June 19, 1962 G. J. PETERSON 3,039,237

CONTROL MECHANISM FOR GRINDING MACHINES

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Fig. 1

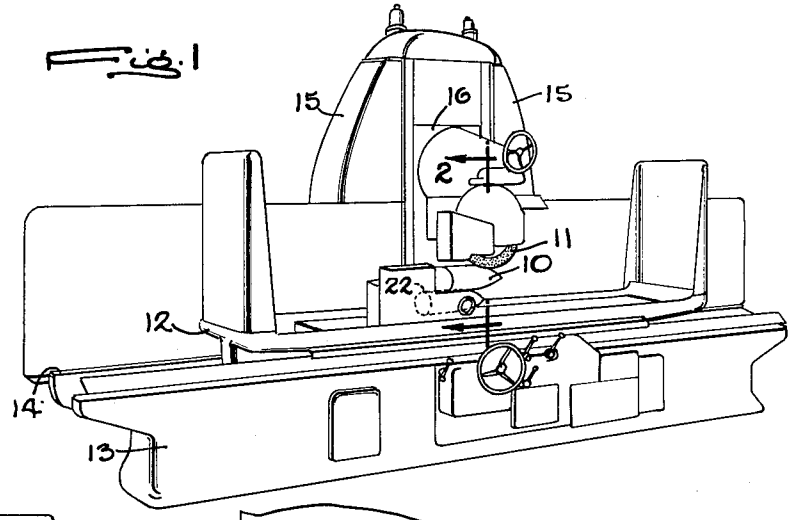
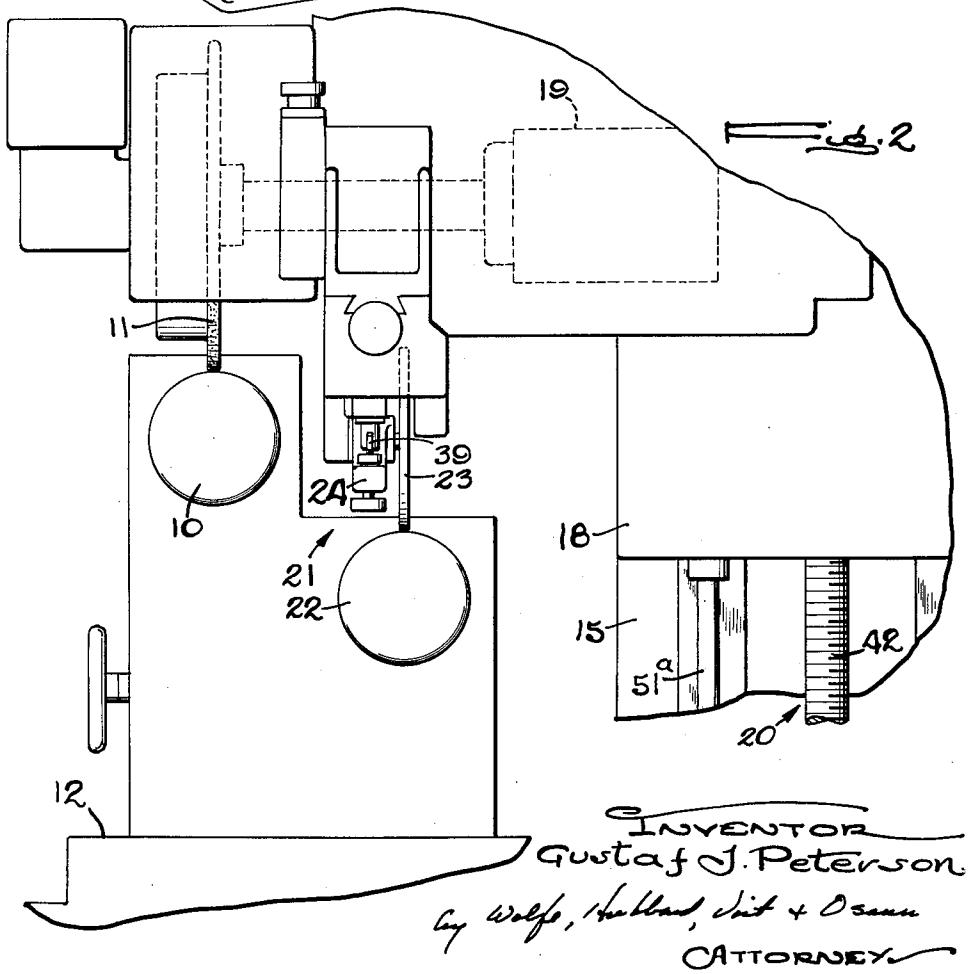


Fig. 2



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Fig. 3

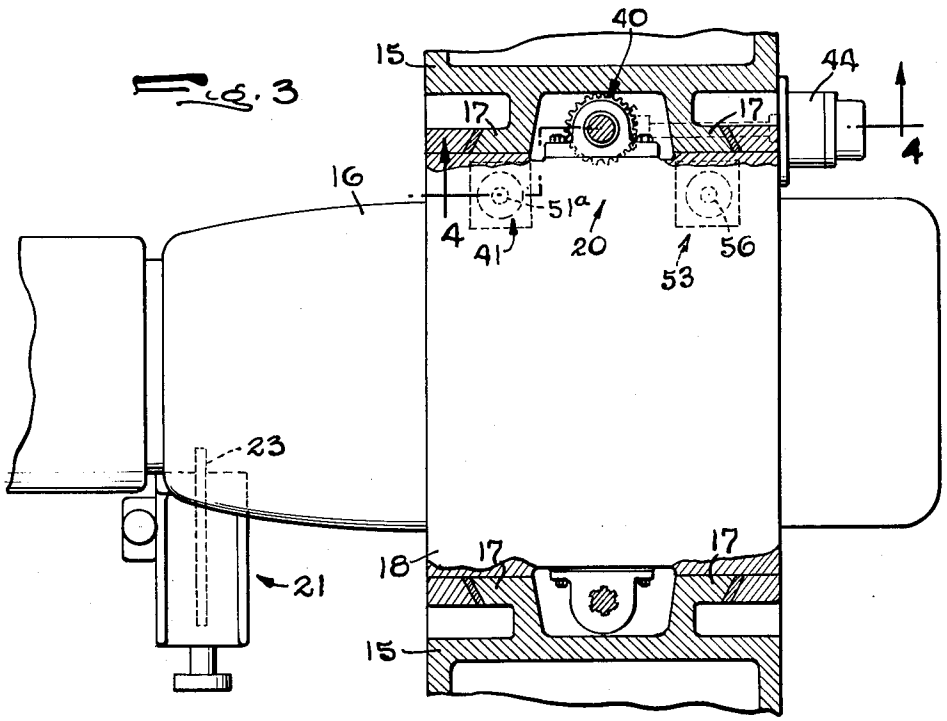
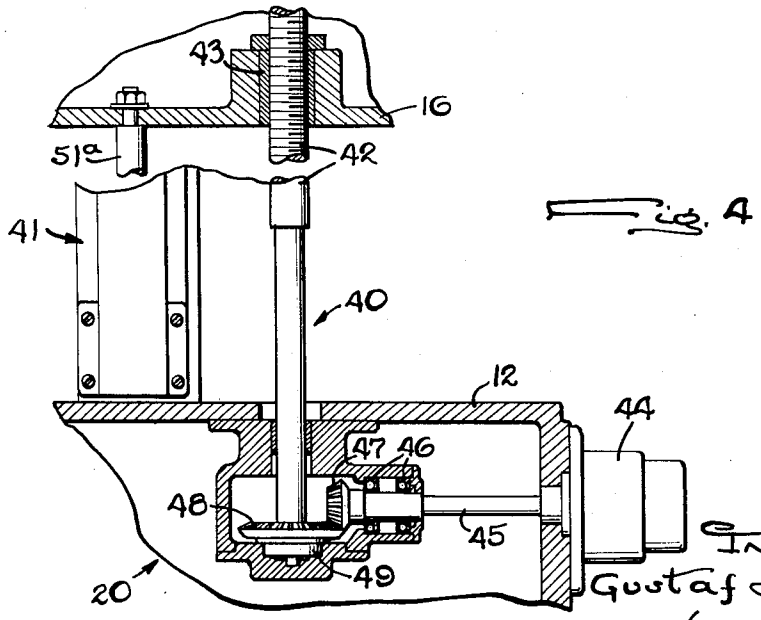


Fig. 4



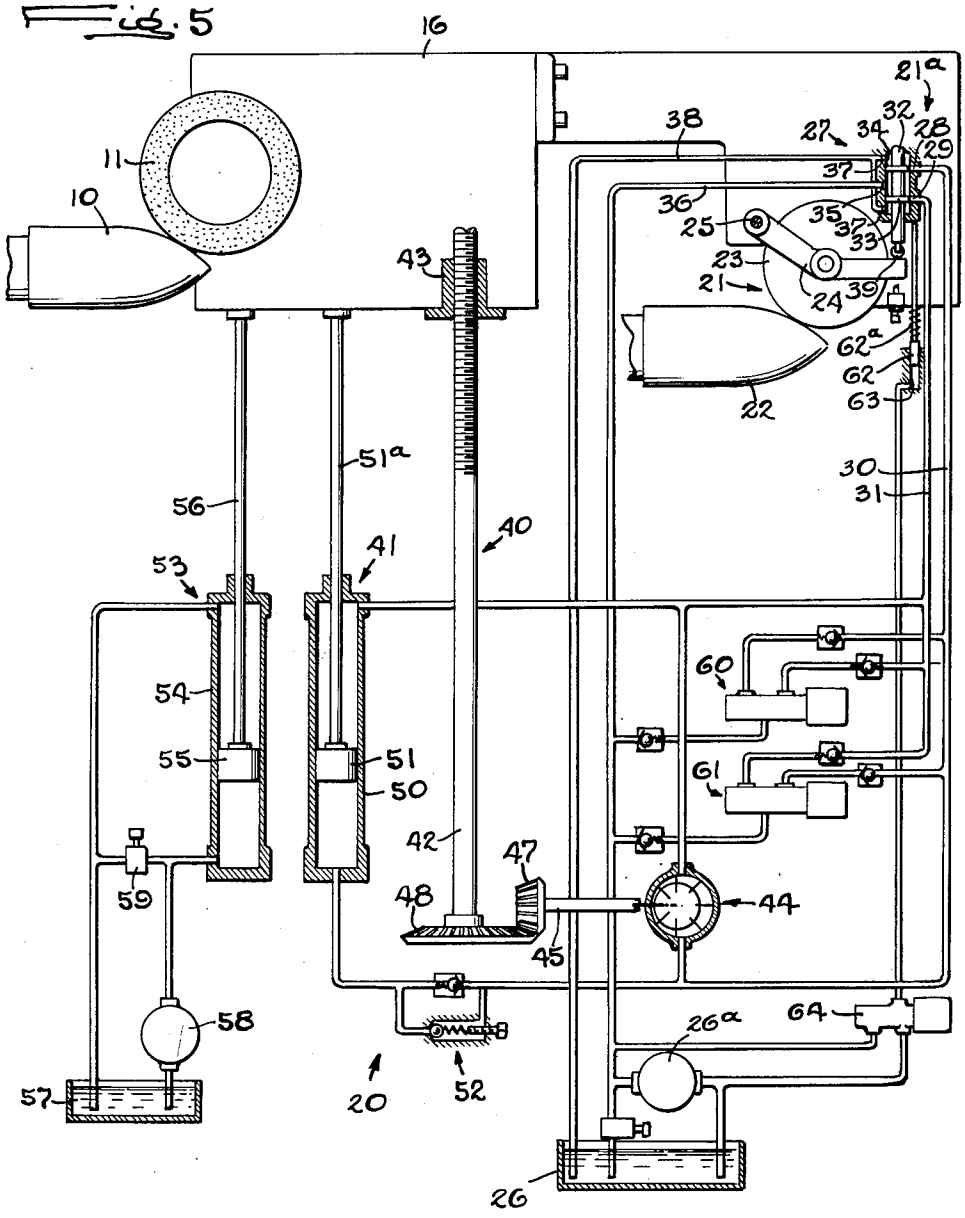
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Fig. 5



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CONTROL MECHANISM FOR GRINDING MACHINES

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Filed Aug. 14, 1959, Ser. No. 833,856
6 Claims. (Cl. 51—100)

The present invention relates to machine tools of the type wherein the workpiece is fixed to a table and reciprocated back and forth past a tool carried by a head which is mounted to move transversely of the work table toward and away from the later and, more particularly, the invention relates to an automatic grinding machine having a tracer element mounted on the head adjacent the grinding wheel to engage a pattern mounted on the work table and reciprocated past the head, the tool head moving relative to the table in response to signals from the tracer element.

The general object of the invention is to provide a new and improved grinding machine of the above character which is adapted to automatically grind the workpiece to the contour and dimensions of the pattern within close tolerances.

Another object is to provide, in a machine of the above character, a novel actuating means for moving the tool head relative to the work table comprising a screw type actuator for controlling the movements of the head and which is connected in parallel with a piston and cylinder type actuator operable to assist the screw in moving the head and thereby eliminate any delay in response due to twisting of the shaft of the screw.

Other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which

FIGURE 1 is a perspective view of a grinding machine embodying the novel features of the present invention.

FIG. 2 is an enlarged fragmentary sectional view taken along line 2—2 in FIG. 1.

FIG. 3 is a fragmentary plan view of the tool head with parts broken away as shown in section.

FIG. 4 is a fragmentary sectional view taken along line 4—4 in FIG. 3.

FIG. 5 is a schematic view showing the hydraulic circuit utilized in the present invention.

The present invention is shown in the drawings for purposes of illustration embodied in a grinding machine of the type in which the work 10 is reciprocated back and forth past a grinding wheel 11 and indexed to present different surfaces of the work to the wheel. The work 10 is carried by a work table 12 mounted on an elongated horizontal bed 13 to slide back and forth on ways 14 formed on the upper side of the bed. Midway between the ends of the bed 13 and at one side thereof, two parallel and upright columns 15 are fixed to the bed and project above the work table. A tool head 16 spans the columns 15 and is guided for movement toward and away from the work table 12 by vertical dovetail ways 17 formed on opposed faces of the columns 15 and adapted to receive a slide 18 formed on the head 16. The latter projects laterally outwardly from the upright columns 15 to overhang the work table 12. The grinding wheel 11 is journaled adjacent the outer end of the tool head 16 to extend below the head and engage the work 10 mounted on the work table 12. A motor 19 disposed within the head rotates the wheel 11 against the work to grind the latter.

In order to grind a workpiece having a specific contour such as the projectile contour illustrated in the

drawings, the tool head 16 is slid up and down the vertical ways 17 by an actuating means 20 controlled by a control mechanism 21a responsive to a tracer element 21 adapted to follow the contour of a pattern 22 having the desired finishing configuration. In the present instance, the pattern 22 is mounted on the work table 12 adjacent the workpiece 10 and is reciprocated by the table back and forth past the tracer element 21. Herein, the tracer element 21 comprises a wheel 23 journaled intermediate the ends of a lever 24 which is pivoted at one end as at 25 to the tool head 16. The outer periphery of the wheel 23 engages and rolls along the pattern 22 as the latter is moved by the table past the wheel. The axis of the tracer wheel 23 is displaced along an arc about the pivot 25 as the wheel rolls along the irregular shape of the pattern 22.

To transmit the movements of this axis to the control mechanism 21a, the free end of the lever 24 extends outwardly past the outer periphery of the tracer wheel 23 to engage the mechanism 21a controlling the actuating means 20 whereby the head 16 is moved in a direction corresponding to that in which the axis of the tracer wheel 23 moves. As the head 16 moves in response to the control mechanism 21a, the pivot 25 of the lever 24 is moved therewith and the axis of the tracer wheel swings about the pivot. When the lever 24 assumes its original position in respect to the head 16, movement of the head ceases. In this manner the movements of the tracer wheel 23 are transmitted to the head 16 which in turn moves the grinding wheel 11 journaled thereon relative to the workpiece 10 passing beneath the grinding wheel. Since the grinding wheel 11 moves relative to the workpiece 10 in the same manner as the tracer wheel 23 moves relative to the pattern 22, the dimensions of the pattern is duplicated on the workpiece.

While various means to move the tool head 16 in response to signals from the tracer wheel 23 may be used, in the present instance a hydraulic system is utilized in which fluid is drawn from a source 26 by a pump 26a and supplied under pressure through the control mechanism 21a to the actuating means 20. The fluid is directed by the control mechanism 21a to the actuating means 20 to move the tool head 16 up or down relative to the work table 12 as directed by the movements imparted to the tracer wheel 23 by the pattern 22.

Herein, the control mechanism 21a comprises a valve 27 operable to open to permit the fluid to flow to the actuating means 20 and to direct the flow through one of two outlet ports 28 and 29 communicating with the actuating means 20 through passages 30 and 31 to move the tool head 16 either up or down. The valve 27 comprises an elongated plunger rod 32 having lands 33 closely fitting and slidable in an elongated vertical bore 34 in a casing mounted on the tool head. The lands 33 are axially spaced apart the same distance as the ports 28 and 29 and are of the same axial length as the diametrical width of the ports so as to block the latter. Axial displacement in either direction of the rod 32 opens one or the other of the ports and permits fluid to flow through one or the other of the passages 30 and 31.

A supply port 35 opening into the bore and formed at the end of a supply passage 36 communicates at all times with the space disposed within the bore and surrounding the rod 32 between the two lands 33. Ports 37 formed at either end of the bore 34 connect a drain passage 38 with the spaces disposed within the bore and surrounding the rod at the outer sides of the lands, the drain passage 38 discharging into the source 26. Movement in either direction of the valve opens one or the other of the outlet ports 28 and 29 permitting

the pressure fluid to flow from the space intermediate the lands to the actuator means through one or the other of the passages 30 or 31.

In order to move the plunger rod 32 in response to the movements of the tracer wheel 23, a roller 39 is journaled on the lower end of the rod to engage the free end of the lever 24 supporting the tracer wheel. The roller is held in engagement with the lever by gravity whereby the rod 32 is slid up and down in the bore 34 as the axis of the wheel 23 turns about the pivot 25 of the lever as the pattern 22 is passed beneath the wheel. As the tool head 16 moves in response to the movements of the rod 32, the casing fixed to the head moves relative to the rod sliding the bore along the lands 33 until the latter again cover the outlet ports 28 and 29 thereby shutting off the flow of fluid to the actuating means 20 and stopping the movement of the tool head.

While various types of fluid actuators may be used to move the tool head 16 up and down along the ways 17 relative to the work table 12, the actuator when used to move the tool head of a grinding machine or the like such as described above should be adapted to move relatively heavy loads to insure that sufficient pressure will be exerted by the grinding wheel on the surface of the work to cut into the surface without riding up on the work. At the same time it is also desirable, when grinding certain articles, that the actuator and the control system be adapted to move the tool head and grinding wheel so as to follow the movements of the tracer wheel within very close tolerances. In the present instance, the weight of the tool head may be on the order of 7500 pounds and the desired tolerances are on the order of .0005 of an inch.

In accordance with the present invention, the tool head is moved up and down along the vertical ways 17 by a novel actuating means operable to move the head in response to the movements imparted to the tracer wheel by the pattern so as to duplicate the dimensions of the pattern on the workpieces within the desired tolerances. To this end, the actuating means comprises two actuators, a screw type 40 to control the movements of the head 16 and thus prevent hunting and a piston and cylinder type 41 to relieve a portion of the load on the screw and thereby improve the response characteristics of the latter. The actuators are connected in parallel to the control mechanism 21a whereby pressure fluid is introduced simultaneously to both actuators which act together to raise or lower the tool head 16.

Herein, the screw type actuator 40 comprises an elongated shaft 42 having one end threaded into a nut 43 fixed to the tool head 16 and the opposite end journaled on the bed 12 of the machine to rotate about a fixed vertical axis. The shaft 42 is rotated to effect raising and lowering of the tool head by a vane motor 44 operatively connected to the shaft 42 and coupled to the fluid passages 30 and 31 leading to the valve 27. The motor 44 is mounted on the side of the bed 12 of the machine with the driven shaft 45 of the motor projecting inwardly along a horizontal axis intersecting the axis of the shaft 42 and journaled in a bearing 46 fixed to the bed adjacent the shaft 42. Fixed to the inner end of the driven shaft 45 is a bevel gear 47 which meshes with a mating bevel gear 48 fixed to the lower end of the screw shaft 42 and journaled in a foot bearing 49 mounted on the bead 12 of the machine (FIG. 4).

In order to rotate the shaft 42 in either direction, the motor 44 is connected to the fluid passages 30 and 31 so that fluid may be passed through the motor in either direction in response to the movementn of the tracer wheel 23. At least a portion of the weight of the tool head 16 is supported by the screw at all times so that, regardless of the direction of rotation of the shaft 42, the threads of the nut 43 bear against the top surface of the threads formed on the shaft 42 thereby eliminating the detrimental effect of the clearance between the mating

threads without the need of a compensated screw and nut to maintain the desired degree of accuracy.

In moving relatively heavy loads with a screw type actuator, the torque exerted on the shaft of the screw tends to twist the shaft somewhat before moving the load thereby delaying the movements of the load in response to the tracer element and resulting in variations between the pattern and work which exceed the permissible limits. In order to minimize the amount of twisting of the shaft, a piston and cylinder type actuator 41 is mounted to act between the tool head and the bed and is operable to assist the screw in moving the load. This reduces the load on the shaft 42 whereby less torque need be exerted thereon to move the load and thus less twisting occurs.

Herein, the actuator 41 comprises a cylinder 50 mounted on the bed 12 of the machine adjacent the shaft 42 of the screw with a piston 51 disposed therein and a piston rod 51a extending vertically upwardly with its upper end attached to the tool head 16. The fluid passages 30 and 31 are attached to the cylinder at both the head end and the rod end whereby force may be exerted against the piston 51 and thus on the head 16 in either direction in response to movement of the tracer wheel 23. A suitable pressure actuated relief valve 52 is disposed in the fluid passage 30 connected to the head end of the cylinder 50 to permit the fluid to flow from the cylinder as the piston is moved downwardly. The rod end of the cylinder is exhausted through the passage 31 when the valve 27 is positioned to introduce the fluid to the head end of the cylinder 50.

As noted above, the cylinder 50 is connected in parallel with the vane motor 44 whereby the fluid is introduced to both simultaneously when the valve 27 is opened. The fluid introduced into the cylinder 50 acts directly on the piston 51 and thus exerts a force on the tool head 16 instantly. On the other hand the force derived from the passage of fluid through the motor 44 is conveyed to the head 16 through a mechanical connection, the gears 47 and 48 in the present instance, and therefore there is a slight lag in response between the introduction of the fluid to the lag in the application of the force against the tool head. As a result of this lag, the force is exerted on the head 16 by the piston 51 first thus relieving part of the load from the screw whereby less torque need be applied to the shaft 42 to move the load and thus less twisting of the shaft will occur. In moving the tool head 16 downwardly the twisting of the shaft 42 is not detrimental since the force exerted by the threads of the nut 43 coacting with the threads on the shaft tends to rotate the shaft in a direction to lower the head. When the fluid is directed through the vane motor to rotate it in a direction to lower the tool head 16, no twisting of the shaft 42 occurs and the response is within the permissible limits.

In order to permit the use of actuators of a practical size, a part of the weight of the tool head 16 is (35 to 40 percent in the present instance) absorbed by a counterbalance means 53 independent of the actuating means 20. To this end, a second cylinder 54 is mounted on the bed of the machine with a piston disposed in the cylinder and with the piston rod 56 projecting upwardly and fixed to the tool head 16. Fluid is supplied to the head end of the cylinder under a constant pressure from a source 57 by a pump 58. A tube connected to the rod end of the cylinder relieves the back pressure from the rod end and conveys any fluid escaping past the piston to the source. The pressure of the fluid entering the cylinder 54 is controlled by an adjustable pressure actuated valve 59 disposed in the line between the pump and the cylinder.

In order to adjust the grinding and tracing wheels in the proper position to commence the work cycle, manually operated valves 60 and 61 are disposed in the fluid passages 30 and 31 between the valve 27 and the actuators 40 and 41 and are operable to open and permit the fluid to bypass the valve 27 and flow directly from the pump 26a to the actuators.

Means also is provided to lift the tool head **16** on the return stroke of the table **12** whereby the grinding wheel **11** is in engagement with the work as the latter moves in one direction only. To this end, the valve casing **27** is held in the proper position relative to the rod during the working stroke by a piston **62** (FIG. 5) disposed within a bore **63** in the head **16**. Pressure fluid is introduced into the bore during the working stroke from the pump **26a** through a suitable valve **64** to act against the piston. To change the position of the valve casing **27** relative to the head **16** and to the plunger rod **32** the valve **64** is closed whereby the piston **62** is urged downwardly by a spring **62a** acting between the piston and the head **26**. When the casing is moved downwardly relative to the rod **32**, the port **28** is uncovered permitting the fluid to flow through the passage **30** to the actuating means **20** whereby the head **16** is moved upwardly to carry the grinding wheel above the work **10** as the head is moved back to the starting position. At the starting position, the valve **64** automatically opens introducing the pressure in the bore **63** whereby the valve casing is raised relative to the head **16**. The bore **34** is thus slid along the lands whereby the port **29** is uncovered permitting the fluid to flow through the passage **31** to the actuators which lower the tool head to bring the grinding wheel **11** into engagement with the work.

It will be apparent that, with a grinding machine such as described above, very close tolerances may be maintained in automatically grinding a workpiece to the dimensions of a pattern. The screw type actuator controls the movements of the tool head at all times and thus substantially eliminates hunting. Delay in response due to twisting of the shaft is substantially eliminated by the piston and cylinder coupled in parallel to the motor rotating the screw and operable to remove part of the load from the threads of the screw.

I claim as my invention:

1. A grinding machine having, in combination, a horizontal bed member, a work table reciprocable on said bed, vertical guideways formed on said bed extending above said table, a head member mounted on said guideways to slide toward and away from said table, a grinding wheel rotatably mounted on said head to engage a workpiece on said table as the table is reciprocated back and forth past said head, a tracer element mounted on said head to engage and move along a pattern mounted on said table, a screw extending between said members and journaled on one member to turn about an axis paralleling said guideways, said screw being axially fixed relative to said one member and having a threaded connection with the other member, a reversible rotary hydraulic actuator coupled to said screw and operable when energized to turn the screw in opposite directions relative to said connection and raise and lower said head along said guideways, a reciprocating hydraulic actuator connected between said members and operable when energized to urge said head alternately back and forth along said guideways, a source of fluid under pressure, and control mechanism responsive to the movements of said tracer to energize said actuators simultaneously in directions corresponding to the directions of the variations of the pattern whereby said reciprocating actuator supplements the action of said rotary actuator and said screw in moving said head along said path.

2. In a machine for grinding workpieces according to a predetermined pattern, the combination of, a base member, a head member mounted on said base for back and forth movement relative thereto along a predetermined path, a grinding tool operatively supported on said head, a screw extending between said members and journaled on one member to turn about an axis paralleling said path, said screw being axially fixed relative to said one member and having a threaded connection with the other member, a reversible rotary hydraulic actuator coupled to said screw and operable when energized to turn the screw alternately in opposite directions relative to said connection and move said head back and forth along said path, a reciprocating hydraulic actuator connected between said members and operable when energized to urge the head alternately back and forth along said path, a tracer element mounted on said head for engagement with and movement along the pattern, a source of fluid under pressure, a valve having an inlet communicating with said source and outlets each communicating with both of said actuators on corresponding sides of the latter, and a valve operator movable back and forth in response to the movements of said tracer to connect said outlets alternately to said source thereby to energize said actuators simultaneously in corresponding directions, said reciprocating actuator supplementing the action of said screw in moving said head and said tool along said path in accordance with the variations in the pattern.

3. In a machine for grinding workpieces according to a predetermined pattern, the combination of, a base member, a head member mounted on said base for back and forth movement relative thereto along a predetermined path, a grinding tool operatively supported on said head, a screw extending between said members and journaled on one member to turn about an axis paralleling said path, said screw being axially fixed relative to said one member and having a threaded connection with the other member, a reversible rotary hydraulic actuator coupled to said screw and operable when energized to turn the screw alternately in opposite directions relative to said connection and move said head back and forth along said path, a reciprocating hydraulic actuator connected between said members and operable when energized to urge the head alternately back and forth along said path, a tracer element mounted on said head for engagement with and movement along the pattern, a source of fluid under pressure, and control mechanism including a valve actuated by the movements of said tracer to connect corresponding sides of said actuators to said source to energize the actuators simultaneously in directions corresponding to the directions of the variations of said pattern whereby said reciprocating actuator supplements the action of said rotary actuator and said screw in moving said head along said path.

4. In a machine for grinding workpieces according to a predetermined pattern, the combination of, a base member, a head member mounted on said base for back and forth movement relative thereto along a predetermined path, a grinding tool operatively supported on said head, a screw extending between said members and journaled on one member to turn about an axis paralleling said path, said screw being axially fixed relative to said one member and having a threaded connection with the other member, a reversible rotary hydraulic actuator coupled to said screw and operable when energized to turn the screw alternately in opposite directions relative to said connection and move said head back and forth along said path, a reciprocating hydraulic actuator connected between said members and operable when energized to urge the head alternately back and forth along said path, a tracer element mounted on said head for engagement with and movement along the pattern, a source of fluid under pressure, and control mechanism responsive to the movements of said tracer and operable to connect corresponding sides of said actuators simultaneously to said source to energize the actuators simultaneously in directions corresponding to the directions of the variations of said pattern whereby said reciprocating actuator supplements the action of said rotary actuator and said screw in moving said head along said path.

5. In a machine for operating on workpieces according to a predetermined pattern, the combination of, a base member, a head member mounted on said base for back and forth movement relative thereto along a predetermined path, a tool operatively supported on said head, a screw extending between said members and journaled on one

member to turn about an axis paralleling said path, said screw being axially fixed relative to said one member and having a threaded connection with the other member, a reversible rotary hydraulic actuator coupled to said screw and operable when energized to turn the screw alternately in opposite directions relative to said connection and move said head back and forth along said path, a reciprocating hydraulic actuator connected between said members and operable when energized to urge the head alternately back and forth along said path, a sensing device responsive to variations in the pattern and operable to initiate signals corresponding to such variations, a source of fluid under pressure, and control mechanism responsive to said signals and operable to connect corresponding sides of said actuators to said source to energize the actuators simultaneously in directions corresponding to the directions of the variations of said pattern whereby said reciprocating actuator supplements the action of said rotary actuator and said screw in moving said head along said path.

6. In a machine for operating on workpieces according to a predetermined pattern, the combination of, a base member, a head member mounted on said base for back and forth movement relative thereto along a predetermined path, a tool operatively supported on said head, a screw extending between said members and journaled on

one member to turn about an axis paralleling said path, said screw being axially fixed relative to said one member and having a threaded connection with the other member, a reversible rotary actuator coupled to said screw and operable when energized to turn the screw alternately in opposite directions relative to said connection and move said head back and forth along said path, a linear actuator connected between said members and operable when energized to urge the head alternately back and forth along said path, a sensing device responsive to variations in the pattern and operable to initiate signals corresponding to such variations, and control mechanism responsive to said signals and operable to energize said actuators simultaneously in directions corresponding to the directions of the variations of said pattern whereby said reciprocating actuator supplements the action of said rotary actuator and said screw in moving said head along said path.

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