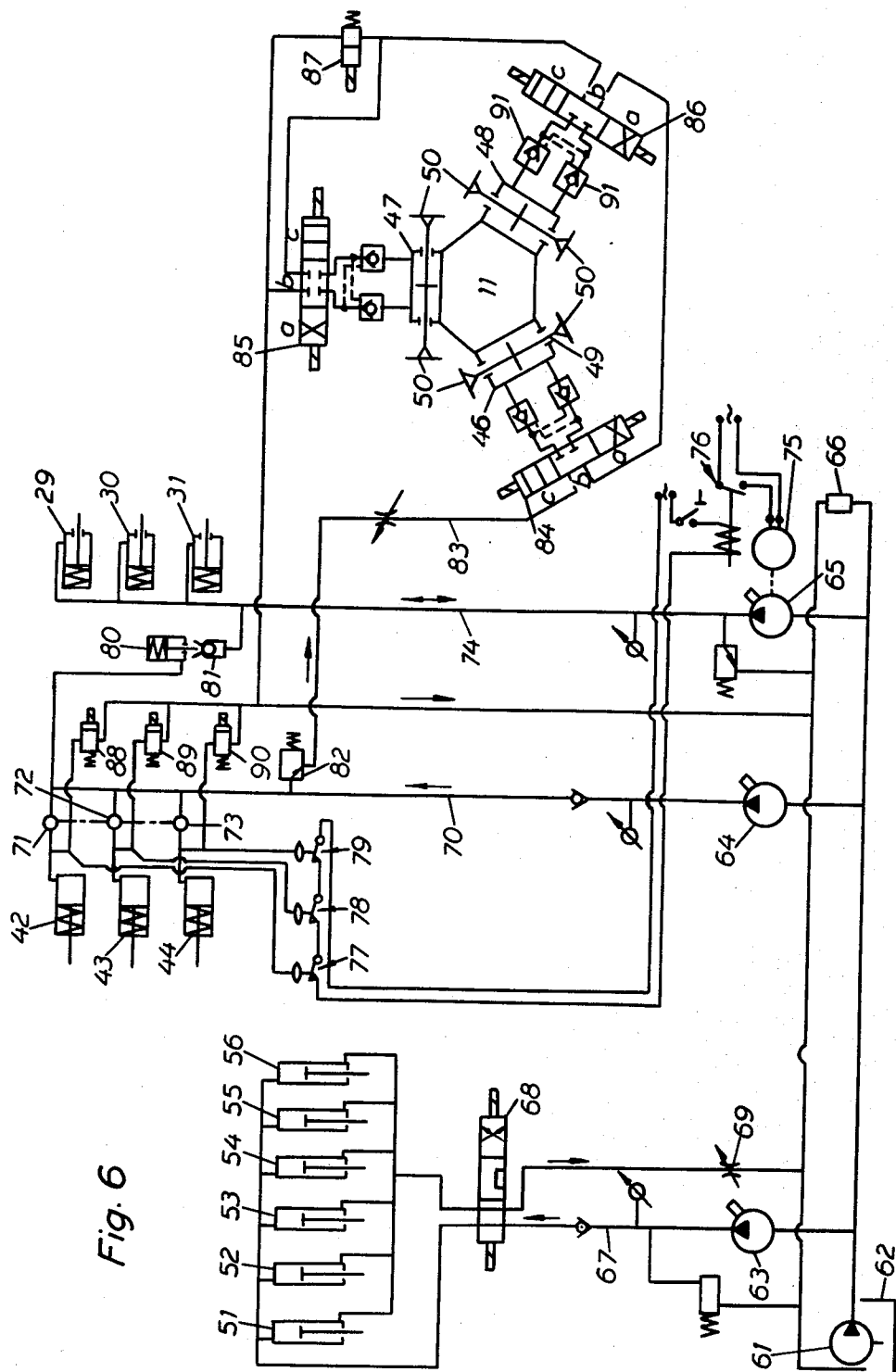
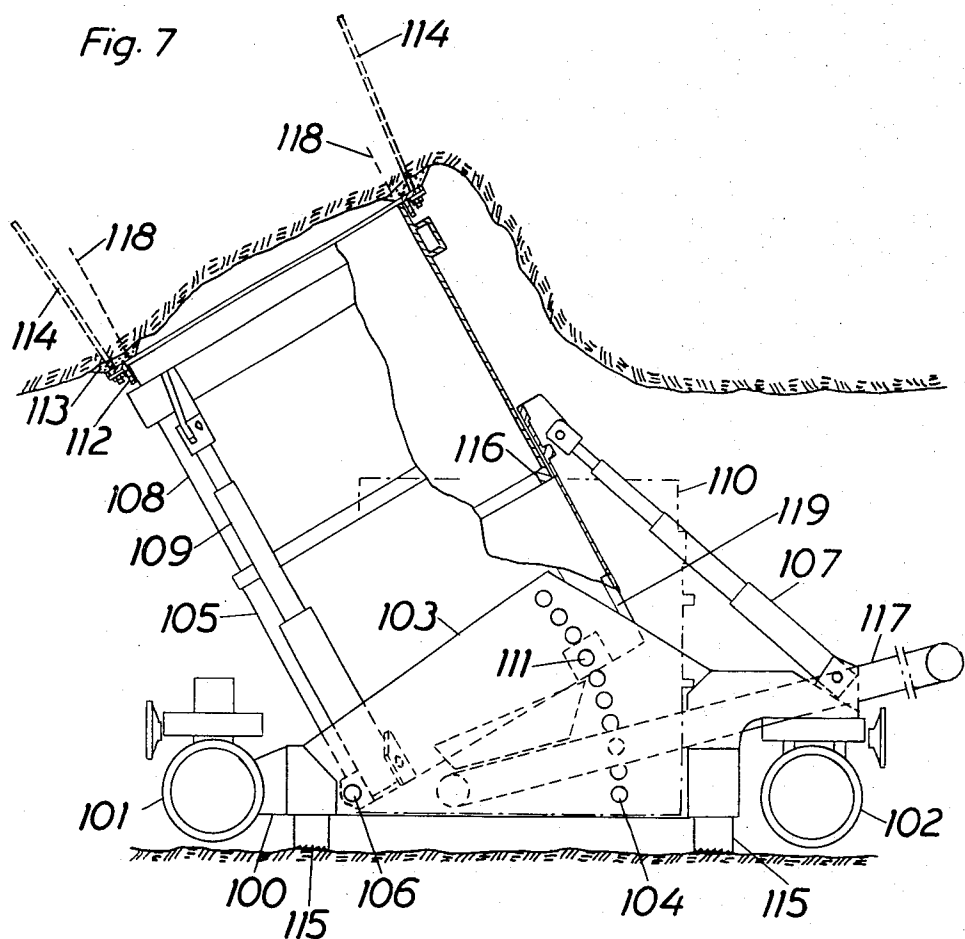


Fig. 6

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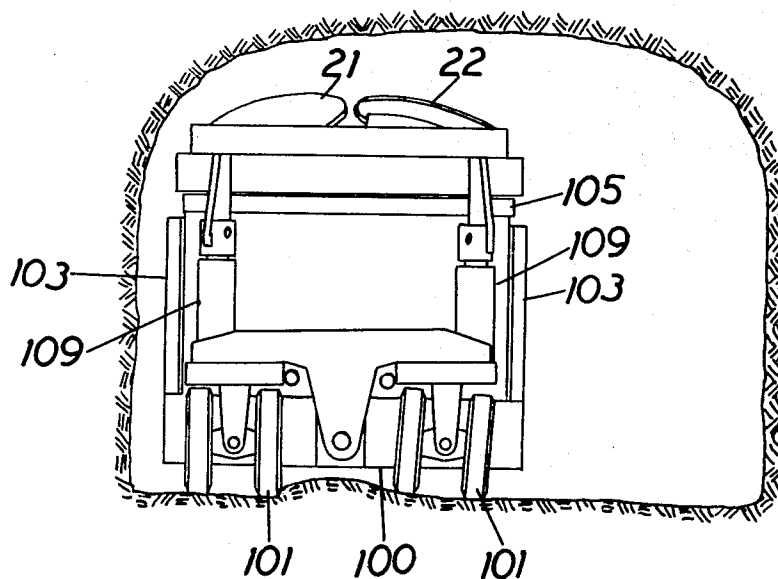
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Fig. 8



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RAISE BORING MACHINE

This invention relates to a raise boring machine for producing a vertical or inclined raise of circular cross section.

In connection with raise driving machines, there is a security problem which does not appear in connection with prior art tunneling machines for producing horizontal or nearly horizontal circular tunnels; namely the risk of the falling backwards of the machine in the tunnel.

It is therefore an object of the invention to provide a raise driving machine which is always secured in the tunnel even if the power system fails. In accordance with the invention there is provided a raise digging machine for producing a raise of circular cross section, comprising a main frame, a drum member rotatably mounted in said main frame for rotating about a central longitudinal axis of the machine which axis normally coincides with the axis of the raise being driven, motor means for rotating said drum member, a number of cutter heads mounted on the drum member for cutting in the face of the raise, a number of wall engaging shoes mounted to said main frame so as to be movable radially thereto, means arranged to bias said shoes against the wall of the raise being driven, obliquely arranged struts pivotably mounted to said main frame with their upper ends and pivotably mounted to said shoes with their lower ends so as to prevent the shoes from sliding rearwards by pressing them against the wall of the raise but permitting the shoes to slide forwards, an anchoring device movable with respect to said main frame and arranged to be immobilized in the raise, and power means for moving one of the main frames and the anchoring device longitudinally of the raise relative to the other.

The invention will now be described with reference to the accompanying drawings in which a preferred embodiment of the invention is shown by way of example.

In the drawings:

FIG. 1 is a side view, partly in section on line 1—1 in FIG. 2, of a raise boring machine in a vertical raise,

FIG. 2 is a fragmentary cross section substantially on line 2—2 in FIG. 1,

FIG. 3 is a fragmentary cross section on line 3—3 in FIG. 1,

FIG. 4 is a fragmentary cross section on line 4—4 in FIG. 1,

FIG. 5 is a developed fragmentary view taken as indicated by the line 5—5 in FIG. 2,

FIG. 6 is a fragmentary circuit diagram of the hydraulic system for advancing and steering the raise driving machine shown on FIGS. 1—4, and

FIGS. 7 and 8 are side views of a vehicle for launching and transporting the raise driving machine shown on FIGS. 1—5.

The raise boring machine has a main frame generally indicated as 11. A drum 12 is journaled in the main frame 11 by means of a roller bearing 13. The left half of the drum 12 is shown in section in FIG. 1 but the right half in view. Three motor and gearing units 14 rotate the drum 12 by means of spur gears 15 which mesh with a ring gear 16 on the drum. In the drum 12 are two identical cutting devices 17, 18 mounted, each comprising a motor portion 19 and a reduction gearing portion 20 for rotating a cutter head 21, 22 with detachable cutters 23 which have sintered carbide hard metal inserts. The interior parts of the cutting devices

are removed in FIGS. 2 and 3 and, for clarity, the sections of their housings are shown circular in these figures although the circular housings should be elliptical in a plane cross section. The cutter heads 21, 22 work on an undercutting principle which is described for instance in Wohlmeyer US patent 2 758 825 and which will therefore not be described here.

Three triangular and arc-formed wall engaging guide shoes 24, 25, 26 are guided by means of guide surfaces 27 sliding on guide members 28 on the main frame 11.

As shown in FIGS. 3 and 5 there are jacks 29, 30, 31 universally pivotally connected between the shoes 24, 25, 26 so as to urge the shoes outwardly against the wall of the raise by the action of springs 32 inside the jacks. The shoes are suspended in the main frame by six rods 33, 34, 35, 36, 37, 38 each rod connected between one of the shoes and the main frame by means of ball joints, the rods providing toggle joints. The jacks 29, 30, 31 press the shoes 24, 25, 26 outwardly so that the main frame 11 is guided by the shoes sliding on the wall of the raise when the main frame is being advanced. The toggle joints prevent automatically the shoes 24, 25, 26 and thereby also the main frame 11 from sliding backwards. When, however, backward movement is wanted, the jacks 29, 30, 31 can be retracted hydraulically to withdraw the shoes 24—26 from the wall so that the toggle joints will not actuate the shoes 24—26.

Three rectangular rear wall engaging shoes 39, 40, 41 together with three jacks 42, 43, 44 form an anchoring frame generally denoted 45. The jacks 42, 43, 44 are connected between the shoes 39, 40, 41 by means of ball joints, and they are biased to retract by means of springs 58, but they extend upon hydraulic actuation. The rear portion of the main frame has three double acting hydraulic steering jacks 46, 47, 48, each having two piston rods all of which referred to as 49. The main frame 11 is guided by means of universally pivotably mounted end parts on the piston rods 49 freely sliding on guide surfaces 50 on the shoes 39, 40, 41. Steering is effected by moving the rear portion of the main frame 11 sidewise in the anchoring frame 45 in any desired direction, thereby causing the longitudinal axis of the main frame 11 to deviate from the longitudinal axis of the raise. With the anchoring frame 45 rigidly clamped to the raise, the main frame 11 can be advanced with its front shoes 24, 25, 26 sliding on the wall of the raise by means of six thrust jacks or advance jacks 51—56 pivotably connected between the main frame 11 and the shoes 39, 40, 41 of the anchoring frame 45. During an advance of the main frame 11, the drum 12 is rotated in the main frame and the cutter heads 21, 22 are also rotated so that the cutter heads cut tangentially in the face of the raise in screw-formed orbital paths. The sliding connections 49, 50 between the steering jacks 46—48 on the main frame 11 and the shoes 39—41 of the anchoring frame 45 transmit the reaction torque resulting from the rotation of the drum 12 to these firmly braced shoes 39—41. Non-illustrated guide plates are arranged to guide through the machine, the rock fragments cut away and broken away by the cutters 23 of the cutter heads.

When the advance jacks 51—56 have been fully extended, the anchoring frame 45 is loosened from the wall of the raise and advanced rapidly by means of the advance jacks 51—56, the main frame 11 being held by

means of its shoes 24-26 which are now braced rigidly against the wall of the raise by means of the toggle rods 33-38. The anchoring frame 45 is again braced and a new slow advance step can start. In FIG. 5, there are illustrated the two advance jacks 51, 52 which are connected to the shoe 39; the left jack 51 is shown retracted and the right jack 52 is shown extended. The shoe 39 is in the figure shown in two positions, the position of the left half of the shoe corresponding to the retracted positions of the advance jacks and the position of the right half corresponding to the extended position of the advance jacks.

A non-illustrated bottom power and control station is located so as to be protected from the rock fragments falling from the machine. A non-illustrated laser and a non-illustrated television camera are arranged to permit the operator to control the machine in safety from the bottom station. Hydraulic and electric power lines and suitable electric lines for controlling various solenoid valves at the machine lead from the bottom station to the machine. All the electric and hydraulic lines are covered in a common non-illustrated protecting plastic cover which is attached to a steel rope 59 which in turn is attached to the hang wall of the raise by means of support pulleys and rock bolts.

In FIG. 6, there are illustrated the advance jacks 51-56, the jacks 29-31 connected between the guide shoes 24-26, the jacks 42-44 of the anchoring frame 45 and the steering jacks 46-48 on the main frame 11. A low pressure supply pump 61 supplies fluid from a tank 62 to three high pressure pumps 63, 64, 65 which are situated on the bottom station. Reference numeral 66 denotes a counter-pressure valve. The pump 63 supplies pressure fluid to the double-acting advance jacks 51-56 through a flexible supply conduit 67 and a solenoid valve 68. The valve 68 has a position for effecting extension of the jacks, a position for effecting contraction of the jacks and a position for locking the jacks. A limiting device shown as a restrictor 69 controls the speed of extension and retraction of the advance jacks. The pump 64 supplies pressure fluid through a flexible branched supply conduit 70 to the gripper jacks 42-44 of the anchoring frame 45 so as to extend these jacks. A fluid divider assembly in the form of three mechanically interconnected motors 71, 72, 73 in the supply conduits of the jacks 42, 43, 44 ensures that the three jacks move conjointly. When necessary, the jacks 42-44 can be individually adjusted or completely retracted by means of three solenoid valves 88, 89, 90. By means of the pump 65, the jacks 29-31 of the main frame 11 can be supplied with pressure fluid through a supply conduit 74 so that these jacks 29-31 retract.

For security, an electric motor 75 driving the pump 65 has its power circuit connected over a relay 76. The actuating circuit for the relay 76 includes three pressure actuated switches 77, 78, 79, each connected to one of the jacks 42-44, respectively. Therefore, the motor 75 can rotate the pump 65 only when there is full pressure in all the jacks 42-44; that is to say, the shoes 24-26 of the main frame 11 can be released only when the anchoring frame 45 is held firmly by its shoes 39-41.

If, however, the pressure in the jacks 42-44 would drop suddenly when the jacks 29-31 are under pressure, for instance if the supply hose 70 breaks a motor

80 will immediately open a check valve 81 through which the jacks 29-31 and the supply conduit 74 will drain. As a result, these jacks 29-31 will therefore immediately force the shoes 29-31 of the main frame against the wall of the raise and toggle rods 33-38 will apply an additional outwardly directed force to the shoes so as to secure the machine in the raise.

A sequence valve 82 is arranged to permit pressure fluid to flow from the supply conduit 70 to a supply conduit 83 of the steering jacks 46-48 only when there is full pressure in the jacks 42-44 of the anchoring frame 45; that is to say, steering is permitted only when the anchoring frame is firmly braced to the wall of the raise. The three steering jacks 46-48 can be connected in series through three solenoid valves 84, 85, 86 having three positions each; the positions of each valve are referred to as positions *a*, *b* and *c* and represented by the corresponding squares *a*, *b*, *c* of the symbol of the valve. A solenoid valve 87 having a closed and an open position is connected in parallel with the valve 85. Since the valves 84-86 are not quite leak proof, there are pairs of pilot actuated check valves 91 connected in the conduits between the steering jacks 46-48 and the valves 84-86 so as to positively lock the jacks except during steering movement. The jack 47 has half the piston area of the jacks 46, 48 which are identical. When driving inclined raises, the machine is located so that this jack 47 is horizontal and the shoe 41 connected to this jack engages the hang wall of the raise.

When it is desired to move the rear portion of the main frame 11 upwards in FIG. 6 (towards the hang wall in the case of an inclined raise), the valve 85 is maintained in its illustrated closed position *b*, the valve 84 is shifted into position *c*, and the valve 86 is shifted into position *a*. Now, when the valve 87 is opened, the cylinders of the steering jacks 46, 48 and thereby the rear position of the main frame 11 are moved upwards in FIG. 6, the end portions of all the piston rods 49 of the jacks 46-48 sliding on the guiding surfaces 50 of the shoes 39-41. In the same way, the valve 87 is used also for moving the rear portion of the main frame 11 downwards in FIG. 6, the valve 84 being in position *a* and the valve 86 being in position *c*.

For moving the rear portion of the main frame 11 to the right in FIG. 6 the valve 87 is closed and the valves 84 and 86 are shifted into positions *a*. The movement starts when the valve 85 is shifted into position *c*. Since the angles between the steering jacks are 60° and the guiding planes 50 are perpendicular to the respective steering jack, the resulting movement of the rear portion of the main frame 11 will be straight to the right in FIG. 6 because it results from the movement of the piston rods 49 in the cylinders of the steering jacks 46-48 and from the sliding movement of the end portions of the rods 49 on the guiding planes 50. For moving the rear portion of the main frame 11 straight to the left in FIG. 6, the valve 85 is shifted into position *a*, the valves 84 and 86 being in positions *c*.

As described, the rear portion of the main frame 11 can thus be moved in one direction by means of the valve 87 and in a direction perpendicular thereto by means of the valve 85 notwithstanding there are only three steering jacks.

For starting a raise, there is used a launching vehicle shown on FIGS. 7-8. The vehicle has an undercarriage

100 movable on two steerable pairs 101 of wheels at the front and two rear pairs 102 of wheels. The undercarriage has two rigid side plates 103 each with a row of holes 104. An outer tube 105 is mounted on the undercarriage so as to be pivotable on a transverse shaft 06 by means of two hydraulic jacks 107 which are pivotably mounted between the tube 105 and the undercarriage 100. Inside the tube 105 there is arranged another tube 108 with circular cross section. Four hydraulic power jacks 109 are arranged to extend and retract telescopically the tube 108 in the tube 105. The raise driving machine shown on FIGS. 1-5 can be placed inside the tube 108 which can be considered as a shell for the machine. The cutter heads 21, 22 of the machine can be seen in FIG. 8; in FIG. 7, however, the machine is not shown at all. In FIG. 8, the telescoping tubes 105, 108 are shown in a retracted vertical transporting position. This position is indicated in FIG. 7 by a dash-and-dot line 110. In FIG. 7, the tube 105 is tilted about the shaft 106 and locked to the side plates 103 by means of a pair of lock pins 111. At the desired starting point of the raise, a guiding ring 112, adapted to suit the forward end of the tube 108, has been fixed to the roof by means of concrete indicated at 113 and a number of rock bolts 114.

The tube 108 is shown braced against the roof by the jacks 109 and held by the ring 112, and the undercarriage 100 is shown supported by four power jacks 115. The raise driving machine has until now been supported by a shoulder 116 inside the tube 108. Now, the machine can be initiated to start a previously described cutting operation, at first climbing on the interior wall of the tube 108, then climbing on the wall of the raise being bored. The contour of the intended raise is indicated by 118. The rock fragments cut and broken away by the cutter heads 21, 22 fall down on a temporarily mounted belt conveyor 117. When the machine has climbed out of the tube 108, the tube 108 can be retracted, the tubes 105, 108 can be tilted into transporting position indicated by the line 110, and the entire launching vehicle can be moved away. However, the power supply lines which, during the start, passed a window 119 in the tube 105 must be disconnected temporarily so as to permit the launching vehicle to move away. The steel ring 112, however, is left so that the vehicle can easily be replaced if it is desired to take down the machine in which case the machine is operated to climb down into the tube 108.

It is to be understood that the invention is not limited to the described embodiment, but that various modifications may be made within the scope of the claims. Instead of the described cutter heads, for instance, a number of cutter heads in the form of freely rotating roller bits may be used.

What we claim is:

1. A raise boring machine for producing a raise of circular cross section, comprising a main frame, a drum member rotatably mounted in the main frame for rotating about the central longitudinal axis of the machine which axis normally coincides with the axis of the raise being bored, motor means for rotating the drum member, a plurality of cutter heads mounted on the drum member for cutting in the face of the raise, an anchoring device movable with respect to the main frame and arranged to be immobilized in the raise,

power means for moving the main frame and the anchoring device longitudinally relative to each other, a plurality of wall engaging shoes mounted to the main frame so as to be movable radially thereto, means for biasing said shoes against the wall of the raise being bored, linkage means coupled between the main frame and the shoes for exerting outwardly directed forces to the shoes so as to prevent the shoes and thereby the machine from sliding backwards when the anchoring device is released, but permitting the shoes and thereby the main frame to slide forwards when the anchoring device is immobilized and the main frame is being advanced.

2. A raise boring machine as claimed in claim 1 in which said shoes on said main frame are arranged at the front end of the raise boring machine; said anchoring device is arranged at the rear end of the raise boring machine, and power jacks are arranged for moving the rear portion of the main frame relative to the anchoring device in directions transverse to the longitudinal axis of the raise so as to effect steering of the raise boring machine.

3. A raise boring machine as claimed in claim 1 in which said cutter heads are rotatably mounted in the drum member, motors are arranged to rotate the cutter heads, and the cutter heads have cutters extending radially from their circular front so that the cutter heads cut tangentially in screw-formed paths upon simultaneous rotation of the cutter heads, rotation of the drum member, and advancing of the main frame.

4. A raise boring machine as claimed in claim 1 in which said linkage means comprise rods which are pivotally connected to the main frame with their upper ends and pivotally connected to the shoes with their lower ends so as to suspend the shoes in the main frame, each shoe being suspended in two rods whose longitudinal axes intersect at an obtuse angle.

5. A raise boring machine as claimed in claim 4 in which the main frame is provided with means for guiding the shoes radially.

6. A raise boring machine as claimed in claim 4 in which said shoes mounted to said main frame are uniformly angularly spaced in a plane transverse to the raise, and said biasing means are braced between the adjacent shoes to bias the shoes against the wall of the raise.

7. A raise boring machine as claimed in claim 4 in which said biasing means comprise a cylinder and a hydraulically actuated piston movable therein, a spring for extending said piston, and means for supplying hydraulic fluid to the pressure chamber of said cylinder so as to cause retraction of said pistons and thereby pull the shoes out of engagement with the wall of the raise.

8. A raise boring machine as claimed in claim 7, in which said anchoring device includes a plurality of wall engaging shoes, and a plurality of hydraulically actuated power jacks arranged to brace said shoes firmly against the wall of the raise so as to immobilize the anchoring device in the raise when the pressure chambers of the jacks are pressurized by hydraulic fluid.

9. A raise boring machine as claimed in claim 8 in which said pressure chamber of the power jacks for actuating the shoes of the anchoring device are connected to a common supply conduit, and said pressure chambers of the cylinder for actuating the shoes of the

main frame are connected to a pilot actuated check valve which is controlled by the pressure in said common supply conduit so as to drain said pressure chambers of the piston and cylinder means when this pressure is below a limit pressure.

10. A raise boring machine as claimed in claim 8 in which said means for supplying hydraulic fluid to the pressure chamber of said cylinder comprises a pump driven by an electric motor, the pressure chamber of each of the power jacks of the anchoring device being connected to one of a plurality of pressure actuated electric switches, which are biased to disconnected state, so as to close its associated switch only when the pressure in the respective pressure chamber is above a limit pressure, and said electric switches are connected in series in an electric circuit for actuating said electric motor.

11. A raise boring machine as claimed in claim 10 in which said pressure chambers of the power jacks for actuating the shoes of the anchoring device are connected to a common supply conduit, and said pressure chambers of the piston and cylinder means for actuating the shoes of the main frame are connected to a pilot actuated check valve which is controlled by the pressure in said common supply conduit so as to drain said pressure chambers of the piston and cylinder means when this pressure is below a limit pressure.

12. A raise boring machine as claimed in claim 11 in which: said anchoring device comprises a number of arc-formed shoe units which are angularly spaced uniformly in a plane transverse to the raise, power jacks are connected between all adjacent ends of said shoe units for pressing the shoe units against the wall of the raise, said main frame is guided by the shoe units of the anchoring device so as to be movable both longitudinally and radially with respect to each of the shoe units, and said power jacks for effecting steering are arranged to move said main frame tangentially with respect to each of said shoe units of the anchoring device, the tangential movements creating simultaneous radial movements between said main frame and the shoe units.

13. A raise boring machine as claimed in claim 12, in which said anchoring device has three shoe units, three double-acting power jacks are arranged for effecting steering, the angle between the power jacks for effecting steering is 60°, and each power jack for effecting steering is firmly connected to either of the main frame and one of the shoe units, but connected to the other one of said main frame and said shoe unit by means of a sliding connection which permits movement both in longitudinal and radial directions.

14. A raise boring machine as claimed in claim 13 in which: each of said steering jacks has two pressure chambers which are connected to one of three direction control valves; each of said direction control

valves has a first position in which movement in one direction of the steering jack to which it is connected is effected, and a second position in which movement in the other direction is effected; each of said steering jacks is balanced with respect to its piston surfaces; the three steering jacks are, connected in series to a source of hydraulic fluid through said control valve; and a conduit, which includes a control valve having an open and a closed position, is connected in parallel with the direction control valve of one of said steering jacks; said one of said steering jacks has half the piston area of each of the other two steering jacks; and said direction control valve of said one of the steering jacks has also a closed position.

15. A raise boring machine for producing a raise of circular cross section, comprising a main frame, a drum member rotatably mounted in said main frame for rotating about a central longitudinal axis of the machine which axis normally coincides with the axis of the raise being driven, motor means for rotating said drum member, at least one cutter head mounted on the drum member for cutting in the face of the raise, a ring-shaped anchoring device axially movable with respect to said main frame, power means for advancing the main frame with respect to the anchoring device, and a number of raise wall engaging shoes so mounted on the main frame as to be prevented from sliding rearwards by being pressed against the wall of the raise when the anchoring device is released but permitted to slide forwards on the wall when the main frame is advanced, said anchoring device comprising a number of arc-formed shoe units which are angularly spaced uniformly in a plane transverse to the raise, and power jacks connected between all adjacent ends of the shoe units for pressing the shoe units against the wall of the raise and thereby immobilizing the anchoring device in the raise.

16. A raise boring machine as claimed in claim 15 in which said shoes on said main frame are arranged at the front end of the raise driver, said anchoring device is arranged at the rear end of the raise driver, and power jacks are arranged for moving the rear portion of the main frame relative to the anchoring device in directions transverse to the longitudinal axis of the raise so as to effect steering of the raise driver.

17. A raise boring machine as claimed in claim 16, in which said main frame is guided by the shoe units of the anchoring device so as to be movable both longitudinally and radially with respect to each of the shoe units, but not turnable, and said power jacks for effecting steering are arranged to move said main frame tangentially with respect to each of said shoe units of the anchoring device, the tangential movements creating simultaneous radial movements between said main frame and the shoe units.

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