Nov. 26, 1935. C. G. FLYGARE ET AL 2,022,542

HYDRAULICALLY OPERATED GRINDING MACHINE

Filed April 28, 1933 5 Sheets-Sheet 1

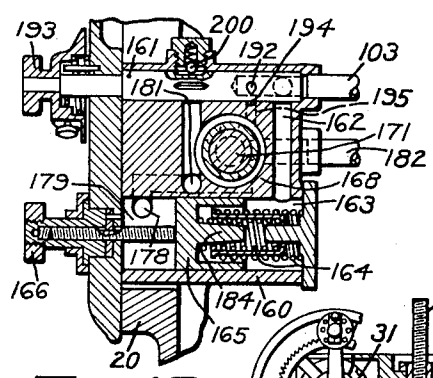
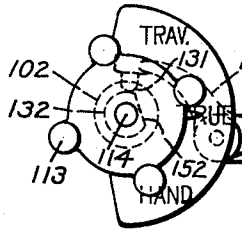


FIG. 12



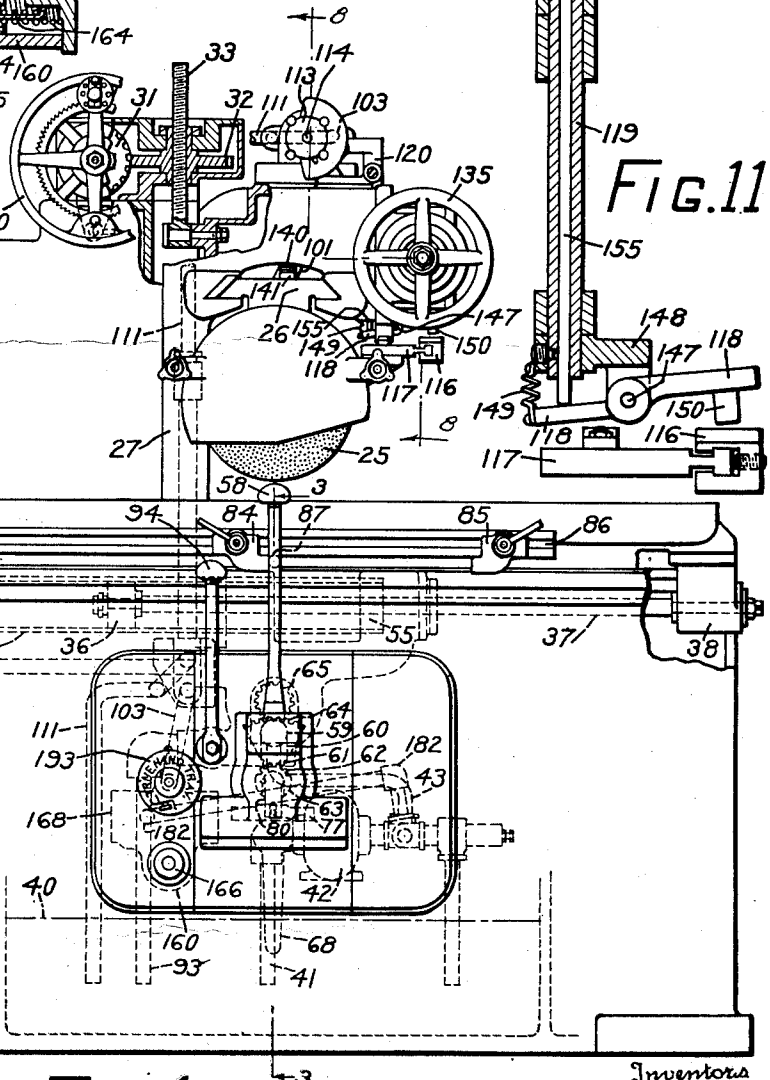


FIG. 1

FIG. 11

Inventors

CARL G. FLYGARE

WALLACE H. WOOD

By Clayton L. Jenks

Attorney

WITNESSES

Franklin E. Johnson

Harold W. Eaton

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HYDRAULICALLY OPERATED GRINDING MACHINE

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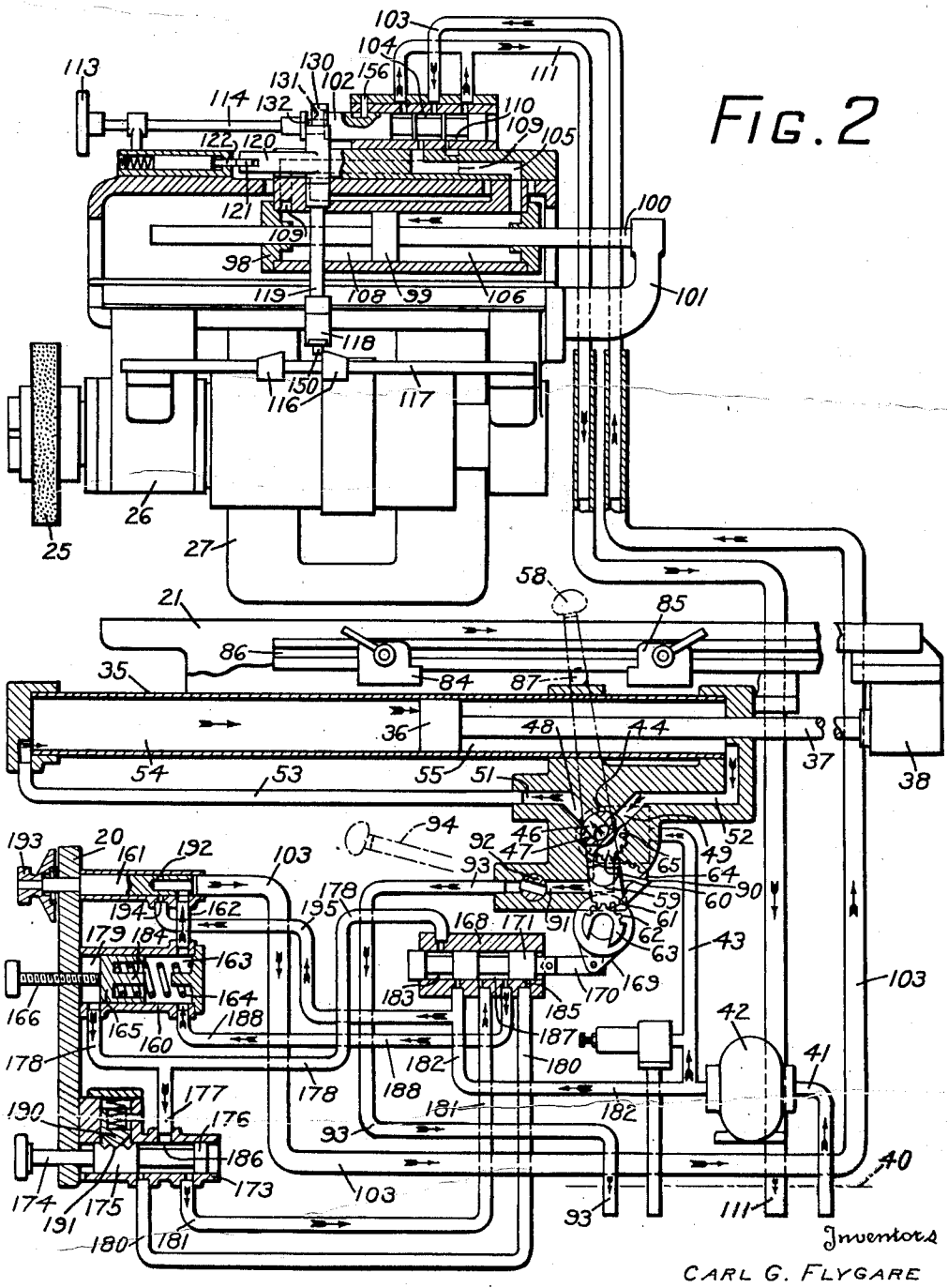
FIG. 2



Inventors

CARL G. FLYGARE

WALLACE H. WOOD

WITNESSES

Franklin E. Johnson

Harold W. Eaton

By Clayton L. Jenks

Attorney

Nov. 26, 1935. C. G. FLYGARE ET AL 2,022,542

HYDRAULICALLY OPERATED GRINDING MACHINE

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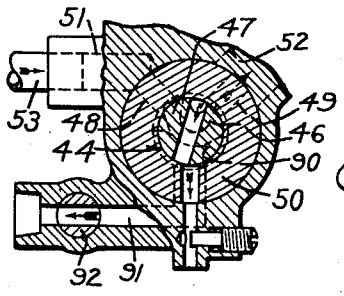

FIG. 7

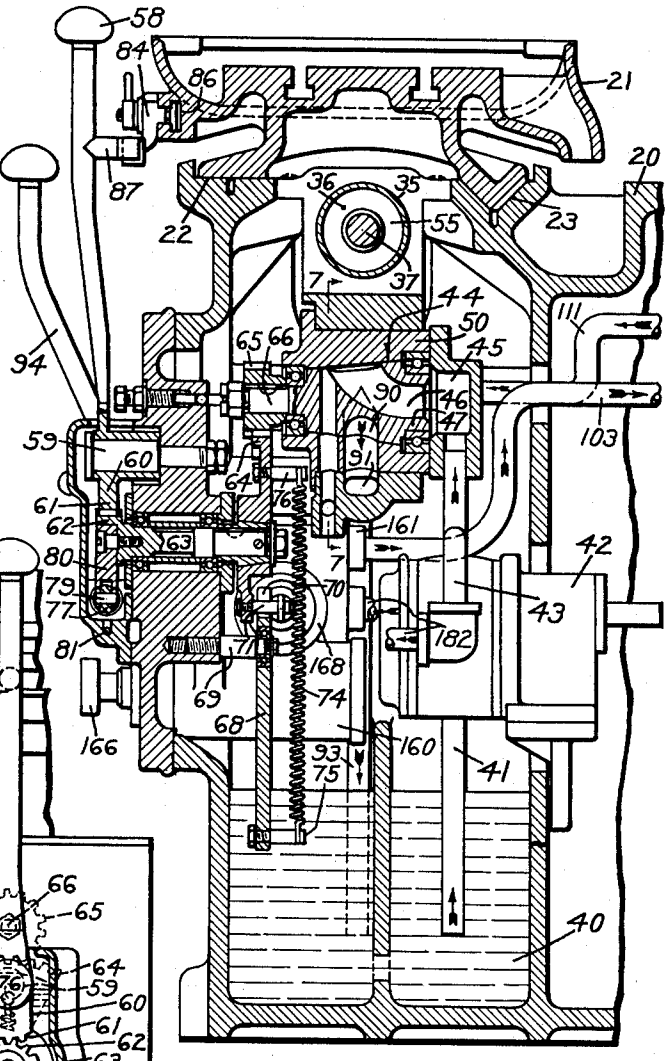

FIG. 3

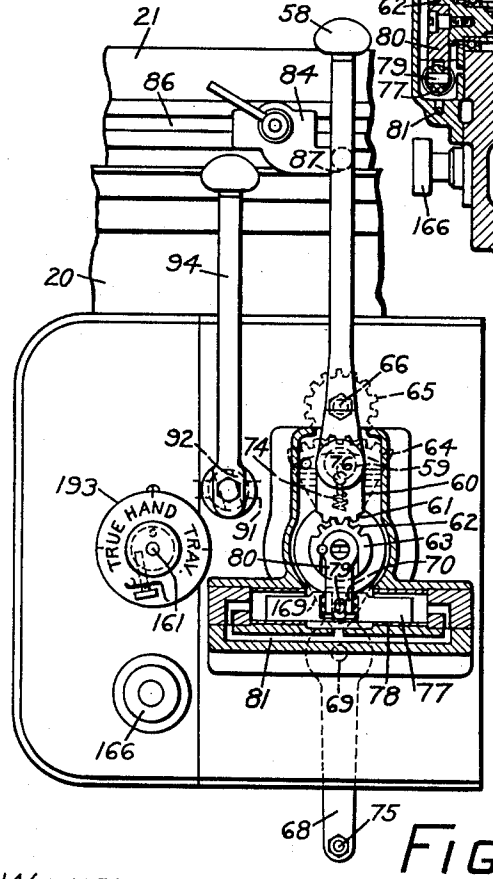

FIG. 4

Inventors
CARL G. FLYGARE
WALLACE H. WOOD

WITNESSES
Franklin E. Johnson
Harold W. Eaton

By Clayton R. Jenks
Attorney

Nov. 26, 1935. C. G. FLYGARE ET AL 2,022,542

HYDRAULICALLY OPERATED GRINDING MACHINE

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FIG. 8

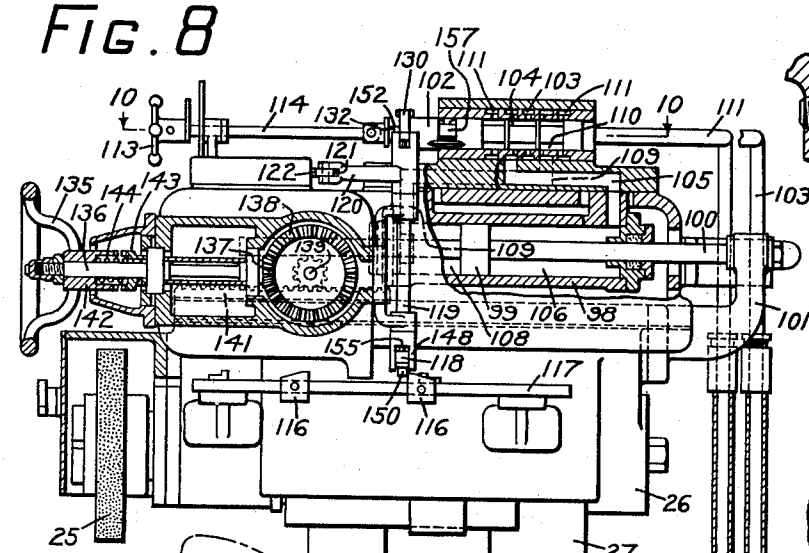


FIG. 14

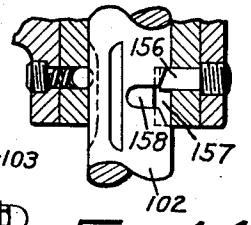


FIG. 13

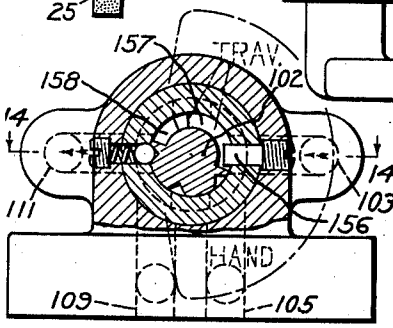


FIG. 5

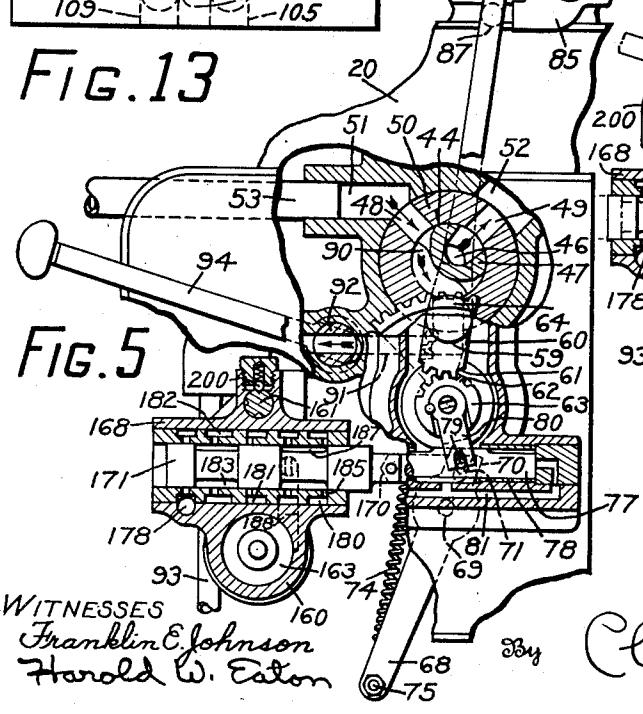
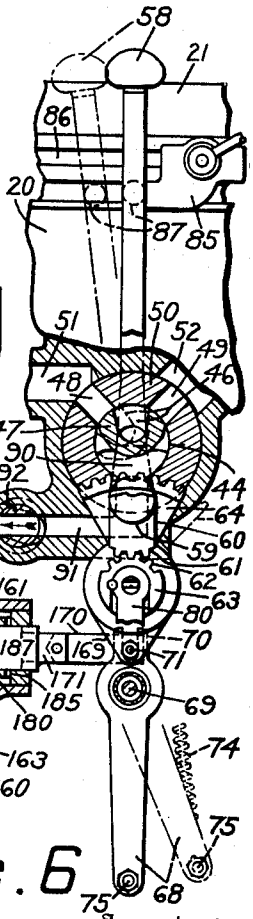


FIG. 6



WITNESSES
Franklin E. Johnson
Harold W. Eaton

Inventors
CARL G. FLYGARE
WALLACE H. WOOD

By Clayton L. Jenks
Attorney

Nov. 26, 1935. C. G. FLYGARE ET AL 2,022,542

HYDRAULICALLY OPERATED GRINDING MACHINE

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FIG. 9

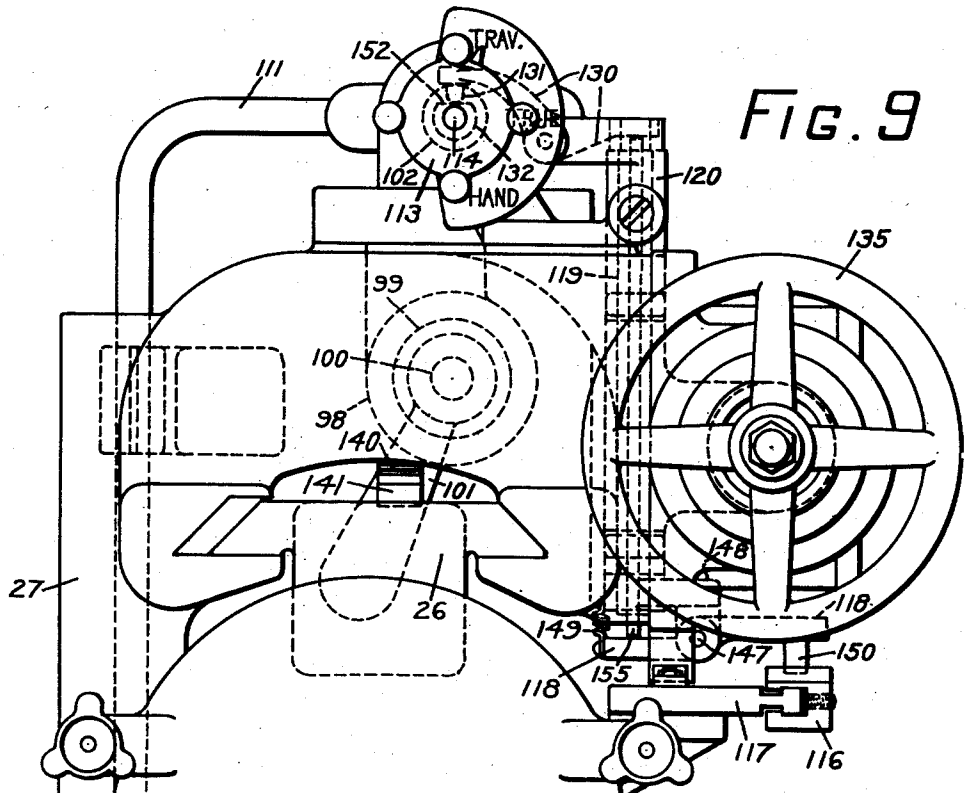
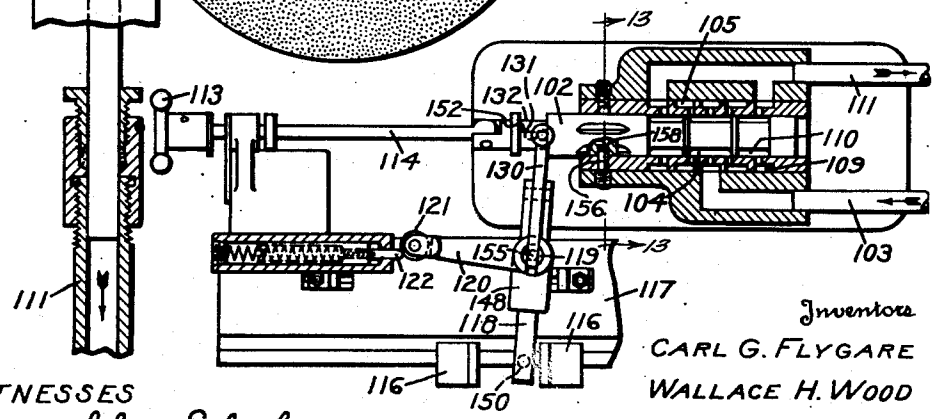


FIG. 10



WITNESSES

Franklin E. Johnson

Harold W. Eaton

Inventors

CARL G. FLYGARE

WALLACE H. WOOD

By Clayton R. Jenks

Attorney

Patented Nov. 26, 1935 2,022,542

UNITED STATES PATENT OFFICE

2,022,542

HYDRAULICALLY OPERATED GRINDING MACHINE

Carl G. Flygare and Wallace H. Wood, Worcester, Mass., assignors to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application April 28, 1933, Serial No. 668,428

31 Claims. (Cl. 51—92)

This invention relates to a mechanism for moving the slide of a grinding machine, and more particularly to a grinding wheel feeding mechanism for a hydraulically driven surface grinding machine.

Heretofore, in grinding machines of the type in which the work table reciprocates longitudinally of the base and the grinding wheel is mounted on a slide movable transversely relative to the longitudinal movement of the table, the transverse feeding movement is obtained by a manually operable feeding mechanism whereby the operator, at the end of the table stroke, may move the wheel transversely so that on the next pass of the work by the wheel, the wheel will grind a fresh path on the surface of the work. Power actuated mechanism, such as a pawl and ratchet mechanism, has been devised for moving the grinding wheel slide transversely, either for a continuous movement or in timed relation with the work table reciprocation. The power actuated feeding mechanisms heretofore provided of the pawl and ratchet type, which are either actuated mechanically, electrically or hydraulically, have been so constructed and arranged that the transverse movement of the wheel at each actuation of the feeding mechanism moves the wheel only a fraction of the wheel width, thereby reducing the efficiency of the machine. To obtain the maximum efficiency of the grinding wheel, it is essential that the wheel be traversed by an amount substantially equal to the width of the wheel so that the operative face of the wheel engages and grinds a different portion of the work at each reciprocation of the work table past the grinding wheel.

The primary object of this invention is to provide a grinding machine having a movable slide with a fluid pressure system for moving the same which includes a metering valve arranged to force a measured amount of fluid through said system to move the slide through a predetermined distance.

It is a further object of this invention to provide a suitable transverse feeding movement for the grinding wheel for traversing the grinding wheel by an amount substantially equal to its width at either or both ends of the work table stroke.

It is another object of this invention to provide a suitable hydraulic mechanism for feeding the grinding wheel slide transversely directly by fluid under pressure.

It is still another object of this invention to provide a suitable hydraulic mechanism including a metering valve which is adjustably controlled to cause a predetermined transverse feeding movement of the grinding wheel at either or both ends of the table stroke.

It is a further object of this invention to provide a suitable transverse feeding movement for the grinding wheel slide which enables the slide to be traversed, at either or both ends of the table reciprocation, by an amount up to and equal to the full width of the grinding wheel, at a very slow continuous traverse for truing the grinding wheel, or to permit a manual control of the transverse movement in setting up the machine.

Other objects will be apparent from the following disclosure. One embodiment of this invention has been illustrated in the accompanying drawings, in which like reference numerals indicate like parts:

Fig. 1 is a front elevation of a hydraulically operated surface grinding machine embodying this invention;

Fig. 2 is a combined fragmentary sectional and diagrammatic view, showing the piping arrangement for the fluid pressure system;

Fig. 3 is a cross-sectional view, on an enlarged scale, taken approximately on the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary front elevation of the control lever shown in Fig. 3, with part of the casing broken away and shown in section;

Fig. 5 is a similar fragmentary view showing the control lever in a different position and showing the valves in section, to more clearly show the operative construction;

Fig. 6 is a fragmentary view similar to Fig. 5 showing the lever and valve in a different position;

Fig. 7 is a fragmentary cross-section of the reversing valve, taken approximately on the line 7—7 of Fig. 3;

Fig. 8 is a sectional view, taken approximately on the line 8—8 of Fig. 1, showing the transverse feeding movement in section and the remainder of the wheel slide and support in side elevation;

Fig. 9 is a fragmentary front elevation, on an enlarged scale, of the wheel slide and the transverse feeding mechanism;

Fig. 10 is a horizontal sectional view, taken approximately on the line 10—10 of Fig. 8, showing the wheel traverse reversing valve;

Fig. 11 is a fragmentary detail view, on an enlarged scale, of the actuating mechanism for the transverse feed reversing valve;

Fig. 12 is a fragmentary vertical section

through the wheel slide traverse control valve, taken approximately on the line 12—12 of Fig. 6;

Fig. 13 is a fragmentary sectional view through part of the actuating mechanism for the traverse reversing valve, taken approximately on the line 13—13 of Fig. 10; and

Fig. 14 is a fragmentary horizontal section, taken approximately on the line 14—14 of Fig. 13.

In accordance with this invention, a grinding machine is provided, in which a work table or a grinding wheel slide is moved by a suitable fluid pressure system including a fluid motor and a metering valve which is arranged to force a measured amount of fluid to the motor to move the table or slide through a predetermined distance. The invention may be employed to move a work table or a wheel slide longitudinally to a definite grinding station, or to move either a work table or a wheel slide transversely towards or from the other to feed the wheel towards the work to a definite position.

The specific embodiment of the invention illustrated in the drawings relates to a surface grinding machine having a work table arranged for reciprocation beneath the peripheral face of the grinding wheel by a fluid pressure mechanism. The grinding wheel there shown is mounted on a transversely movable wheel slide which is supported on a vertically movable slide arranged for adjustment in a vertical direction to permit grinding the work to the desired thickness. A wheel feeding mechanism is provided to traverse the grinding wheel transversely, either by a manually operable hand wheel mechanism for use in manually adjusting the wheel during grinding and for setting up the machine or directly by a fluid pressure mechanism. The latter is so arranged that the wheel may be moved at a slow continuous rate for passing the grinding wheel across the face of a diamond or truing tool or intermittently at the end of the work table stroke by an amount up to substantially the width of the grinding wheel so as to present the operative face of the grinding wheel to a new portion of the work at each pass of the work beneath the wheel. The fluid pressure actuating mechanism comprises a metering valve which is preferably actuated by fluid under pressure and controlled in timed relation with the work table reversing mechanism to force a predetermined amount of fluid through the system to the fluid pressure actuator on the vertical slide so as to traverse the grinding wheel transversely through the desired distance. This mechanism is so arranged that the grinding wheel may be traversed through a predetermined distance, at either or both ends of the table reciprocation, up to and substantially equal to the width of the grinding wheel. A suitable, readily accessible controlling device is provided which enables the mechanism to be manually adjusted so as to traverse the grinding wheel manually across the face of the work or by manipulation of a control knob arranged for a slow, uniform hand traverse of the grinding wheel for truing the wheel, or an intermittent feed at the end of the table stroke.

The surface grinding machine, as shown, is provided with a base 20 having a longitudinally movable work table 21 supported on a flat way 22 and V-way 23 on the base. A grinding wheel 25 is rotatably mounted on a transversely movable wheel slide 26 which is supported on a vertically movable slide 27 carried by an upwardly extending portion 28 of the base 20. The vertical slide 27 is arranged for manual adjustment to position the periphery of the grinding wheel relative to the surface of the work piece which is mounted on the table 21 so as to grind the surface to the required extent. This mechanism may comprise a manually operable feed wheel 30 which is preferably of a type similar to the well-known feeding mechanism, such as shown in the prior patent to Norton No. 1,108,779 dated August 25, 1914. A manually operable feed wheel 30 is connected to rotate a gear 31 meshing with a gear 32. The gear 32 is formed with an internal thread which engages a feed screw 33, the lower end of which is fastened to the slide 27. By rotating the wheel 30, the operator may raise or lower the grinding wheel relative to the surface of the table 21.

Table reciprocating mechanism

The table 21 is arranged so that it may be reciprocated by a suitable power operated mechanism to carry the work beneath the operative face of the grinding wheel. In the preferred form, the reciprocating mechanism comprises a fluid pressure system including a cylinder 35 mounted in the base 20. A piston 36 is slidably mounted within the cylinder 35 and is connected by a piston rod 37 to a depending bracket 38 on the under side of the table 21. The base is provided with a fluid reservoir 40, from which fluid is pumped through a pipe 41, a pump 42, a pipe 43, to a reversing valve 44. Fluid from the pipe 43 enters a chamber 45 in the rear portion of the reversing valve and passes through a central aperture 46 in a frusto-conical rotary reversing valve member 47. Fluid passing through the passage 46 in the reversing valve is admitted through a port 48 or a port 49 in the reversing valve casing 50 through a passage 51 or a passage 52. Fluid admitted through the passage 51 passes through a pipe 53 into a cylinder chamber 54 in the left-hand of cylinder 35, as illustrated in Figs. 1 and 2. Fluid passing through the passage 52 enters a cylinder chamber 55 at the right-hand end of the cylinder, as viewed in Figs. 1 and 2. In the position of the valve member 47, as illustrated in Fig. 2, fluid under pressure is admitted through the passage 51, the pipe 53 and into the cylinder chamber 54 to move the piston 36 and the table 21 toward the right, as viewed in Figs. 1 and 2.

Reversing valve actuating mechanism

The reversing valve member 47 may be actuated manually or by power. As illustrated in the drawings, a manually operable reversing lever 58 is pivotally mounted on a stud 59 which is fixed to the base 20. A depending portion 60 of the lever 58 is provided with a gear segment 61. The gear segment 61 meshes with a gear segment 62 mounted on the outer end of a rock shaft 63. The inner end of the rock shaft 63 carries a gear segment 64 which in turn meshes with a gear 65 mounted on the valve stem 66 of the reversing valve member 47. It will be readily apparent from the foregoing disclosure that when the lever 58 is rocked on the stud 59, motion will be transmitted through the gear segments 61 and 62, rock shaft 63, gear segment 64, to actuate the reversing valve 47. In order that the reversing valve 47 may be shifted rapidly into a reverse position after the lever has moved towards a central position, a suitable load and fire mechanism is provided which includes a lever 68 pivoted on a stud 69 on the base 20. The upper end of the lever 68 is provided with a yoked portion 70 which straddles a pin 71 mounted on the downwardly extend-

ing projection of the gear segment 64. A spring 74 is interposed between a stud 75 on the lower end of the lever 68 and a stud 76 which is fixedly mounted on the gear segment 64. It will be readily apparent from this disclosure that when the reversing valve is moved from one extreme position to the other, the swinging of the lever 68 to a central position increases the tension on the spring 74 until the stud 75 passes a central line drawn between the center lines of the rock shaft 63 and the stud 69. At this point, the released tension of the spring 74 serves to shift the reversing valve rapidly into a reverse position.

To prevent too rapid a motion of the reversing valve into its reversed position, it is desirable to provide a suitable mechanism to retard the motion of the reversing valve so as to give the desired action at reversal. In the preferred construction, this mechanism comprises a dash pot piston 77 which is slidably mounted in a dash pot cylinder 78. The dash pot piston is connected by a pin 79 with a lever 80 which is fixedly mounted on the rock shaft 63. The dash pot cylinder 78 is arranged with a passage 81 which permits by-passing of fluid from one end of the dash pot cylinder to the other. As the reverse valve is moved from one extreme position to the other, the rotation of the rock shaft 63 rocks the lever 80 and slides the dash pot piston in one direction to cushion the motion of the reversing valve.

The lever 58 may be actuated manually or, in the preferred form, may be actuated in timed relation with the table movement by dogs 84 and 85 which are adjustably supported by a T-slot 86 on the front of the table 21. Assuming the table to be traveling in the direction of the arrow, as indicated in Fig. 2, the table continues moving in this direction until the dog 84 strokes a projection 87 on the reversing lever 58 and swings the reversing lever in a clockwise direction. This movement of lever 58 transmits a corresponding movement to the gear segments 61, 62, rock shaft 63, gear segment 64, gear 65, to rock the reversing valve member 47 also in a clockwise direction. During this movement, fluid under pressure passing through the passage 46 in the reversing valve is cut off from the passage 51 and, after the lever 68 passes its central position, the released tension of the spring 74 moves the reversing valve rapidly into a reverse position, admitting fluid under pressure through passage 52 into cylinder chamber 55 to start the table moving in a direction toward the left, as viewed in Figs. 1 and 2.

Similarly, the table continues motion in the direction toward the left (Figs. 1 and 2) until the dog 85 strikes the projection 87 and moves the reversing lever 58 in a counterclockwise direction to again reverse the flow of fluid to the table reciprocating cylinder.

While the fluid is being admitted through passage 51 and pipe 53 to the cylinder chamber 54 to move the table toward the right (Fig. 2), fluid is being exhausted from the cylinder chamber 55 through passage 52, a passage 90 in the reverse valve and through a passage 91, a throttle valve 92 and a pipe 93, into the reservoir 40. Similarly, when the valve is in the opposite reverse position, as illustrated in Fig. 5, fluid is exhausted from the cylinder chamber 54 through pipe 53, passage 51, valve passage 90 and through the throttle valve 92, pipe 93, into the reservoir.

Throttle valve

In order that the normal speed of the table may be varied to give the desired relative feed between the operative face of the grinding wheel and the work piece, a suitable throttle device is provided which preferably comprises the throttle valve 92 located in the exhaust side of the fluid pressure system so that the speed of the table 21 is regulated by the exhaust of fluid from the cylinder 35. The throttle valve 92 is preferably provided as an integral part of the reversing valve mechanism and is actuated by a manually operable lever 94. By manipulation of the lever 94, the operator may vary the aperture of the throttle valve 92 and thereby control the normal feed of the table.

Traverse wheel feeding mechanism

In grinding of plane surfaces on a surface grinding machine of the type in which the table reciprocates beneath the wheel, it is desirable to provide a feeding mechanism to traverse the grinding wheel transversely at the end of a table stroke so as to present the wheel face to a different portion of the work on the next table stroke. In the preferred form, it is desirable to provide such a mechanism with a suitable power actuating device, which operates to automatically index or traverse the grinding wheel transversely at either or both ends of the table stroke. In the preferred form, as illustrated in the drawings, a fluid pressure cylinder 98 is mounted within the vertically movable slide 27. A slidable piston 99 within the cylinder 98 is connected by a piston rod 100 to a bracket 101 which projects rearwardly from the wheel slide 26. A reversing valve 102 is provided to permit changing the direction of movement of the slide. The valve 102 is of the balanced piston type, in which fluid conveyed from a source of fluid pressure enters through a pipe 103 into a valve chamber 104 between two valve pistons. As illustrated diagrammatically in Fig. 2, fluid under pressure passing through pipe 103 and into valve chamber 104 passes through a passage 105 into a cylinder chamber 106 so as to cause a movement of the piston 99, the wheel slide 26 and the grinding wheel 25 toward the left, as viewed in Fig. 2. During the movement of the piston 99 toward the left, fluid is exhausted from a cylinder chamber 108 through a passage 109, a valve chamber 110, and then through an exhaust pipe 111 into the reservoir 40 in the base of the machine.

The reversing valve 102 may be moved manually by means of a knob 113 mounted on the outer end of a valve stem 114; or, if desirable, an automatically actuated reversing mechanism may be provided for shifting the reversing valve when the wheel slide has been moved through a predetermined distance in either direction. In the preferred construction, such a mechanism preferably comprises adjustable dogs 116 which are mounted on a member 117 fixed to the wheel slide 26. The dogs 116 are arranged to engage a lever 118, which is fixed at the lower end of a rock shaft 119. The rock shaft 119 carries an arm 120 having a roller 121 engaging a spring-pressed plunger 122. The upper end of the rock shaft 119 carries an arm 130 having a pin 131 riding in a groove 132 in the valve 102. It will be readily seen, as illustrated in Fig. 10, that the slide 26 carrying the adjustable dogs 116 moves toward the right, as viewed in Fig. 10, until the dogs 116 engage the arm 118 and rock the roller 121 by the spring-pressed plunger 122, thereby moving the reversing valve 102 into a reversed position to change the

direction of transverse movement of the grinding wheel 25 and its supporting slide 26.

Hand traverse mechanism

For certain types of grinding, it may be desirable to provide a suitable manually operable means to traverse the wheel transversely as desired. As illustrated in the drawings, this mechanism may comprise a hand wheel 135 mounted on a shaft 136, which carries a bevel gear 137 meshing with a bevel gear 138 on a shaft 139. The shaft 139 carries a pinion 140 which meshes with a rack 141 on the wheel slide 26. It will be readily apparent from the foregoing disclosure that the rotation of the hand wheel 135 will operate through the bevel gears, pinion, and rack to traverse the wheel slide transversely as desired.

In order that the hand wheel may be stationary during the power traverse of the wheel slide, a suitable spring-actuated clutch member 142 is provided on the inner end of the hand wheel 135. The clutch member 142 cooperates with a corresponding clutch member 143 which is connected to rotate with the shaft 136. The hand wheel 135 and clutch member 142 are freely rotatable on the shaft 136. A spring 144 is provided to hold the hand wheel is an inoperative position with the clutch members disengaged during the power operation. If it is desired to operate the wheel traverse by hand, the hand wheel 135 is pushed inwardly against the tension of the spring 144 to engage the clutch members 142 and 143. Rotation of the wheel 135 then transmits a transverse traversing movement to the grinding wheel slide.

During the hand traverse or a slow continuous traverse of the wheel for truing, it is desirable that the dog actuated reversing mechanism be made inoperative. This is preferably accomplished by providing a suitable means for rendering ineffective the adjustable dogs 116. In the preferred construction, the reversing arm or lever 118 is preferably pivotally mounted on a stud 147 on a bracket 148 carried by the rock shaft 119. The lever 118 is normally held by a spring 149 so that a pin 150 is in the normal path of the dogs 116. In order that the reversing lever 118 may be moved to an inoperative position, a cam 152 is provided on the stem 114 of the valve 102. The cam 152 is arranged to engage the follower pin 131 which is mounted on the end of a pivoted lever 130. The other end of the lever 130 engages the upper end of a rod 155 which is slidably mounted within the rock shaft 119. The lower end of rod 155 engages a projection of the reversing lever 118. By rotation of the knob 113, the rod 114 and the cam 152 are rotated into the position as illustrated in Fig. 11 to rock the reversing lever 118 and to raise the pin 150 out of the path of the reversing dogs 116. In this position of the parts, the wheel slide may be traversed to its maximum extent, either manually or by power.

During the hand traverse of the wheel slide, it is desirable to provide a suitable means for bypassing fluid from one end of the cylinder 98 to the other so as to enable the slide to be traversed readily. As illustrated, such a device may comprise a pin 156 fixed in the valve case which serves as a follower and engages a cam groove 157 in valve 102 (Figs. 2, 13 and 14). When the knob 113 is turned to the hand position, rotation of valve 102 causes cam 157 to move relative to the fixed follower pin 156. This movement continues until the portion 158 of the cam 157 engages the pin 156 and slides the valve 102 to a neutral position, permitting by-pass of fluid between cylinder chambers 106 and 108.

Metering valve for actuating power traverse

The fluid under pressure for actuating the piston 98 to traverse the grinding wheel slide 26 relative to the work may be from any source of fluid pressure, but in the preferred construction, a suitable mechanism is provided so that the wheel slide may be accurately advanced through a predetermined extent at each or either reversal of the work table. In the preferred construction, this mechanism comprises a metering valve 160 which is arranged to force a predetermined volume of fluid into the cylinder 98 so as to cause the wheel slide to move a predetermined distance at each actuation of the metering valve. The pipe 103 is connected through a valve 161 and a pipe 162 to a chamber 163 in the metering valve 160. A spring 164 is provided to hold a metering valve piston 165 toward the left, as indicated in Fig. 2. The outer or left-hand position, as illustrated in Fig. 2, is determined by an adjustable screw 166 which permits adjustment of the capacity of the chamber 163 and thereby regulates the amount of fluid forced into the cylinder 98 at each actuation of the piston 165 and also regulates the distance of the wheel movement.

A suitable means is provided after each actuation of the piston 165 to fill the metering valve chamber 163 and pipe 103 so that at the next actuation of the valve, movement of the piston 165 is against a solid column of fluid. This mechanism may comprise a piston type control valve 168 which is actuated in timed relation with the work table reversing mechanism. As illustrated in Fig. 2, the gear segment 62 has a depending projection 169 which is connected by a link 170 with the valve piston 171.

A wheel slide traverse control valve is provided, which enables the wheel slide to be traversed at each or either end of the table stroke. This mechanism comprises a control valve 173 of the piston type having a valve stem 174 provided with valve pistons 175 and 176 which is connected by a pipe 177 and pipe 178 with the actuating chamber 179 in the metering valve 160. The valve 173 is connected by pipes 180 and 181 with the control valve 168. The pipe 178 is also connected with the valve 168.

Assuming the parts to be in the position as illustrated in Fig. 2, the work table continues moving toward the right until the dog 84 strikes the lever 58 and moves it in a clockwise direction. This movement of the lever 58 moves the gear segment 62 in a counterclockwise direction, and moves the valve 171 toward the right, as viewed in Fig. 2. This movement continues until the port at the end of pipe 182 is uncovered and fluid under pressure is admitted from the pump 42 through the pipe 182, the valve chamber 183 and pipe 178 into the metering valve chamber 179 to actuate the metering valve piston 165. The admission of fluid under pressure to the chamber 179 serves to force fluid in the metering valve chamber 163 and the column of fluid in the pipe 103 and force fluid into the cylinder chamber 106 to move the piston 99 and traverse the grinding wheel slide toward the left, as viewed in Fig. 2.

The metering valve piston moves towards the right until a projection 184 on the piston 165 strikes a projection on the end of the valve chamber, which serves to limit the movement of the piston. By regulating the adjusting screw

166 the length of stroke of the metering valve piston 165 may be regulated so as to force the desired amount of fluid through the system to move the piston 99 and the wheel slide 26 transversely through the desired extent. The valve piston 171 continues its movement toward the right, as viewed in Fig. 2, covering the port at the end of pipe 178 and shortly thereafter uncovering a port 185 connected with pipe 180, as shown in Fig. 5. The mechanism functions in a similar manner when the table 21 is moving in a direction toward the left, as viewed in Fig. 5.

Wheel slide traverse control valve

The wheel slide traverse control valve 173 is preferably so arranged that the grinding wheel slide 26 may be traversed transversely at either or both ends of the table stroke. As illustrated in Fig. 2, the valve pistons 175 and 176 are positioned so as to allow passage of fluid through either pipe 180 or pipe 181 so as to advance or traverse the wheel slide at each end of the work table stroke. The valve stem 174 (Fig. 2) is held in a central position to permit traverse at both ends of the stroke by means of a spring-pressed plunger 190 which engages a notch 191 on the valve piston 175. If it is desired to traverse the grinding wheel slide only at one end of the table stroke, then the valve stem 174 may be moved so that the valve piston 175 covers the port at the end of the pipe 180 or so that the valve piston 176 covers the port at the end of the pipe 181. The covering of the ports at the end of either pipe 181 or 180 serves to prevent fluid passing through one of the pipes so that during the actuation of the valve 168, fluid cannot be admitted through pipe 177 and the closed pipes 180 or 181 to fill up the metering valve chamber 163 and the pipe 103. If the valve is adjusted into either of these positions and the chamber 163 is not filled, then at the next actuation of the metering valve, no motion is transmitted to traverse the wheel slide.

Slow traverse of the wheel for truing

It is desirable that a suitable means be provided so that the grinding wheel slide may be traversed at a uniform but slow rate to carry the grinding wheel across a diamond or truing tool which may be mounted on the work table. To permit readily changing from a grinding condition in which the wheel slide is traversed rapidly and intermittently at the end of a table stroke to a slow but continuous traversing movement for truing, a valve 161 is provided which serves in the position illustrated in Fig. 2 to pass fluid from the metering valve chamber 163 through pipe 103 into the cylinder 98 to intermittently traverse the grinding wheel slide at either or both ends of the table stroke. The valve 161 is provided with a port 192. A knob 193 is mounted on the outer end of the valve stem to facilitate adjustment of the valve 161. When it is desired to true the grinding wheel, the knob 193 is rotated to bring the valve port 192 into alignment with a port 194 to admit fluid under pressure from the pipe 182 through a pipe 195, the port 194, into the pipe 103, and admits fluid under pressure to move the piston 99 at a slow but uniform rate and traverse the grinding wheel across the diamond or truing tool. The port 192 is preferably a V-port so that the aperture may be varied so as to regulate the admission of fluid through pipe 103 and thereby control the rate of traverse of the grinding wheel across the truing tool.

To facilitate adjustment of the valve 161, a spring-pressed ball 200 is arranged to engage one of a plurality of grooves in the periphery of the valve stem 161 so that the valve may be turned quickly to any one of several predetermined positions so that the operator may readily change from a truing speed to a grinding traverse at the end of the table stroke. The valve 161 has three positions, hand traverse, traverse at the end of the table stroke, and a truing or slow continuous traverse. When the machine is set for hand traverse of the grinding wheel, the valve 161 is turned to entirely cut off fluid under pressure from the pipe 103. To facilitate positioning of the valve, a dial is provided associated with the knob 193 so that the valve may be readily turned to any one of the three positions. In the hand position, as illustrated in Fig. 1, the valve 161 is turned so as to cut off fluid under pressure from the cylinder in the wheel head.

The operation of this machine will be readily apparent from the foregoing disclosure. The work table 21 is reciprocated in the manner described above. Assuming the valves to be adjusted into the position as illustrated in Fig. 2, the table travels in the direction of the arrow, as indicated in Fig. 2, until the dog 84 engages the reversing lever 58 and moves it in a clockwise direction to cause a reversal of the valve 44 to change the direction of movement of the table. At the same time, the valve piston 171 is moved toward the right, as viewed in Fig. 2, so as to admit fluid from the pump 42 through pipe 182, valve chamber 183, pipe 178, into metering valve chamber 179 to actuate the metering valve piston 165, forcing fluid in the metering valve chamber 163 through pipe 162, valve 161, pipe 103, into valve chamber 104, through passage 105, into cylinder chamber 106, to move the piston 99 and the wheel slide 26 and grinding wheel 25 toward the left, as viewed in Fig. 2. It will be noted in Fig. 2, which is a combined diagrammatic and constructional view, that the wheel head assembly is turned at right angles relative to the line of travel of the work table to facilitate illustration of the operation of the mechanism. The uncovering of port 185 permits the fluid to exhaust from the valve chamber 179, due to the released tension of the spring 164 which in turn forces the fluid through the pipe 178, pipe 177, valve chamber 186, pipe 180, port 185, valve chamber 187, pipe 188, into the metering valve chamber 163, and serves to fill up the chamber 163, pipe 103 and passage 105 and cylinder chamber 106 so that the entire system is filled with fluid and ready for the next actuation of the metering valve. As the table 21 travels in the reverse direction, that is, toward the left, as viewed in Fig. 2, and continues in this direction until the dog 85 strikes the lever 58 (Fig. 5) so as to rock the lever 58 in a counterclockwise direction, this movement serves to move the valve stem 171 toward the left, as viewed in Figs. 5 and 2. The first part of this movement cuts off the port 185 so as to lock the column of fluid in the metering valve and its associated system, and at the same time stops the flow of fluid through the pipe 180 and allows the fluid under pressure passing through the pipe 178 to be forced into the metering valve chamber 179 to actuate the metering valve piston 165 and cause a transverse movement of the piston 99 and the grinding wheel slide toward the left, as viewed in Fig. 2. The intermittent traverse of the wheel slide in one direction takes place at each end of the work table stroke until one of the dogs 116 actuates the reversing lever 118 to reverse the posi-

tion of the valve 102 so as to admit fluid into the chamber 108 and cause an intermittent traversing movement toward the right, as viewed in Fig. 2, at each end of the table stroke. As previously stated, by manipulation of the knob 193 on the base and knob 113 on the wheel head, either a predetermined traverse may be obtained at one or both ends of the table stroke, a manual traverse, or a slow uniform traverse for truing the grinding wheel.

The term "fluid pressure piston and cylinder" as used in the specification and claims is intended to cover broadly any suitable type of fluid pressure motor, either reciprocatory or rotary.

Having thus described the invention, what is claimed as new and desired to secure by Letters Patent is:

1. A grinding machine comprising a base having a work support and a rotatable grinding wheel thereon, a traversable slide carrying one of said parts which is movable relative to the base, a fluid pressure system including a piston and cylinder operatively connected to traverse said slide, and a metering valve in said system which is operatively connected to force a measured amount of fluid to said cylinder to move the slide through a predetermined distance.

2. A grinding machine comprising a base having a work support and a rotatable grinding wheel thereon, a traversable slide carrying one of said parts which is movable relative to the base, a fluid pressure system including a piston and cylinder operatively connected to traverse said slide, a metering valve in said system which is operatively connected to force a measured amount of fluid to said cylinder to move the slide through a predetermined distance, and means to adjust said metering valve so as to vary the distance the slide moves at each actuation of said valve.

3. A grinding machine of the type covered by claim 2 in which the metering valve comprises a cylinder and a movable piston arranged to force a definite amount of fluid from the cylinder and the adjustable means is arranged to vary the extent of movement of the valve piston.

4. A grinding machine comprising a base having a work support and a rotatable grinding wheel thereon, a traversable slide carrying one of said parts which is movable relative to the base, a fluid pressure system including a piston and cylinder operatively connected to traverse said slide, a reversing valve to change the direction of movement of said piston and slide, and a metering valve in said system which is operatively connected to force a measured amount of fluid to said cylinder to move the slide through a predetermined distance.

5. A grinding machine comprising a base having a work support and a rotatable grinding wheel thereon, a traversable slide carrying one of said parts which is movable relative to the base, a fluid pressure system including a piston and cylinder operatively connected to traverse said slide, a metering valve in said system which is operatively connected to force a measured amount of fluid to said cylinder to move the slide through a predetermined distance, and fluid pressure means to actuate said metering valve.

6. A grinding machine comprising a base having a work support and a rotatable grinding wheel thereon, a traversable slide carrying one of said parts which is movable relative to the base, a fluid pressure system including a piston and cylinder operatively connected to traverse said slide, a metering valve in said system which is operatively connected to force a measured amount of fluid to said cylinder to move the slide through a predetermined distance, means to adjust the extent of movement of said metering valve so as to vary the distance the slide moves at each actuation of said valve, and fluid pressure means in said system to actuate said metering valve.

7. A grinding machine comprising a base having a work support and a rotatable grinding wheel thereon, a traversable slide carrying one of said parts relative to the base, a fluid pressure system including a piston and cylinder operatively connected to traverse said slide, a reversing valve to change the direction of movement of said piston and slide, a metering valve in said system which is operatively connected to force a measured amount of fluid to said cylinder to move the slide a predetermined distance, and a fluid pressure means in said system to actuate said metering valve.

8. A grinding machine comprising a base, a work support, a rotatable grinding wheel thereon, a wheel slide to support said wheel for movement relative to the base, a fluid pressure system including a piston and cylinder operatively connected to traverse said wheel slide relative to the base, and a metering valve operatively connected to force a measured amount of fluid to said cylinder to traverse said wheel through a predetermined distance.

9. A grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, means to reciprocate said table, a fluid pressure piston and cylinder operatively connected to traverse said slide, and a metering valve actuated in timed relation with the table reciprocation and operatively connected to force a measured quantity of fluid to said cylinder and cause a predetermined transverse movement of the wheel slide at the end of the table stroke.

10. A grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, means to reciprocate said table, a fluid pressure piston and cylinder operatively connected to traverse said slide, and a metering valve actuated in timed relation with the table reciprocation and operatively connected to force a measured quantity of fluid to said cylinder and cause a predetermined transverse movement of the wheel slide at either or both ends of the table stroke.

11. A grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve to change the direction of movement of said table, means including a piston and cylinder operatively connected to traverse said wheel slide, and a metering valve actuated in timed relation with said reversing valve and operatively connected to force a measured quantity of fluid to said second cylinder and cause a predetermined transverse movement of the wheel slide at the end of the table stroke.

12. A grinding machine comprising a base, a work support, a rotatable grinding wheel, a wheel slide to support said wheel for a movement relative to the base, a fluid pressure system including a piston and cylinder operatively connected to traverse said slide relative to the base, a me-

tering valve operatively connected to force a measured amount of fluid to said cylinder to cause said movement of the grinding wheel, and means to adjust said metering valve to vary the amount of fluid which is forced into the cylinder so as to vary the amount of movement transmitted to the grinding wheel.

13. A grinding machine comprising a base, a work support, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the base, a fluid pressure system including a piston and cylinder operatively connected to traverse said wheel slide transversely relative to the base, a metering valve operatively connected to force a measured amount of fluid to said cylinder to cause a transverse movement of the grinding wheel, means to adjust the extent of movement of said metering valve to vary the amount of fluid and also the amount of transverse movement of the grinding wheel at each actuation of the metering valve, and fluid pressure means in said system to actuate the metering valve.

14. A grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel slide for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of the table, a second piston and cylinder operatively connected to traverse said wheel slide, and a metering valve actuated in timed relation with the reversing valve and operatively connected to force a measured quantity of fluid to said second cylinder and cause a predetermined transverse movement of the wheel slide relative to the table.

15. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel slide for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of flow of fluid under pressure to and from said cylinder so as to change the direction of movement of the table, a second piston and cylinder operatively connected to traverse said wheel slide, and a metering valve operatively connected to said second cylinder which is actuated in timed relation with the reversing valve and at an end of the table stroke to cause a predetermined flow of fluid to said second cylinder to cause a predetermined transverse movement of the wheel slide relative to the table.

16. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel slide for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve to change the direction of movement of the table, a second piston and cylinder operatively connected to traverse said wheel slide, a metering valve operatively connected to force a measured quantity of fluid to said second cylinder which is actuated in timed relation with the reversing valve to cause a predetermined transverse movement of the wheel slide relative to the base, and fluid pressure means for actuating said metering valve.

17. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel slide for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of said table, adjustable dogs on said table to actuate said valve, a second piston and cylinder operatively connected to traverse said wheel slide, and a metering valve which is operatively connected to cause a predetermined transverse movement of the wheel slide relative to the table, and a valve operatively connected with the reversing valve to admit fluid to actuate the metering valve at each reversal of the table so as to traverse the grinding wheel through a predetermined distance at each end of the table stroke.

18. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel slide for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of said table, adjustable dogs on said table to actuate said valve, a second piston and cylinder operatively connected to traverse said wheel slide, and a metering valve which is operatively connected to cause a predetermined transverse movement of the wheel slide relative to the table, and means including a valve device operatively connected with the reversing valve to admit fluid to actuate the metering valve at each end or either end of the table stroke so as to cause a predetermined transverse movement of the grinding wheel either at each end of the table stroke or at either end of the table stroke.

19. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel slide for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of the table, a second piston and cylinder operatively connected to traverse said wheel slide transversely relative to the table, a metering valve which is actuated in timed relation with said reversing valve to admit a predetermined amount of fluid to said second cylinder to cause a transverse movement of the wheel slide relative to the table when the reversing valve is actuated at the end of the table stroke, and a control valve for said metering valve which is adjustable so that the metering valve may be actuated at either end of the table stroke.

20. A surface grinding machine according to claim 16 in which a reversing valve is provided on the vertical slide, which is actuated by adjustable dogs on the wheel slide to change the direction of transverse movement of the grinding

wheel after it has moved transversely to a predetermined extent.

21. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of the table, a second piston and cylinder operatively connected to traverse said wheel slide, a metering valve operatively connected to said second cylinder which is actuated in timed relation with the reverse valve to cause a predetermined transverse movement of the wheel slide relative to the table, and a throttle valve in said system arranged to direct fluid under pressure from the metering valve to intermittently traverse the wheel slide or to exclude fluid from the metering valve and pass it directly to the second cylinder to continuously traverse the wheel slide.

22. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel slide for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of the table, a second piston and cylinder operatively connected to said wheel slide, a metering valve operatively connected to said second cylinder which is actuated in timed relation with the reversing valve to cause a predetermined transverse movement of the wheel slide relative to the table at each actuation of the reversing valve, and means to adjust the extent of movement of the metering valve so as to vary the transverse movement of the wheel slide at each reversal.

23. A surface grinding machine according to claim 2 in which a control valve is provided which is operatively connected with the metering valve and the fluid pressure line so that the metering valve may be operative to admit fluid at reversal to cause a transverse movement of the grinding wheel, or may be shifted into a second position to admit fluid under pressure through a V-port to cause a slow, uniform transverse movement of the grinding wheel relative to the work table for truing the grinding wheel, or may be shifted to a third position in which the metering valve is entirely cut out of the system to permit a transverse hand movement of the wheel slide.

24. A feeding mechanism for grinding machines comprising a base, a work support, a rotatable grinding wheel, a transversely movable slide therefor, a fluid pressure system including a piston and cylinder operatively connected to move said slide, a reversing valve to change the direction of movement of the piston and slide, means including adjustable dogs to actuate said reversing mechanism, a manually operable device arranged to render said dogs inoperative during the hand and truing traverse of the slide, and a throttle valve in said system having two ports, one for normal traverse of the slide and the other for a slow traverse for use during the grinding wheel truing operation.

25. A feeding mechanism for grinding machines comprising a base, a work support, a transversely movable wheel slide thereon, a rotatable grinding wheel carried thereby, a fluid pressure system including a piston and cylinder operatively connected to move said slide, a reversing valve to change the direction of movement of said piston and slide, said valve being arranged when in a neutral position to by-pass fluid between opposite ends of said cylinder, means including adjustable dogs to actuate said reversing valve, a manually operable mechanism to traverse said slide, and a device to shift said valve to a neutral position so that fluid may by-pass from one end of the cylinder to the other during the manual traverse of the slide.

26. A feeding mechanism for grinding machines comprising a base, a work support, a transversely movable wheel slide thereon, a fluid pressure system including a piston and cylinder operatively connected to move said slide, a reversing valve to change the direction of movement of the piston and slide, means including adjustable dogs to actuate said reversing valve, a manually operable mechanism to traverse said slide, a manually operable cam device to shift said valve to a neutral position so that fluid may be by-passed from one end of the cylinder to the other and to render said dogs inoperative during manual traverse of the slide.

27. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel slide for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of said table, adjustable dogs on said table to control the actuation of said valve, a second piston and cylinder operatively connected to traverse said wheel slide, a metering valve which is operatively connected to cause a predetermined transverse movement of the wheel slide relative to the table, and a valve operable to admit fluid to actuate the metering valve at each reversal of the table so as to traverse the grinding wheel through a predetermined distance at each end of the table stroke.

28. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said wheel for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of the table, a second piston and cylinder operatively connected to traverse said wheel slide, a metering valve operatively connected to said second cylinder which is actuated in timed relation with the reverse valve to cause a predetermined transverse movement of the wheel slide relative to the table, and a throttle valve in said system arranged to direct fluid under pressure from the metering valve to intermittently traverse the wheel slide or to exclude fluid from the metering valve and pass it directly to the second cylinder to continuously traverse the wheel slide.

29. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relative to the table, a vertically movable slide to support said

wheel for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of the table, a second piston and cylinder operatively connected to traverse said wheel slide, a metering valve operatively connected to said second cylinder which is actuated in timed relation with the reverse valve to cause a predetermined transverse movement of the wheel slide relative to the table, and a throttle valve in said system arranged to cause fluid to flow under pressure from the metering valve to intermittently traverse the wheel slide or to exclude fluid from the metering valve and pass it directly to the second cylinder to continuously traverse the wheel slide.

30. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relatively to the table, a vertically movable slide to support said wheel slide for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of the table, a second piston and cylinder operatively connected to traverse said wheel slide, a second valve operatively connected to said second cylinder which is actuated at the end of each movement of the table to cause a transverse movement of the wheel slide relatively to the table, and a third valve in said system arranged to direct fluid under pressure from said second valve to intermittently traverse the wheel slide or to exclude fluid from said second valve and pass it directly to the second cylinder to continuously traverse the wheel slide.

31. A surface grinding machine comprising a base, a work supporting table thereon, a rotatable grinding wheel, a wheel slide to support said wheel for a transverse movement relatively to the table, a vertically movable slide to support said wheel for movement toward and from the table, a fluid pressure system including a piston and cylinder operatively connected to reciprocate said table, a reversing valve arranged to change the direction of movement of the table, a second piston and cylinder operatively connected to traverse said wheel slide, a second valve operatively connected to said second cylinder which is actuated at each end of the movement of the table to cause a transverse movement of the wheel slide relatively to the table, and a third valve in said system arranged to cause fluid to flow under pressure from said second valve to intermittently traverse the wheel slide or to exclude fluid from said second valve and pass it directly to the second cylinder to continuously traverse the wheel slide.

CARL G. FLYGARE.
WALLACE H. WOOD.