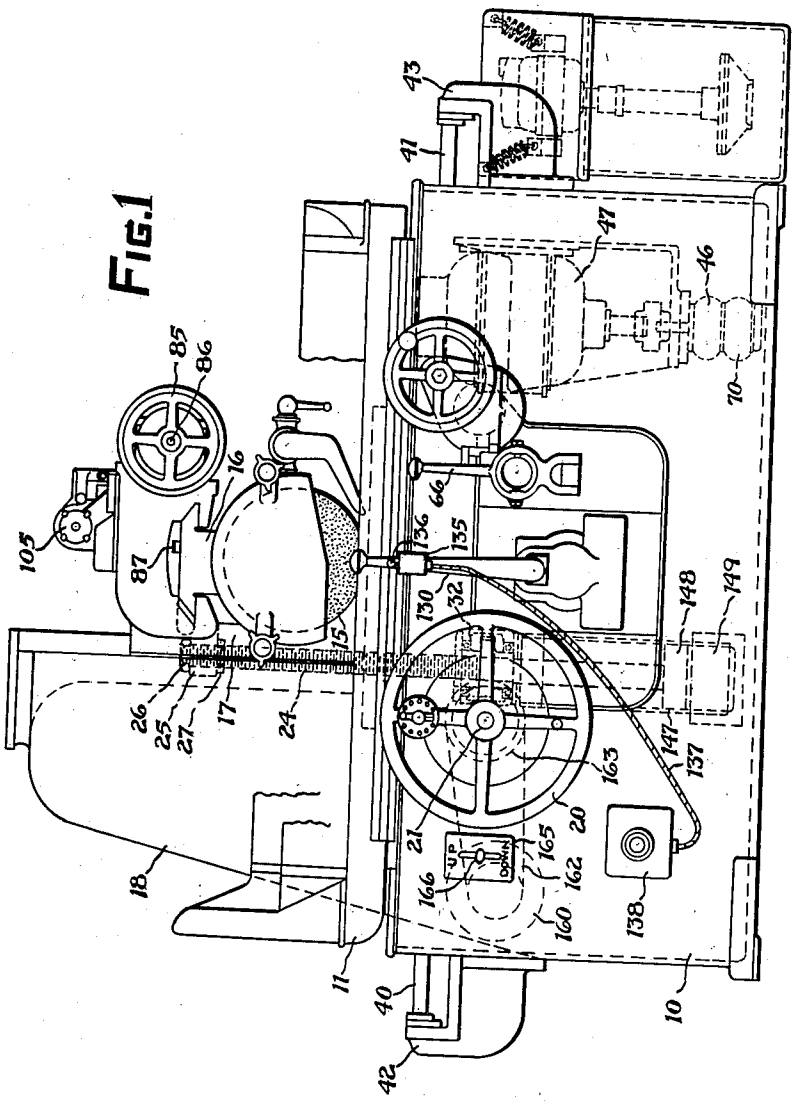
Sept. 5, 1939. A. G. BELDEN ET AL 2,171,519

HYDRAULICALLY OPERATED SURFACE-GRINDING MACHINE

Filed Aug. 20, 1938 3 Sheets-Sheet 1

FIG. 1



Inventor

ALBERT G. BELDEN

CARL G. FLYGARE

By Harold W. Eaton

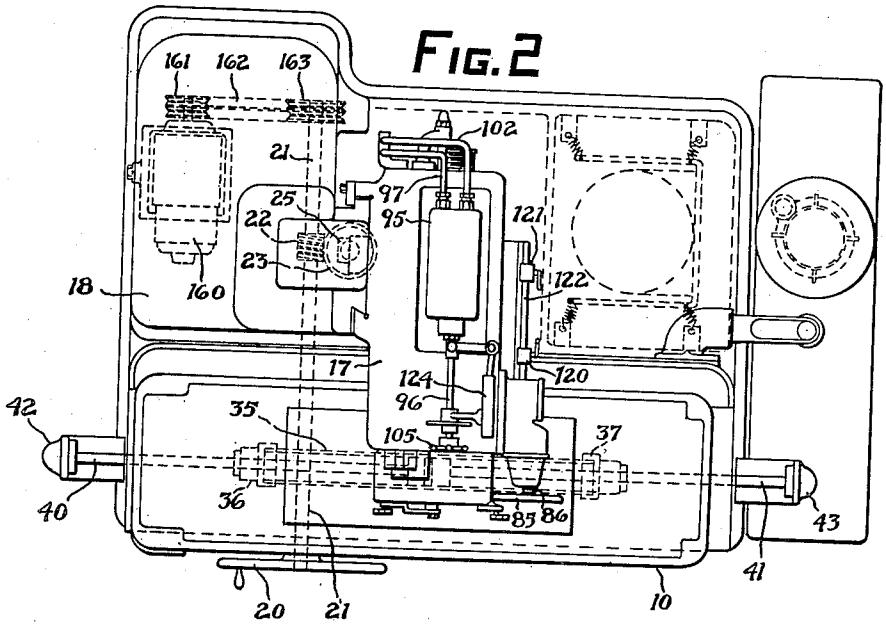
Attorney

Sept. 5, 1939. A. G. BELDEN ET AL 2,171,519

HYDRAULICALLY OPERATED SURFACE-GRINDING MACHINE

Filed Aug. 20, 1938 3 Sheets-Sheet 2

FIG. 2



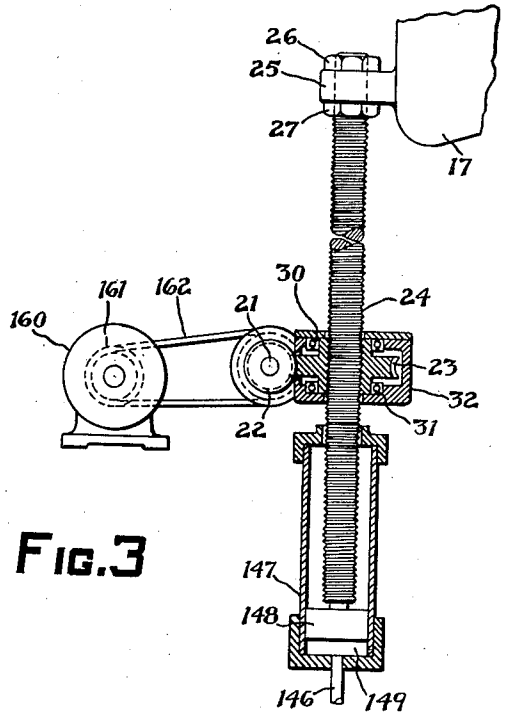


FIG. 3

Inventor
ALBERT G. BELDEN
CARL G. FLYGARE

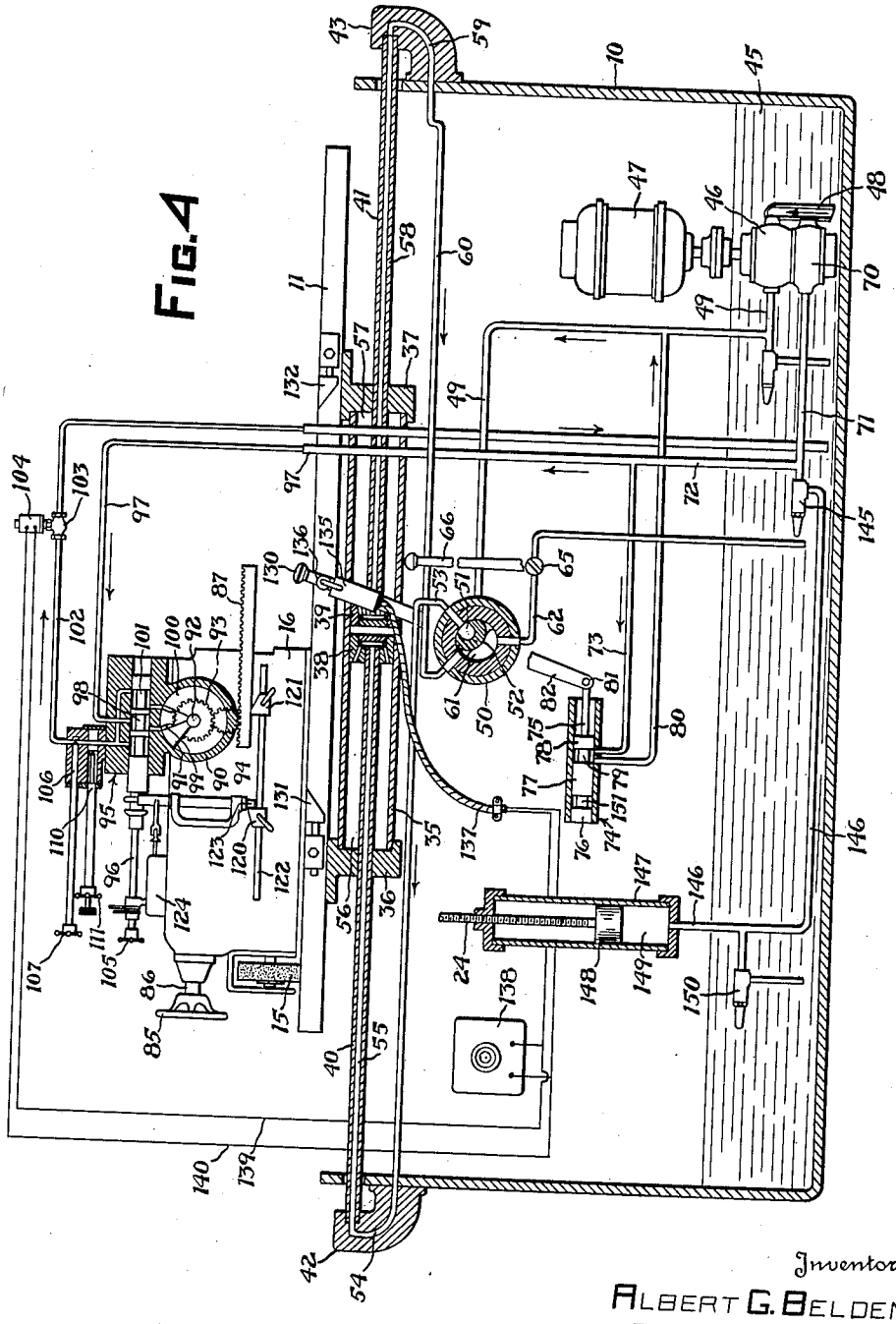
By Harold W. Eaton
Attorney

Sept. 5, 1939. A. G. BELDEN ET AL 2,171,519

HYDRAULICALLY OPERATED SURFACE-GRINDING MACHINE

Filed Aug. 20, 1938 3 Sheets-Sheet 3

FIG. 4



Inventor
ALBERT G. BELDEN
CARL G. FLYGARE

By Harold W. Eaton
Attorney

Patented Sept. 5, 1939 2,171,519

UNITED STATES PATENT OFFICE

2,171,519

HYDRAULICALLY OPERATED SURFACE-GRINDING MACHINE

Albert G. Belden and Carl G. Flygare, Worcester, Mass., assignors to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application August 20, 1938, Serial No. 225,978

9 Claims. (Cl. 51—92)

The invention relates to grinding machines, and more particularly to a surface grinding machine for grinding plane surfaces on a work piece.

One object of the invention is to provide a surface grinding machine with an electrically controlled transverse feeding movement for the grinding wheel. Another object of the invention is to provide a surface grinding machine with a hydraulically actuated electrically controlled transverse feeding movement for the grinding wheel. A further object of the invention is to provide a hydraulically operated surface grinding machine with a tandem fluid pump one of which serves to feed the grinding wheel transversely during the period of reversal at the end of the table stroke and both of which serve to traverse the work table during the grinding stroke.

A further object of the invention is to provide a hydraulically operated transverse grinding wheel feeding mechanism with an electrically controlled time delay mechanism to regulate the extent of transverse feed of the wheel. Another object of the invention is to provide a hydraulic counterbalance for the vertical slide to facilitate manual vertical adjustment of the grinding wheel. A further object of the invention is to provide a power operated vertical positioning mechanism for positioning the grinding wheel. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts, as will be exemplified in the structure to be hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which is shown one of various possible embodiments of the mechanical features of this invention,

Fig. 1 is a front elevation of the improved surface grinding machine;

Fig. 2 is a plan view of the improved surface grinding machine, on a slightly reduced scale;

Fig. 3 is a fragmentary detail view of the power operated vertical feeding mechanism and the hydraulic counterblance; and

Fig. 4 is a diagrammatic illustration of the hydraulic system and the electrical wiring diagram for the automatic cross feed.

A surface grinding machine has been illustrated in the drawings having a base 10 which supports a longitudinally reciprocable work table 11 on the usual V-way and flat way (not shown). A grinding wheel 15 is rotatably mounted on a transversely movable slide 16 which is supported by a dovetailed slideway on a vertically movable slide 17 carried by an upwardly extending projection 18 of the base 10. The vertical slide 17 is arranged for a manual adjustment to position the periphery of the grinding wheel 15 relative to the surface of a work piece which is mounted on the table 11 so as to grind a plane surface thereon to the required extent. This mechanism may comprise a manually operable feed wheel 20 which is mounted on the outer end of a shaft 21 which is journalled in bearings (not shown) in the base 10. The shaft 21 supports a worm 22 which meshes with a worm gear 23. The worm gear 23 is provided with a central aperture which is threaded to mesh with a feed screw 24. The upper end of the feed screw 24 is connected to a lug 25 projecting from the vertically movable slide 17. A pair of nuts 26 and 27 serve rigidly to secure the screw 24 to the lug 25. The worm gear 23 is rotatably supported in housing 32, which is fixed relative to the base 10, so as rotatably to support the worm gear 23 and hold it against endwise movement so that when the gear 22 is rotated, the threaded aperture meshing with the feed screw 24 will produce an endwise vertical movement of the screw 24 together with the vertical slide 17, the wheel slide 16 and the grinding wheel 15.

Table reciprocating mechanism

The table 11 is arranged so that it may be reciprocated by a power operated mechanism to pass the work piece beneath the operative face of the grinding wheel 15. In the preferred form, the reciprocating mechanism comprises a fluid pressure system comprising a cylinder 35 which is fixedly mounted by means of brackets 36 and 37 to the under side of the table 11. A pair of spaced pistons 38 and 39 are slidably mounted within the cylinder 35 and are connected with the hollow piston rods 40 and 41, respectively, which are in turn fixed at their outer ends to brackets 42 and 43, respectively. The brackets 42 and 43 are fixedly mounted on opposite ends of the base 10.

The base 10 is preferably of a hollow box-like construction forming a fluid reservoir 45, from which fluid is pumped by means of a fluid pump 46 driven by an electric motor 47. The pump draws fluid through a pipe 48 and forces fluid out through a pipe 49 to a reversing valve 50 within the base of the machine. The valve 50 is preferably of the rotary type in which fluid passing through the pipe 49 enters through a port at the

rear of the valve and passes through an aperture 51 in the valve rotor 52 and out through a pipe 53, through a passage 54 in bracket 42 and a passage 55 within the piston rod 40, into a cylinder chamber 56 to cause the table 11 to move toward the left (Fig. 4). During this movement fluid within a cylinder chamber 57 is forced out through a central aperture 58 in the piston rod 41, through a passage 59 in the bracket 43 and through a pipe 60 into a valve chamber 61, and out through a pipe 62 into the reservoir 45.

Throttle valve

In order to control the speed of movement of the table 11 during grinding, it is desirable to provide a suitable throttling device which in the preferred form comprises a throttle valve 65 preferably located within the exhaust pipe line 62 whereby the exhaust of fluid from the system is throttled to regulate the speed of movement of the table. This valve has been illustrated diagrammatically as a rotary type throttle valve (Fig. 4). A control lever 66 is provided for actuating the throttle valve to regulate the speed of movement of the table or to close the valve to stop the table movement when desired.

A second fluid motor 70 preferably arranged in tandem with the fluid pump 46 and driven by the motor 47 is provided for actuating the transverse or cross feeding movement of the grinding wheel 15 which occurs during the reversal movement of the work table 11. During the normal grinding stroke of the table 11, the pressure from the pump 70 is utilized to supplement fluid under pressure from the pump 46 so as to drive the work table 11 at a higher rate of speed. The pump 70 forces fluid through a pipe 71 and a pipe 72 to the grinding wheel cross feeding mechanism to be hereinafter described.

Fluid under pressure from the pipe 72 may also pass through a pipe 73 to a control valve 74 which is connected to operate in timed relation with the reverse valve 50. The valve 74 is preferably a piston type valve comprising a valve stem 75 having formed integrally therewith a plurality of valve pistons 76, 77 and 78. In the position of the valve shown in Fig. 4, fluid under pressure from the pump 70 passing through the pipe 73 enters a valve chamber 79 located between the valve pistons 77 and 78 and is forced out through a pipe 80 which is connected with the pipe 49 so that fluid under pressure from the pump 70 is forced through the pipe 49 to the table reversing valve 50 to aid the pump 46 in driving the table 11 at a rapid rate. The valve stem 75 is connected by a stud 81 with the lower end of a lever 82 which is actuated at reversal to cut off the pipe 80 and thereby force all of the fluid from the pump 70 through pipe 72 for a definite interval during the shifting of the valve 50 into its reverse position.

Transverse movement—grinding wheel

The grinding wheel 15 and its supporting slide 16 are arranged so that they may be moved transversely by a manually operable mechanism including a manually operable hand wheel 85 mounted on the outer end of the shaft 86 which is operatively connected through a gear mechanism to move a rack bar 87 endwise. The rack bar 87 is preferably fixed to the upper surface of the wheel slide 16 and serves to move the slide 16 and grinding wheel 15 in either direction according to the rotation of the manually operable wheel 85. The manually operable feeding mechanism has not been illustrated in detail in the present application. This mechanism is substantially identical to that shown in the prior patent to Flygare et al. No. 2,022,542 dated November 26, 1935, to which reference may be had for details of disclosure not found herein.

A power operated mechanism is also provided for moving the grinding wheel slide 16 and the grinding wheel 15 transversely at the ends of the table stroke so that on successive reciprocations of the work beneath the wheel 15, the wheel will grind a different overlapping path on the work piece. In the preferred construction, a rotary fluid motor 90 is mounted on the vertical slide 17. This motor is a vane type motor having a single vane 91 mounted on a rotor shaft 92. The shaft 92 also carries a gear 93 meshing with a pinion 94 which in turn meshes with the rack bar 87 carried by the wheel slide 16. A control or reversing valve 95 is provided to control the admission of fluid and the exhaust of fluid from the motor 90. The reversing valve 95 is of the piston type comprising a valve stem 96 having a plurality of valve pistons formed integrally therewith. Fluid under pressure passing through the pipe 72 passes through a pipe 97, a portion of which is preferably either flexible or telescopic, to a valve chamber 98 and passes out into a motor chamber 99 to cause the vane 91 to move in a counterclockwise direction (Fig. 4) which serves through the gear 93 and pinion 94 to move the rack bar 87 and wheel slide 16 toward the left (Fig. 4). During this movement fluid under pressure exhausts from a motor chamber 100 through a valve chamber 101 and a pipe 102 which exhausts into the reservoir 45.

A manually operable knob 105 is mounted on the outer end of the valve stem 96 and serves to facilitate manual shifting of the reversing valve 95. A solenoid operated valve 103 connected in the pipe line 102 and actuated by a solenoid 104 is normally closed and thereby serves to prevent movement of the fluid within the wheel traverse system so as to hold the wheel slide 16 and grinding wheel 15 against transverse movement. The valve 103 is merely a shut-off valve and does not serve in any way to throttle the fluid when opened.

A throttle valve, preferably a needle type valve 106, is actuated by a manually operable knob 107 and serves to regulate the exhaust of fluid from the system above described to control the normal rate of transverse feeding movement of the grinding wheel as it is indexed transversely.

In order to facilitate truing of the grinding wheel, it is desirable to provide a truing speed valve which is independent of the normal speed control valve whereby the wheel may be continuously traversed at a slow truing speed without disturbing the normal speed adjustment of the transverse movement of the grinding wheel. This is preferably accomplished by providing a second needle valve 110 which may be readily adjusted to throttle the exhaust of fluid from the motor 90 to produce the desired truing speed, and the valve is arranged so that it may be readily shifted to and from an operating position by means of a knob 111 so that during the normal operation of the machine, the valve 110 is rendered inoperative and the valve 106 serves to control the exhaust of fluid from the system.

Wheel slide reversing mechanism

A reversing mechanism is preferably provided for automatically shifting the reversing valve 95

in timed relation with the transverse movement of the wheel slide 16. A pair of adjustable dogs 120 and 121 are supported on a bar 122 carried by the wheel slide 16. The dogs 120 and 121 are arranged to engage a reversing lever 123 which is operatively connected to shift the valve stem 96 in an endwise direction to reverse the direction of movement of the wheel after it has traversed transversely through a predetermined distance to cover the width of the work piece being ground. A load and fire spring-pressed plunger (not shown) is contained within a casing 124 and serves normally to snap the reversing lever from one position to the other when actuated by the wheel slide dogs 120 and 121. This reversing mechanism has only been illustrated diagrammatically in Fig. 4. This reversing mechanism is identical with that shown in the prior patent to Flygare and Wood No. 2,022,542 dated November 26, 1935, to which reference may be had for details of disclosure not found herein.

Table reversing lever

A reversing lever 130 is pivotally mounted on the front of the machine base and is operatively connected to shift the reversing valve 50 in timed relation with the longitudinal movement of the table 11 to reverse the direction of movement of the same after it has traversed a predetermined distance. A pair of adjustable dogs 131 and 132 mounted on the front edge of the table 11 serve to engage the reverse lever and to shift the lever and the reversing valve 50 to change the direction of flow of fluid to the cylinder 35. A load and fire mechanism (not shown) is provided to aid in shifting the valve 50 into its reverse position. This has not been illustrated in detail in the present case since it is identical with that shown in the above mentioned prior patent to Flygare and Wood No. 2,022,542 dated November 26, 1935, to which reference may be had for details of disclosure not found herein.

Automatic grinding wheel cross feed

The shut-off valve 103 above described is normally closed and is arranged to be opened by means of the solenoid 104. The valve 103 is maintained in a closed position during the longitudinal reciprocatory movement of the work table 11 so as to hold the grinding wheel 15 against transverse movement. The valve 103 is opened during the period of reversal of the table 11 to feed the wheel 15 transversely for grinding a new path on the work piece mounted on the table 11. It is desirable to control the opening and closing of the solenoid valve 103 in timed relation with the reversing mechanism of the table 11. A normally open limit switch 135 is mounted on the reversing lever 130 and is provided with an actuating roller 136 which is arranged in the path of the table dogs 130 and 131. When either of the table dogs 131 or 132 engages the roller 136 of the limit switch 135, the limit switch is closed, after which continuous movement of the table 11 through either the dog 131 or the dog 132 serves through the roller 136 to shift the lever 130 into its reverse position to reverse the position of the control valve 50 and thereby change the direction of flow of fluid to the cylinder 35 so as to start the table 11 traversing in the reverse direction. The switch 135 is connected by flexible BX conduits 137 with an adjustable electrical time delay relay 138 and is connected by the wires 139 and 140 with the solenoid 104 on the valve 103. When the table dogs rock the roller 136 in either direction to close the limit switch 135, it closes a circuit to set the time delay relay 138 in motion and also serves simultaneously to energize the solenoid 104 to open the valve 103, which allows fluid under pressure to exhaust from the feed motor 90. No fluid will flow into the feed motor 90, however, until the reversing mechanism has shifted a sufficient distance so that the valve piston 77 of the valve 74 cuts off the pipe 80, cutting off the output of the fluid pump 70 from the table cylinder 40 and shifting to the pipe 97 to actuate the feed motor 90. The adjustable time delay relay 138 may be set to allow the solenoid 104 to be energized for a definite time interval, after which the solenoid 104 is deenergized and the valve 103 automatically closed to stop the transverse movement of the wheel 15 after a predetermined transverse feed of the grinding wheel has been accomplished.

Hydraulic counterbalance

An adjustable by-pass valve 145 is provided in the pipe 71. This valve determines the pressure applied to actuate the cross feed movement of the wheel. This valve is preferably set so that sufficient fluid exhausts therethrough into a pipe 146 which is conveyed to a hydraulic counterbalance mechanism comprising a cylinder 147 having a piston 148 slidably mounted therein. The piston 148 is connected to the lower end of the feed screw 24. Fluid under pressure passing through the pipe 146 enters a cylinder chamber 149 below the piston 148 and serves normally to exert a pressure on the screw 24 in an upward direction. This uniform pressure is applied at all times to the feed screw so as to, in effect, counterbalance either the whole or part of the weight of the vertical slide 17 and the parts carried thereby, so that the manually operable feed wheel 20 may be easily and readily rotated vertically to adjust the slide without undue exertion on the part of the operator. This vertical pressure exerted on the feed screw 24 also serves more accurately to control the positioning of the slide 17 as well as the wheel slide 16 and grinding wheel 15 due to the fact that the pressure between the screw and the nut is always in the same direction regardless of whether the vertical slide 17 is being moved upwardly or downwardly. The pressure within the cylinder chamber 149 may be governed by a by-pass valve 150 so that the required pressure may be obtained to produce the desired results.

Motor driven vertical movement of wheel

It is desirable to provide a suitable power operated mechanism for raising and lowering the wheel in setting up the machine for grinding work pieces of varying predetermined sizes. This is preferably accomplished by providing a motor drive for the shaft 21. An electric motor 160 is mounted within the base 10. A pulley 161 mounted on the motor shaft, which is preferably of a multiple V-grooved type, is connected by means of multiple V-belts 162 with a multiple grooved pulley 163 mounted on the rear end of the shaft 21. It will be readily apparent that when the motor 160 is rotated in either direction, a rotary motion will be transmitted to the shaft 21 to rotate it in either direction which, through the worm 22 and worm gear 23, will produce a vertical movement of the feed screw 24, the vertical slide 17, as well as the grinding wheel slide 16 and grinding wheel 15. A suitable control switch 165 is mounted on the front of the

machine base. This control switch is preferably of a reverse type having an actuating knob 166 which when moved into the up position serves to rotate the motor in one direction so as to cause an upward movement of the vertical slide 17, wheel slide 16 and grinding wheel 15, and when moved to a down position serves to rotate the motor 160 in the reverse direction to cause a downward movement of the slide 17 and grinding wheel 15. This motor driven mechanism serves as a rapid positioning movement for the grinding wheel 15 in setting up the machine, the fine adjustment of the same being obtained by a manual manipulation of the feed wheel 20.

The operation of this improved surface grinding machine will be readily apparent from the foregoing disclosure. Assuming all of the parts have been previously adjusted, a work piece is placed on the table 11 and the lever 66 is shifted to permit exhaust of fluid from the table system. The motor 47 being in running condition serves to force fluid under pressure through the system to reciprocate the table 11 through a stroke of a predetermined length as governed by the adjustable table dogs 131 and 132. At the end of the stroke in either direction, when the dog 131 or the dog 132 engages the roller 136 of the reversing lever 130, the roller 136 first rocks relative to the lever 130 to close the limit switch 135, thereby starting the time delay relay 138 in operation and simultaneously energizing the solenoid 104 so that the exhaust pipe line from the feed motor 90 is opened. Continued movement of either table dog 130 or 132 shifts the reversing valve 50 into a reverse position and at the same time, through the lever 82, shifts the valve 174 to cut off the fluid motor 70 from the table cylinder 35 and transfers this fluid under pressure from the pump 70 to index or feed the grinding wheel slide 16 and the grinding wheel 15 transversely during the time interval when the reverse valve is shifting to change the direction of movement of the table 11. By manipulation of the time relay 138, the extent of cross feed of the grinding wheel may be varied as desired. During all of this movement of the machine, both reciprocation of the table during grinding and the transverse feeding movement of the wheel at reversal, a uniform pressure is maintained within the hydraulic counterbalance cylinder chamber 149 so as accurately to locate the wheel 15 and maintain it in the desired adjusted position.

Assuming the table 11 (Fig. 4) is traveling in a direction toward the left, the valve 50 shifts to change the direction of flow of fluid to the table cylinder 35 and the lever 82 also shifts to move the valve stem 75 of the valve 74 toward the right to cut off the pipe 73 so that valve piston 74 cuts off the pipes 73 and 80 so that all the fluid under pressure from the pump 70 is conveyed to the wheel traversing or feeding motor 90. When the valve 74 shifts to its extreme right-hand position, a valve chamber 151 located between the valve pistons 76 and 77 again connects the pipe 73 with the pipe 80 so that substantially the entire volume of fluid from the pump 70 is conveyed to the table cylinder to assist the pump 46 in traversing the table 11 at a rapid rate. In all positions of the valve above described, there is sufficient fluid escaping through the by-pass valve 145 to facilitate obtaining the desired fluid pressure within the chamber 149 of the hydraulic counterbalance cylinder 147. It will be readily apparent from the foregoing disclosure that the upper pump 46 of the tandem pump is utilized to traverse the table 11 exclusively, whereas fluid from the lower pump 70 of the tandem pump is utilized to maintain a pressure at all times within the counterbalance cylinder chamber 149 and during the normal table traverse to supplement the pressure from the pump 46 to reciprocate the table 11 at a rapid rate and also during the period of reversal serves to actuate the fluid motor 90 to cause a transverse feeding movement of the wheel slide 16 and grinding wheel 15.

It will thus be seen that there has been provided by this invention apparatus in which the various objects hereinbefore set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. In a surface grinding machine, a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally reciprocable work supporting table, a separate fluid motor for said slide and table, a separate control valve for each of said motors, a fluid pressure system including two motor driven pumps, operative connections between one of said pumps and said table valve and motor to reciprocate the table, and operative connections between said second pump and said slide motor and valve to feed the wheel transversely at the end of the table stroke, said latter connections being arranged to connect the second pump with said table valve and cylinder during the normal reciprocatory movement of the table to supplement said first pump.

2. In a surface grinding machine, a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally reciprocable table, a separate fluid motor for said slide and table, a separate control valve for each of said motors, a fluid pressure system including two motor driven fluid pumps, operative connections between one of said pumps and the table valve and cylinder to reciprocate the table, and means alternately to connect said second pump to said wheel slide motor during the table reversal period and to said table valve and cylinder during the normal reciprocatory movement of said table.

3. In a surface grinding machine, a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally reciprocable table, a separate fluid motor for said slide and table, a separate control valve for each of said motors, a fluid pressure system including two motor driven fluid pumps, operative connections between one of said pumps and said table valve and cylinder to reciprocate the table, and operative connections alternately to connect said second pump to the wheel slide valve and motor to feed the grinding wheel transversely at the end of the table stroke and to connect said second motor to said table valve and cylinder during the normal grinding stroke of said table.

4. In a surface grinding machine, a rotatable grinding wheel, a transversely movable wheel slide therefor, a vertically movable slide for said transverse slide, hydraulic counterbalance for said vertical slide including a piston and cylinder, a longitudinally reciprocable table, a separate fluid motor for said wheel slide and table, a sep-

arate control valve for each of said motors, a fluid pressure system including two motor driven pumps, operative connections between one of said pumps and said table valve and cylinder to reciprocate said table, operative connections between said second pump alternately to connect said second pump to the wheel slide valve and motor to feed the wheel transversely at the end of the table stroke and to connect said second pump to said table valve and cylinder during the normal grinding stroke thereof, and operative connections between said second pump to maintain a uniform pressure in said counterbalance cylinder at all times.

5. In a surface grinding machine, a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally reciprocable table, means including a reversing lever to reciprocate said table, a fluid pressure piston and cylinder operatively connected to traverse said slide, a control valve to control the admission to and exhaust of fluid from said cylinder, a solenoid valve to control the exhaust of fluid from said valve and cylinder which is normally closed during reciprocation of said table, a limit switch on said reverse lever, dogs on said table to engage said limit switch to actuate the same and to shift the reversing lever, and an electrical time delay relay which is rendered operative when the reverse lever is shifted to energize said solenoid valve to permit exhaust of fluid from the slide cylinder and thereby cause a transverse traversing of the grinding wheel during the table reversal.

6. In a surface grinding machine, a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally reciprocable table, means including a reversing lever to reciprocate said table, a fluid pressure piston and cylinder operatively connected to traverse said slide, a control valve to control the admission to and exhaust of fluid from said cylinder, a solenoid valve to control the exhaust of fluid from said valve and cylinder which is normally closed during reciprocation of said table, a limit switch actuated in timed relation with said reverse lever, dogs on said table to shift the reversing lever, and an electrical time delay relay which is rendered operative when the reverse lever is shifted to energize said solenoid valve to permit exhaust of fluid from the slide cylinder and thereby cause a transverse traversing of the grinding wheel during the table reversal.

7. In a surface grinding machine, a rotatable grinding wheel, a transversely movable slide therefor, a vertical slide to support said transverse slide, a longitudinally reciprocable work supporting table, means including a manually operable nut and screw mechanism to feed said vertical slide in either direction to cause the grinding wheel to approach or recede from said work table, means including a reversible electric motor to actuate said nut and screw mechanism including a piston and cylinder operatively connected to the end of said screw, means to supply fluid under pressure to said cylinder, said pressure being sufficient to take up the backlash between the nut and screw and to assure the thrust between the screw and nut is always in the same direction regardless of whether the screw and nut are operated to move the slide up or down.

8. In a surface grinding machine, a rotatable grinding wheel, means including a vertical slide to support said wheel, manually operable means including a nut and screw mechanism to adjust the position of said slide and wheel in a vertical direction, means including a reversible electric motor to operate said nut and screw in either direction to cause an up or down movement of said slide and wheel, and a fluid pressure end thrust mechanism for said screw including a piston and cylinder operatively connected to the end of said screw, means to supply fluid under pressure to said cylinder, and means to adjust said pressure so that the screw and nut are always held in the same position relative to each other regardless of whether the nut and screw are actuated to cause an up or down movement of the slide.

9. In a surface grinding machine, a rotatable grinding wheel, means including a vertical slide to support said wheel, a manually operable feed mechanism for said slide including a rotatable nut which is held against endwise movement, a non-rotatable feed screw, connections between the upper end of said screw and said slide, means including a reversible electric motor to rotate said nut in either direction, a reversing switch therefor, and a fluid pressure end thrust mechanism for said screw including a piston and cylinder operatively connected to the lower end of said screw, means to supply fluid under pressure to said cylinder, and means including a manually adjustable valve to maintain a uniform pressure in said cylinder so that the thrust between the nut and screw is always in the same direction.

ALBERT G. BELDEN.
CARL G. FLYGARE.